Filippo Arfini
Valentin Bellassen *Editors*

Sustainability of European Food Quality Schemes

Multi-Performance, Structure, and Governance of PDO, PGI, and Organic Agri-Food Systems

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Editors
Filippo Arfini
Department of Economics
and Management Science
University of Parma
Parma, Italy

Valentin Bellassen
CESAER
AgroSup Dijon, INRA
University of Bourgogne Franche-Comté
Dijon, France

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Preface

This book originates from one of the current challenges facing the European Common Agricultural Policy (CAP): contributing to the sustainable development of European agriculture. The CAP has in fact taken account of sustainability considerations, wider than production issues alone, since the 1990s, but the results remain unsatisfactory in the view of many stakeholders (Baudrier et al. 2015). In this book, we use the principle of sustainable development as posited by the FAO, which includes environmental, social, and economic dimensions (FAO Council 1989).

In fact, climate change, pollution, and the loss of natural resources, like biodiversity, are not the only dimensions of concern to European policy-makers; there is also the challenge of promoting the development of rural areas and identifying a strategy that leads to the emergence of prosperous and viable rural communities and is capable of generating public goods for European society as a whole (EU Commission 2016). In the face of anthropic and technological pressures on agricultural production, the agricultural model of the CAP today seeks to follow the principles of the "Bio-economy Strategy" (EU Commission 2018) and the "Sustainable Development Goals" (UN 2015).

Among the actions that the CAP has undertaken to increase the vitality of rural areas and improve the quality of food and the health of consumers, we focus on the policies supporting food quality represented by food quality schemes (FQS). These include food productions designated as geographical indications and organic products. With the Quality Package (Regulation (EU) No. 1151/2012), the CAP explicitly seeks to improve and promote GIs for agri-food products. The Regulation details the rationale for establishing and promoting the diversity and the quality of EU agricultural and food products. This is in fact widely seen as one of the CAP's main strengths on both domestic and international markets. Supporting GIs is thus regarded as consistent with Europe 2020 priorities for "sustainable growth and inclusive growth," which seek to achieve competitive high employment economies delivering social and territorial cohesion.

Moreover, the EU has recently reformed the organic production sector (Regulation (EU) No. 848/2018), continuing the policy that leads to strengthening the European organic sector in the interests of consumer health. This is an ongoing attempt to promote greener and more sustainable agriculture practices, with less reliance on subsidies and stimulating market demand.

However, the economic performance of FQS has been called into question (London Economics 2008). While some GIs bring significant value-added production results, many others have failed to become economically sustainable. Similarly, the economic performance of organic products varies between sectors and countries (EU Commission 2013). Performance of GIs has been generally disappointing in the New Member States of Central and Eastern Europe (Tregear et al. 2016). The environmental and social performance of the FQS remains largely unassessed. There are also few studies that consider sustainability in the environmental, social, and economic dimensions of GI products and in organic products.

It is however difficult to evaluate sustainability. Evaluation needs to be holistic, but at the same time, methods need to be applied to the different FQS and their reference products in different contexts of production. To date, only the FAO has put forward a methodology for this, the Sustainability Assessment of Food and Agriculture systems (FAO 2014). The challenge of generating and verifying a holistic methodology capable of measuring the sustainability of the FQS in the environmental, social, and economic dimensions was thus taken up by the H2020 Project "Strengthening European Food Chain Sustainability by Quality and Procurement Policy" (Strength2Food). This book reports the methodological approach designed in this project and the field research findings from its implementation.

The aim of the book is therefore to present a holistic methodology to assess the sustainability level of 27 FQS (European and non-European) and describe the main results. The book has two parts:

– The first part presents the theoretical framework and the analysis methodology used for 23 indicators defined on the basis of SAFA.
– The second part presents the results of the sustainability analysis for 29 FQS, which include GIs and organic products, European and non-European products, FQS, and generic products. The analysis was carried out on five product categories: (i) cereal and bakery, (ii) fruits and vegetables, (iii) meat, (iv) dairy, and (v) fish and seafood.

The innovative aspect of the new methodology is that, for the first time, sustainability indicators are used following an approach that considers both the value chain and the territory in which the process takes place, embedded in a single production system.

The sustainability analysis for each of the 27 FQS describes the impact on the supply chain and production areas by providing both a qualitative description of each FQS and its governance and a quantitative summary of key data on these FQSs. This data is used at the end of each chapter to assess the sustainability of each FQS along key comparable indicators such as value added, number of jobs, and carbon footprint. A data bank of the indicators and the underlying data can be downloaded at https://www2.dijon.inra.fr/cesaer/informations/food-sustainability-indicators/, thus allowing scholars to continue their research on sustainability in case studies of different regions.

Parma, Italy — Filippo Arfini
Dijon, France — Valentin Bellassen

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Contents

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Part I
Assessing the Sustainability Performance of Food Quality Schemes

Conceptual Framework

Filippo Arfini, Federico Antonioli, Michele Donati, Matthew Gorton, Maria Cecilia Mancini, Barbara Tocco, and Mario Veneziani

Why a Conceptual Framework to Analyze the Sustainability of Food Quality Schemes?

The objective of this chapter is to provide a conceptual framework suitable for evaluating the sustainability of the following Food Quality Schemes (FQSs): Protected Designation of Origin (PDO), Protected Geographical Indication (PGI), Traditional Specialty Guaranteed (TSG) and Organic products. This conceptual framework was initially developed under the Horizon 2020 Strength2Food Project, which seeks to assess the level of sustainability of different production systems across the world. Here we aim to generate a holistic approach useful not only for the Strength2Food project, but for all FQSs.

A conceptual framework for assessing the sustainability of agri-food systems and their products, should start from defining what is meant by sustainability and then developing a framework that includes the elements that influence sustainability over time. FAO defines sustainable development as

> […] the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable (FAO Council 1989:65).

Sustainability is the result of a complex process that deals with multiple dimensions, which must be considered as a coherent system. Among others, the

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F. Arfini (✉) · F. Antonioli · M. C. Mancini · M. Veneziani
Department of Economics and Management, Università di Parma, Parma, Italy
e-mail: filippo.arfini@unipr.it

M. Donati
Department of Chemistry, Life Sciences and Environmental Sustainability, Università di Parma, Parma, Italy

M. Gorton · B. Tocco
Newcastle University Business School, Newcastle upon Tyne, UK

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characteristics of the production system affect the specificity of the product and consumers' perception of quality and value. In this respect, Geographical Indications (GIs) and Organic production schemes, as regulated by European Union (EU) Regulation 1151/2012 and Council Regulation (EC) 803/2007 respectively, differ substantially.

In the case of GIs, the territory (including its biodiversity and human skills endowment) plays a key role, while in organic production, it is not paramount. Similarly, the structure of the supply chain and its management can be viewed as complex systems in some instances, while they may be extremely easy to characterise in others. Of course, it might happen that the sustainability of the territory affects the sustainability of the supply chain, and/or vice versa. Overall, the sustainability of FQSs is affected by different components that act together on the territory and/or on the chain, such as: (i) the quality dimension; (ii) the structure of the value chain; (iii) the role of the local agri-food system; (iv) the creation of public goods; (v) the governance model.

The Quality Dimension

A key feature of FQS products is the nature of intrinsic and extrinsic quality attributes perceived by consumers that generate value along the chain and, to some extent, may contribute to added value in the territory. Furthermore, different dimensions, depending on the perspectives of the actors (e.g., farmers, processors, distributors/retailers, consumers, regulators, public authorities), shape the perceptions and understanding of quality and sustainability of food products.

The theory of conventions offers a way to understand the worth related to food production, especially since it can be adapted to food markets and policy beyond the level of formal institutions and decisions (Boltanski and Thevenot 1991). Convention theory assumes quality to be the central "point of reference" of the conventional agreement in a food market, depending on many factors which are linked to juridical, economic and political purposes. Quality is then a two-sided concept, one aspect referring to a formal, institutional perspective (law and regulatory arrangements) and, the other, where expectations of quality emerge within an unforeseen frame, based on implicit agreements. In the first case, the regulations are well known before judgement; in the second case, there is a constant dynamism, determined by different rules, norms and conventions. Convention theorists consider "quality" associated with goods as a matter of conventions, linking social behaviour to specific identification models (or personal beliefs) between people, more than to social facts or market interests.

According to Salais and Storper (1993), conventions constitute a system of rules that all involved actors respect and follow and which evolve over time (Storper and Salais 1997).

Salais and Storper (1993) proposed that four "possible worlds of production" explain the quality of a product, where each of them is supported by at least two types of conventions. The model is represented by two axes: one spanning from a dedicated to a generic production and the other extending from a specialised to a standardised production (Fig. 1).

The model fits four different "worlds of production":

1. Interpersonal world (between specialised and dedicated products);
2. Market world (between standardised and dedicated products);
3. Immaterial world (between specialised and generic products);
4. Industrial world (between standardised and generic products).

For generic products, the quality of the product follows production standards and it is based on controls and contracts; instead concerning productions that are not generic and present specific quality attributes, the quality is unique and more open but also uncertain (because it depends on, inter alia, conventions between different actors, norms and practices). Even for this reason, the price of FQSs reflects the quality perception by consumers rather than standardized products that present measurable characteristics (Amilien and Kjærnes 2017).

These perspectives present a common theoretical background since sustainable food products and sustainable food chains are considered from the point of view of "conventions", established by the value of the quality perceived by the consumer. In the framework of Salais and Storper (1993), sustainable food products and sustainable food chains would likely fit the "interpersonal" world of production.

Considering this, different actors follow specific arguments belonging to different "*orders of worth*" with a possible compromise on which criteria from different orders of worth are joined together in an evaluation (Wagner 1999). From this perspective, the sustainability of food chains becomes one of the quality attributes

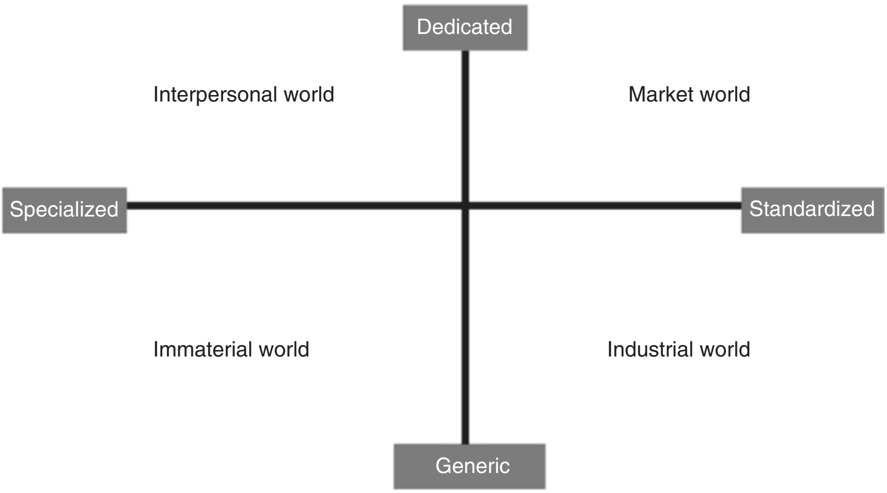

Fig. 1 The four possible worlds of production. (Source: Salais and Storper 1993:16)

and emerges between actors defending specific viewpoints through the justification of their practices.

The Characteristic of Value Chain

The value of the product is not only linked to consumer perceptions, but also to the complex system of relationships that links the product from production to consumption, creating value for agents. The concept of value chain generalizes the technological functions of a supply chain to more economic and managerial actions. The value chain, especially in the agri-food sector, is regarded as a production management tool useful to create proper product quality levels and develop marketing strategies aimed at creating value for all the actors of the chain.

Malassis and Paddilla (1986) considered the food chain as a "*path*" followed by a product within the agri-food system. It links agents (companies and institutions) to operations (production, distribution, financing) and contributes to the creation and delivery of products to the consumer, including the adjustment mechanisms along the supply chain until their final stage (Malassis and Padilla 1986).

The level of efficiency of the food chains and the ability to transfer (or retain) value to the benefit of agents can vary between different supply chains in relation to the production and processing techniques. It also depends on the bargaining power of the agents and strategies employed to enhance the means of production and the perception of quality by the consumer (Mariani and Viganò 2002). Value chains are dynamic structures since they are subject to the evolution of structural and economic phenomena (internal and external) of the value chain.

The architecture of a generic value chain can be presented as a three level structure: (i) the upstream level where inputs are produced; (ii) the processing level, where the production of the FQS product takes place; (iii) the downstream level, where the product is delivered to the end consumer (Fig. 2).

Consequently, FQS value chains can have very different characteristics in relation to the combination of different elements, such as: the structural features of the agents; their level of integration; the ability of agents to exert market power; the presence of intermediaries within the supply chain; and their ability to create added value. Strategies based on the use of FQSs, however, face the challenge of securing remunerative prices on the target market. In this regard, while many FQSs find their commercial positioning in large-scale distribution, others have great difficulty in relating with this trade channel, preferring the direct sales or traditional distribution channels.

The choice of the distribution channel is a central factor in the search for a sales strategy capable of combining quality, price, communication capacity and environmental impacts. It is no mystery that relations with large-scale distribution are particularly problematic for FQSs producers. Given the characteristics of the value chain, the relationship between the agricultural and the industrial component, as well as the relationship between companies and inter-branch organizations (when

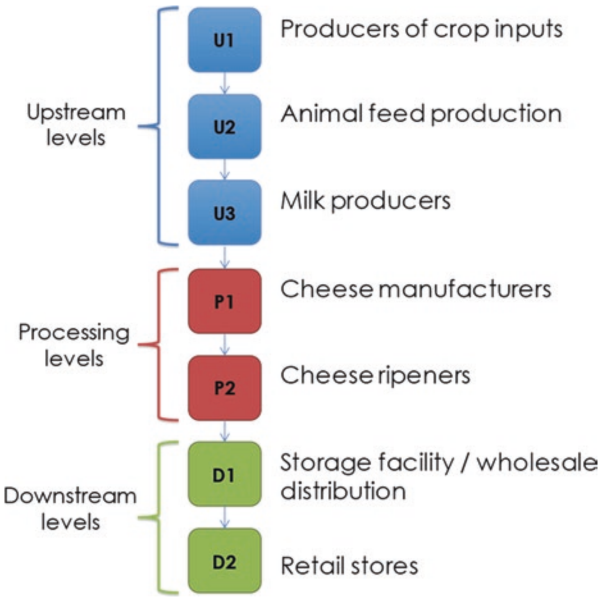

Fig. 2 The standard cheese value chain. (Source: Bellassen et al. 2017)

present) is important. Attention must be given to how to develop commercial strategies capable of increasing the added value of the product and generate a positive economic return to the producers of the values chain and, in particular for GI products, to the territory of production.

The Role of Local Agri-Food Systems

The characteristics of the value chain alone, however, are insufficient to assess the sustainability of FQS products and, in particular, of the GI products whose value chain can be considered embedded within the territory that gives the name to the food products.

The scientific debate around the role of the territory in terms of its contribution to enhancing the level of economic competitiveness often draws on the notion of the *Industrial District (ID)*[1] (Becattini 1989; Becattini et al. 2009) as the most efficient industrial organisation model capable of delivering this result. The *ID* offers a model of production that can help Small and Medium sized Enterprises (SMEs) to attain the same level of competitiveness as large firms and thus contribute to local,

[1] The concept of Industrial District was developed in Italy by Becattini (1989) although it is quite close to the concept of *cluster*.

regional and national economic growth and social development (Sforzi and Mancini 2012).

The *ID* concept informed similar concepts such as the *localised agri-food system* (Courlet 2008), and hinted at the "territorial dimension" of concepts such as the *cluster* (Porter 1990; Porter and Ketels 2009). All these approaches consider that the geographical proximity of the actors involved in the local production system is a valuable asset. Development and regional economists also employed this concept to interpret economic changes resulting from joint actions between local and extra-local social, economic and institutional forces. The outcome of this process is known as *local development* (Sforzi and Mancini 2012). *Local development* is a tool for interpreting the economic changes occurring within a community of citizens and entrepreneurs, entangled in a process of cumulative knowledge in which economic agents specialize in producing a certain class of goods (or services), which satisfies the needs (or desires) of consumers, located outside the local market.

Referring to the agri-food sector, a useful conceptualization of the interaction between the territory, production systems and *local development* is the *Local AgriFood System* (LAFS). The LAFS concept is similar to that of IDs, since they are considered as multi-dimensional and capable of raising the competitiveness level of the territory by forging opportunities in a sustainable manner. Hence, LAFSs and IDs represent models of economic growth, social development and environmental management. Their main characteristics are the strong links with the territory in all its dimensions, including not only its environmental, social and economic aspects, but also the role played by all territorial actors and their managing institutions, governance actions, local resources and specific environmental characteristics. Three distinctive features identify a LAFS:

(i) the place: intended in its broadest meaning, as used by the French school "*terroir*", it covers the specific nature of natural resources, the production history and tradition and the presence of local know-how (De Sainte-Marie et al. 1995; Sylvander 1995; Bérard and Marchenay 1995; Barjolle et al. 1998; Casabianca et al. 2005);
(ii) the social relationships: which consist of trust, reciprocity and co-operation among actors; they are the "glue" of local action (Zambrano 2010) and an endogenous development mechanism can arise from the interaction with place;
(iii) the institutions: private and public agents who promote actions regulated by formal and informal rules (Sforzi and Mancini 2012; Arrighetti and Serravalli 1999)

According to Torres Salcido and Muchnik (2012:103): "*the specific nature of LAFS lies in the conjunction of food culture-human action-institutions*". Hence, the LAFS can be analysed as the result of a process of cooperation among companies with common interests, located in a given area, which organize themselves and agree on certain production and marketing norms and rules in order to obtain a competitive advantage. The interaction of agents and institutions have led to the first conceptualization of LAFS:

> Production and service organizations (agricultural and agri-food production units, marketing, services and gastronomic enterprises, etc.) linked by their characteristics and operational ways to a specific place. The environment, products, people and their institutions, know-how, feeding behaviour and relationship networks combine within a territory to produce a type of agricultural and food organization in a given spatial scale (CIRAD-SAR 1996:5).

However, Fournier and Muchnik (2010) inter alia, recognise that the specificity of the *LAFS* resides into the spatial features of producers, people, institutions and social relations; elements that create/constitute the linkages between food and the territory. Nowadays, researchers consider the relationship between LAFSs and the qualification processes of territorial products as the most relevant, since collective actions are developed in view of the necessity to obtain a recognition of the product's origin (Giacomini 2013). In this regard, Muchnik (2009) identifies four elements that define a LAFS: (i) product qualification, (ii) co-ordination of stakeholders and collective action, (iii) resource management and (iv) dynamics of knowledge. Their interaction explains the diversity of existing agri-food systems, their evolution, stability and crises.

LAFS can take different forms, depending on the role that the natural environment, the agricultural sector and food industries play in the production process and in managing the whole system (Arfini et al. 2012; Arfini and Mancini 2018). The way in which agri-food systems reorganise themselves, meet consumer needs, generate positive (negative) externalities and trigger spatial dynamics, are a cause, rather than an effect, of the evolution process.

The interaction between LAFS stakeholders is then a central point when defining the evolution process of a local system, considering the linkages between the territory and the food chain. The various possible combinations between food chains and territories leads to different classes of agri-food systems:

(a) *The Closed System: local agricultural outputs are processed by local food industries (mainly SMEs), and purchased by local consumers.*

A strong and unique link between agricultural production and the processing phase, companies and/or the local consumers characterises this type. This has a great impact on product quality, firm structure, market strategies and relationships with the environment. Hence, managing the local environment is the most important issue since it contributes to governing input quality and the volume of production, guaranteeing the reproduction of natural resources and reinforcing the image and the reputation of the entire system. The characteristics of local resources become then relevant, since they are not just bonded/linked to environmental characteristics (e.g., land and water), but also to those aspects, like biodiversity, animal breeds, and local tradition, with highly specific features associated with the history and the natural environmental conditions of the region. Their specificity, thus, is in contrast with standardized resources, which are "generic" (OECD 2008), and characterizes the quality of the final local product (Belletti et al. 2012).

Territorial reputation represents a further element that is, at the same time, a consequence and a distinctive feature of the LAFS production model; it becomes an economic asset thanks to the characteristics of the local production system and the role of the consumption model of the local population. Local food, conceived as food with strong roots in a specific geographical place, which gives the product its identity (Belletti et al. 2012), defines well the link between local consumers and local productions systems. Reputation plays a fundamental role in the process of adding value to the raw materials, and contributes to guaranteeing an income from local resources, which is crucial to the economic dimension of the sustainable development process.

Under a territorial approach, the process of local capital accumulation, generated by managing local resources and producing local food, is considered a condition to establish and activate the "*virtuous circle of typical product valorization*", and thus generates a socio-economic environment suitable for the sustainable local development process. In adopting the virtuous circle approach, the fundamental implication is the preservation of the agri-food system and related social networks, which contribute to the economic, socio-cultural and environmental sustainability (Belletti and Marescotti 2010; Vandecandelaere et al. 2010).[2]

While a "closed" LAFS deals just with local resources, it may have relationships with consumers belonging to other regions/territories. Local consumers are attracted by local food because of the perceived quality, including several attributes such as: cultural and historical reasons, zero-miles food, organic production systems, specific intrinsic quality features, new forms of direct marketing (e.g., short food supply chains (SFSCs) or farmers' markets) (Mancini and Arfini 2018).

In this framework, new models of purchase and consumption are defined. Food becomes a common good and its value is no longer determined solely by private prices. Food becomes a public concern and it has to ensure an income to the farmer, capable of securing the realization of those positive externalities (i.e., social and environmental) appreciated by consumers and citizens who belong to the same community. That is to say, that the farmer, through SFSCs, has an incentive to choose the optimal solution, within a community, capable of creating new attributes for agricultural production, improving the relationship with the environment and raising social welfare as a whole. The outcome of this path leads to rewarding those farmers operating in line with the common/shared goals, recognizing the value that has been created. This might happen when considering farmers' markets and Community Supported Agriculture (CSA), which build horizontal networks between producers or consumers, implying also social relationships and ties that go beyond the consumer-producer relationship. Similarly, it is the local system itself that is activated to facilitate access to essential goods for all its members, regardless of social class, gender, race or age groups (Sonnino and Marsden 2006; Renting et al. 2003).

[2] This can be considered as an ideal model of the process of production and reproduction of typical products in a logic of regional development, boosting the economic development of the entire system and region.

In this book, several products belong to this type, including PDO Opperdoezer Ronde potatoes, PDO Croatian olive oil, PGI Kaszubska strawberries and PGI Ternasco de Aragon.

(b) *The Open System: agricultural outputs are not processed by local food industries or purchased by local consumers.*

When considering the value chain (i.e., all the stages involved in producing a certain food product, inside and outside the LAFS), for many LAFSs upstream and downstream actors may not solely belong to the territory. This happens whenever local supply does not satisfy the demand from the territory and when consumption is not able to completely absorb the output, compelling the LAFSs to look for larger markets (Becattini 1989).

The extent and strength of the LAFS'/product's reputation determines the distance between the product and the new market. Subsequently, the higher the reputation, the farther the new markets can be. Therefore, the food chain is characterized by the presence of new agents that operate outside the territorial boundaries, together with the, already established, local actors. Outside agents deal with individual and collective strategies, including the relationship with the local environment, and raise further the effectiveness of the food chain.

The sustainable development of an open system eventually depends on the governance and management of both local resources and the interactions between the in-situ actors and the stages of the value chain operating outside the territory (Reviron and Chapuiss 2011). Similar to the downstream ones, upstream production stages can use inputs and have relationship with companies that are located outside the LAFS. Hence, the link between the local agricultural system and the processing industry is weak, since inputs come from outside the boundaries (e.g., PGI and organic food chains), which can have important consequences for the local production system.

Considering the concept of ID, its linkages with the territory are made explicit through the labour force, cultural heritage and skills, research activities, logistic infrastructures and the network of other enterprises involved in the same food chain. These local firms are rooted in the area and have developed efficient and effective marketing strategies toward global markets and consumers. They have generated global food chains characterised by a very effective management of both the production system and consumer relationships. Often, firms become multi-national companies, with branches spread all over the world but the headquarters remains within the territory of origin, in order to maintain the core of the decision-making process in the original area of production and benefit from the presence of the ID. The benefits of the ID include low transaction costs, higher bargaining power with local stakeholders and policy makers concerning the decision-making process and, therefore, the evolution of the company. Being able to differentiate agricultural inputs on the basis of the desired quality features and marketing costs of the final product represents a further advantage, since the availability of agricultural inputs in this model is not a constraint for local companies. Consequently, their strategy aims to buy agricultural commodities with an adequate level of quality for processing at a low cost.

Moreover, in "*open*" LAFS models, local companies might benefit from connections with local and non-local research systems, which allow them to innovate and follow new technological paths, raising their level of competitiveness without losing the link with local traditions.

In this book, several products belong to this type. Some are mostly open at the producer end, such as the PGI Gyulai sausage or the PGI Dalmatian ham which procure their raw materials from outside the area, while others are mostly open at the consumer end, such as PDO Parmigiano Reggiano, PGI Lofoten stockfish or organic raspberries, which are sold on a global market. The book does not include LAFS that would be largely "open" at both ends although these could exist, as in the case of PDO Parma Ham.

(c) *The Mixed Systems: coexistence of close and open LAFS.*

These systems are characterized by the coexistence of both "closed" and "open" LAFS models. The territory at the same time has specific natural characteristics and develops strategies that are typical of both industrial and rural districts. The outcome of this combination is the reinforcement of meanings of all the variables that characterize and influence the development process of local areas, including reputation. Reputation becomes an asset for all the agents involved in the food production system, materialized by a distinctive label, and, when associated with local products rooted in the area, bearing a geographical name related to the region of production (often recognized in GI products). The geographical name becomes then a brand carrying a clear message of quality, from which not only the industries involved in the GI scheme benefit, but the entire food sector and all the local companies. Reputation affects the economic growth of a territory through the so-called "*spillover effects*" (Mayer 2006; Giacomini et al. 2010b), generated from the stock of intangible capital created within the area (i.e., the district), as a consequence of the reputation achieved by those goods/food products particularly appreciated by consumers. The spillover effect attached to the reputation of a territory is known as "*spillover reputation*", and it gives a special importance to the reputation of the actors and their ability in managing and governing the development process (Mayer 2006; Yu and Lester 2008).

The presence of simultaneous spillover effects within the district, from one food product to another, attributable to the geographical condition and reputation, can lead to important consequences for firms' management and strategy building. Territorial reputation may fall when some companies misuse the reputation and adopt unfair practices against their competitors in the same region (Rossi and Rovai 1999; Yu and Lester 2008), leading to a decline in reputation and market competitiveness. Especially in mixed LAFS, reputation might also be reduced whenever stakeholders do not consider properly the adoption of specific policies aimed to preserve the "virtuous circle" (Belletti and Marescotti 2010; Vandecandelaere et al. 2010).

Reputation is a convention by which local actors handle the link between the quality of the product and the territory, reaching a dynamic agreement in binding the product to the society (consumers and, more in general, citizens) on the basis of certain conventional rules (Belletti et al. 2012; De Sainte-Marie et al. 1995). Therefore, reputational assets should be conceived as a local qualification process.

Open and mixed systems may embed economic disadvantages for local agricultural producers, since agricultural inputs may come from different territories, where price and quality differ and can be lower than local ones. There exist two main implications, which apply to both PGI and organic products:

(i) farmers can suffer from price competition and are pushed to adopt more intensive production systems or introduce new varieties which, in turn, may reduce biodiversity;
(ii) food industries may be more competitive when operating also in distant markets to reduce input costs, but the reputational value may decline as well, if a lower input quality affects the quality of the final product.

The level of sustainability and the variables that might have an effect on it can be different between “closed”, “open” or “mixed” LAFS. A clear example of different strategies with implications in terms of sustainability is provided by the Italian cured ham chain (Oostindie et al. 2016; Dentoni et al. 2012). In this case, although the main output of the chain is PDO Parma Ham, processors have established an alternative network for low quality ham affecting the economic sustainability of local farmers (Oostindie et al. 2016).

In order to preserve a sustainable “*virtuous circle*”, Belletti et al. (2012) consider three different areas of action: technology, collective action and market failures. Effective management of these three dimensions can reduce conflicts and allows for a fairer balance of power among actors, helping with the process of recognising product quality. Moreover, this prevents local resources from being under-paid drawing on the price premium established on the consumer market (via a reduction in the extent of information asymmetries between producers and consumers) and its more equitable redistribution on the intermediate market (i.e., reducing imperfect competition that generates unfair value distribution along the supply chain).

In summary, the LAFS paradigm (either industrial or rural) supports an endogenous development model based on the intrinsic characteristics of the production system, intended in its broadest sense, which – also in the case of the so called rural development – takes the form of a neo-endogenous development model (Ray 2006; Hubbard and Gorton 2011). It delineates an endogenous-based development in which extra-local factors are recognised and regarded as essential, while retaining a belief in the potential of local areas to shape their future. In contrast to the theoretical underpinnings of both exogenous and endogenous models of rural development, neo-endogenous rural development is based on the interplay of both local and external factors, so that the development strategy is built upon the link between local conditions and external opportunities. However, the neo-endogenous-based development model requires greater attention to its impact on sustainability, since the maintenance of local environmental and social sustainability can be stressed by the pressure of external factors both on the demand for goods and on the supply of inputs.

The Role of Public Goods

In this framework, institutions can contribute positively to local development, producing several types of externalities and, thus, specific public goods, both for producers and consumers. Those for producers include immaterial goods instrumental to improving the level of skills, preserving quality, avoiding unfair competition, increasing the reputation of the FQS and/or the territory, facilitating relationships among stakeholders, reducing transaction costs, increasing the value of output by raising the firms' reputation and facilitating the marketing of local products (Muchnik 2009; Belletti et al. 2017). This can improve market efficiency, but also preserve local knowledge, cultural heritage and local biodiversity.

Moreover, when agri-food systems are considered, the perception of sustainability as a public goods should be stronger in LAFSs (Muchnik 2009). The intrinsic quality attributes of food, related to the environment and the quality of social relationship among actors[3] become the main economic levies, instead. Hence, the LAFS becomes a suitable dimension for interpreting economic changes and strategies within a rural community of citizens and entrepreneurs involved in a process of knowledge accumulation, where economic actors specialize in the production of certain types of goods (or services), which satisfy the needs (or desires) of citizens and consumers inside and outside the local area. Besides, rural development includes natural resources as active components of the production system, and their evolution should be carefully managed in order to avoid future environmental problems, a decline in the volume of production, in its quality and in the sustainability of the whole system.

The Governance Model

The literature indicates that within value chains and LAFSs, organizations and local institutions should be considered as largely positive elements (Reviron and Chapuiss 2011). This is fuelled by a sense of belonging, by the necessity to develop chain strategies, as well as by the common interests of territorial actors, which are represented by governance actions. Chain and LAFS organizations are the result of the interactions between participating actors (e.g., companies, institutions), generating a set of dynamic forces that allow for adapting to the challenges posed by the market (Giacomini 2013; Rallet and Torre 2004; Torre 2000).

[3] Note, however, that some environmental or social impacts may become too diluted over time (e.g. knowledge transmission) or space (e.g. carbon footprint) to be effectively internalized in LAFSs.

Considering the supply chain, governance actions are always more relevant in managing technological, institutional and market pressures with the aim to reduce transaction costs within the value chain (Fischer and Hartmann 2010). Even for FQS, the governance actions developed by agents of the supply chain have the following objectives: (i) create, maintain and increase a distinctive quality character of the product and the producers; (ii) mobilize institutional support from local and extra-local institutions; (iii) develop relationships among economic agents; (iv) protect local producers from unfair competition.

These objectives are achieved through the ability to create a climate of trust between the agents of the value chain (i.e., producers and consumers) reducing, at the same time, the conditions for conflict. Gereffi et al. (2005) observe the coexistence of different models of value chain governance on the basis of the complexity and codification of transactions and of the competence of suppliers.

These different "models" may have different impacts in terms of the sustainability of the chain and the territory. Moreover, in the case of GIs, governance actions, combined with legal protection, can serve as a useful framework to drive an integrated form of market-oriented rural development that can facilitate equitable participation among all of its stakeholders (Giovannucci et al. 2009). In sum, for most FQS, their impact is strictly related to the territory.

In this framework, local institutions represent a group of stakeholders that play key roles in the process of increasing territorial competitiveness. Their role is mainly to strengthen relationships between stakeholders, with the general aim of obtaining the delivery of those public goods and positive externalities which mostly serve the process of development, increasing the level of competitiveness of the entire local system. Local institutions can be considered as all those institutions that represent the groups having an interest in the economic, social and political life of the locality (Vandecandelaere et al. 2010). They represent groups of stakeholders debating the evolution of local systems and attempting to modify/introduce development paths useful to the needs of the local society. Their main contribution to local development is to express governance strategies (at the chain and territorial levels) that reflect the interests of the stakeholders. Their role is to contribute to higher wellbeing by managing the tangible and intangible resources available in the territory. This means managing, directing and coordinating socioeconomic processes in a specific environmental context, with local institutions and social actors (within and outside the territory), in terms of the value appropriation of territorial resources or the expectation of wellbeing generated by the valuing of those resources (Torres Salcido and Muchnik 2012).

According to Torres Salcido and Muchnik (2012), local institutions inside the LAFS develop a set of actions aimed at reaching agreement and managing the main issues related to local development processes regarding: institutional, social and market effectiveness, technological improvement, territorial valorisation, quality assurance, knowledge transfer, environmental safeguarding and sustainability.

Hence, local institutions play a political role, which considers local production systems as complex systems relevant for the constitution and operation of both local enterprises and citizens. The LAFS, ideally, is not only self-regulating and self-managing organizations devoted to local resources' administration, but interact with the market and the National Government (Giacomini 2013), managing and conditioning also the local natural environment. As previously mentioned, it develops a set of common rules aimed at obtaining a collective competitive advantage from which each actor benefits individually (Giacomini and Mancini 2015; Giacomini et al. 2010a; Perrier-Cornet and Sylvander 2000; Torre 2000) and preserves natural environmental resources from productive and anthropic pressures. Therefore, this model encompasses a clear process of cooperation that involves several types of actors (i.e., within and outside the boundaries of the territory) which manage the whole system.

Referring to FQS (especially GIs), the inter-branch organisation is the institution most appropriate for managing its relationship with the territory and the supply chains (Giacomini et al. 2010a; Giacomini 2013; Arfini 2013). Such governance structures are based on the cooperation between the operators in the supply chain, defined by long-term contractual relationships, which does not affect their autonomy or ownership rights. In regard to hybrid forms of governance, relationships between the parts are regulated by the principle of authority, transferring part of the decision-making power to a third-party institution. In the case of GIs, this "third-party institution" may consist of "groups" (as defined by the EU Regulation 1151/2012), such as producer groups or Inter-branch Organisations (Perrier-Cornet and Sylvander 2000). As demonstrated in this book, organic chains also developed their own institutions to fulfil these roles in several countries (e.g., Agence Bio, FNAB and ITAB in France, BÖLW, AÖL and BNN in Germany).

The third-party institution, responsible for supply chain governance, acts as a mediator between the operators in the different phases of the chain and steers product quality towards compliance with production specifications also by introducing payment systems based on the quality of raw materials. The aforementioned third-party organization plays a key role in defining a "strong territorial governance" (Barjolle et al. 1998; Arfini et al. 2011), given its capacity to organise the supply chain and establish fair relations between members, increasing their ability to protect their interests against competitors and, also, to protect the natural systems and local resources.

It is apparent that collective action plays a fundamental role since it can reinforce the sustainability of the whole production system. This approach is the core of the "origin-based quality virtuous circle" approach proposed by Belletti and Marescotti (2010) and Vandecandelaere et al. (2010). This approach aims at preserving the local agricultural system and enhancing the supply chains of the territory, considering the area where the collective action takes place both inside and outside the region involving, by definition, many actors. Producers, processors, traders and consumers share their knowledge, their good practices regarding production, processing, trading, consumption and preserving the system. Furthermore, the market recognition obtained by local products reflects the collective capacity to define and efficiently manage the combination of natural and human factors. Therefore, collective rules and governance actions should not be considered as constraints but rather as conditions to ensure the sustainability and efficiency for the entire local system (Vandecandelaere et al. 2010).

The Interaction Between Value Chains and Local Agri-Food Systems

In conclusion, the enhancement of local products through the activation and capitalization of tangible and intangible assets, which include social capital and natural resources, may allow a fair remuneration and, therefore, the re-production of the LAFS by encouraging preserving the territorial system, in its social, economic and environmental dynamics. On the contrary, inadequate remuneration of local resources, especially labour, endangers the sustainability of the LAFS, organised to deliver the product with the present quality features, requiring a possible re-definition of the quality delivered or the mode of production.

It is evident that the sustainability of FQS depends on a close relationship between value chains and territorial systems. The link between the two productive dimensions (value chain and LAFS), that guarantees its irreproducibility, is due precisely to the environmental dimension, which by its nature is irreproducible, combined with the cultural and social dimension relatives to the ability to interact with specific environments.

For food production, and in particular for FQSs, there is a “cause-effect” relationship between the actions of the actors, (based on their strategies) and the impact on the economic, environmental and social variables of the value chains and LAFSs. The local, domestic, or global scope of the value chain becomes the factor capable of explaining the extent of the ecological footprint and economic performance, but

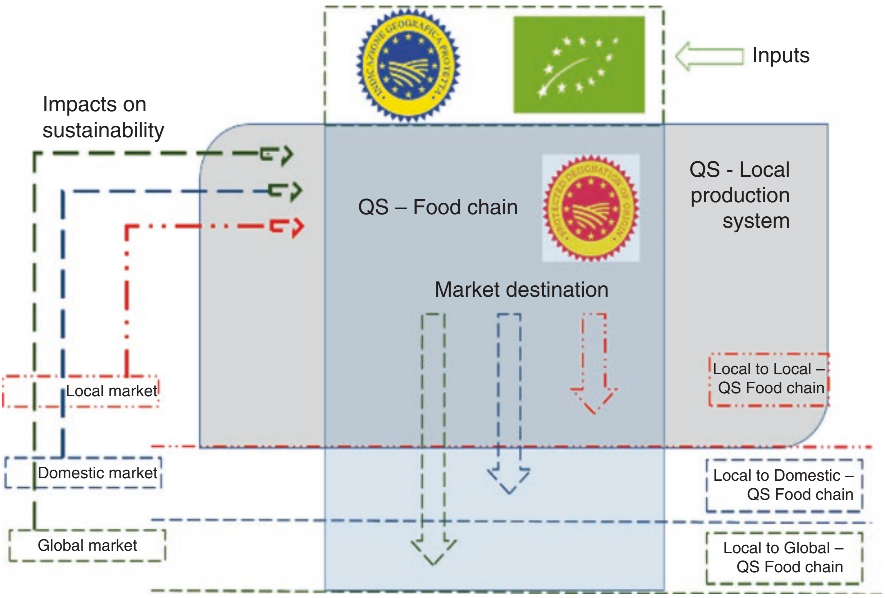

Fig. 3 Relationship among Value Chain and Local Agri-food System

to evaluate its implications in terms of sustainability it is necessary to place them in a territorial logic aimed at maintaining and reproducing specific resources. In the realm of the analysis proposed in this book, the local scope equates to a market characterised by proximate relationships resting on trust and knowledge of all the actors involved. A domestic market is characterised by the same trading rules (i.e., the EU Single Market or the European Economic Area) and does not require paying duties or tariffs to have access to it. Long term relationships have led to formalising trust relationship into formal legal agreements (i.e., the Free Trade Area; the Customs Union). Lastly, global markets are those which are accessible via tariffs or duties, regulated by the ultimate safeguard of trust in global relationship, the WTO.

In this regard, the proposed scheme (Fig. 3) illustrates how both the productive dimensions (value chain and territory) are considered in this book. For reasons both related to the organization of the research and to the specificity of firms, the analysis of sustainability focused mostly on the agricultural phase and the transformation phase of the value chain ("U3" and "P1" level of Fig. 1). It is at these levels that most of the sustainability indicators are estimated for each case study in this book. Indeed, the distribution level is usually not specific to the value chain considered, and its impact cannot easily be attributed to it.

The differences for the same indicators are due to the different intensity of the process, the production organization of the chain, the organizational model, the social role and commercial strategy of the agents and of the nature of the governance institutions, both for the supply chain and the territory.

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Common Methods and Sustainability Indicators

Valentin Bellassen, Federico Antonioli, Antonio Bodini, Michele Donati, Marion Drut, Matthieu Duboys de Labarre, Mohamed Hilal, Sylvette Monier-Dilhan, Paul Muller, Thomas Poméon, and Mario Veneziani

General Points on Indicators and Their Analysis

Overview of Indicators and Minimal Systematic Comparison

This chapter describes the indicators used in the Horizon 2020 Strength2Food project to measure the sustainability level of food products with very different characteristics: fresh, processed, organic, designated by Geographical Indication and conventional. The choice of indicators was made on the basis of the SAFA methodology (Sustainability Assessment of Food and Agriculture systems) developed by FAO (2013) to measure the sustainability of food production.

With the SAFA methodology, the FAO presents a holistic approach and provides a list of 116 sub-dimensions grouped by the contribution made to sustainable development in environmental, social, economic and governance aspects for production of crops, livestock, forestry, fisheries and aquaculture enterprises. For each indicator, SAFA provides guidelines on how to consider each sub-dimension, including which indicators could be relevant and useful indications on how to implement them. SAFA however is primarily focused on processing firms and stops short of

V. Bellassen (✉) · M. Drut · M. D. de Labarre · M. Hilal
CESAER, AgroSup Dijon, INRA, Univ. Bourgogne Franche-Comté, Dijon, France
e-mail: valentin.bellassen@inra.fr

F. Antonioli · A. Bodini · M. Donati · M. Veneziani
Università di Parma, Parma, Italy

S. Monier-Dilhan · T. Poméon
Observatoire du Développement Rural (ODR), INRA, Toulouse, France

P. Muller
Bureau d'Economie Théorique et Appliquée (BETA, UMR CNRS 7522), Université de Lorraine, Metz, France

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formulating a complete method which goes from primary data collection to indicator estimation and interpretation.

The Strength2Food indicators presented in this chapter operationalize a subset of SAFA indicators, complementing them along the following three lines:

- Most SAFA indicators cannot be directly implemented from the SAFA indicators report. They require the definition of specific data to be collected and calculation or aggregation methods which are not explicated in the report, although the report sometimes refers to existing tools for doing this. The Strength2Food method defines all necessary data and variables, and provides associated calculators or aggregation methods, together with a data storage and source traceability system.
- Because they were designed to be collected for a single firm, many SAFA indicators require a substantial amount of data. This makes it difficult to cover more than a few indicators for an entire value chain within 3 person-months. The Strength2Food method simplifies indicators by prioritizing data collection on the key drivers of the indicators, by providing default values for many non-key but necessary variables and, where necessary, by restricting the scope of an original SAFA indicator down to the scope for which data is most accessible. As a result, it is possible in most cases to estimate 23 sustainability indicators across the three sustainable development pillars for both a specific product produced by several firms and a generic reference product in 3 person-months.
- Finally, several SAFA indicators rely only on the subjective views of specific stakeholders. Where stakeholder views are a necessary part of the indicator (e.g. bargaining power distribution), the Strength2Food indicators combine stakeholder views with objective data.

To make the collection of information and the subsequent analysis on the 27 case studies of the Strength2Food project efficient, operational choices were made with regard to the type of indicators and their management. One of the most important choices is the distinction between "systematic indicators" which should be computed on all case studies and "complementary indicators" which concern only a subset of case studies, oftenon the basis of data availability. There was a total of 13 systematic indicators (four economic; four environmental; five social), and a total of ten complementary indicators (five economic; three environmental; two social). Around 150 variables were collected and refined into the 23 indicators (Table 1).

Analysis of Indicators

In multi-criteria analysis such as those undertaken here, there are two ways to look at the indicators: one can either combine them into a single composite indicator or use radar charts or similar display formats (Bockstaller et al. 2015; Rigby et al. 2001). Both have pros and cons in relation to the objective of the research. A composite indicator allows for a synthetic performance score for the system under study why for an

Table 1 List of indicators for sustainability assessment

	Sustainability pillar	Indicathor type	Indicator sub-type	Level of analysis along the value chain
Systematic	Economic	Price premium	Price premium	One value per level of the value chain
		Profitability and value added distribution	Gross operating margin	
		Trade	Share of value exported within Europe	Single value for the whole value chain
		Local multiplier	Local multiplier	
	Environmental	Foodmiles	Distance travelled per unit of product	One value per level of the value chain
		Carbon footprint	Carbon footprint per unit of product	Single value for the whole value chain
		Water footprint	Blue water footprint (surface and ground water consumption)	
			Grey water footprint (water pollution by nitrates)	
	Social	Employment	Labour to production ratio	One value per level of the value chain
		Governance	Bargaining power distribution	
		Social capital	Educational attainment	
			Generational change	
			Gender equality	
Complementary	Economic	Profitability and value added distribution	Gross value-added	One value per level of the value chain
		Profitability and value added distribution	Net result	
		Trade	Share of value exported outside Europe	Single value for the whole value chain
			Share of volume exported within Europe	
			Share of volume exported outside Europe	
	Environmental	Foodmiles	Emissions from transportation per unit of product	One value per level of the value chain
		Carbon footprint	Carbon footprint per hectare	
		Water footprint	Green water footprint (rainwater consumption)	
	Social	Employment	Turnover to labour ratio	One value per level of the value chain
		Social capital	Wage level	

quick evaluation also by non expert policy makers but results. However, this benefit is obtained at the expense of a substantial information loss. In particular, one may miss threshold effects such as a system which is performing quite well overall but which seriously underperforms in one of the dimensions. In addition, the assumptions necessary to add up the “apples and pears” heavily weigh on the final results: should an equal weigh be applied to the economy and the environment? Should environmental indicators be converted into euros? If so, which externality valuating technique should be used? And many other fundamental questions (Gan et al. 2017).

Considering the objective of this research, in describing the contribution of each indicator to the sustainability of the value chain, we decided not to combine indicators and instead resort to radar charts. Each chapter thus contains one radar chart summarizing the sustainability assessment comparing the product under Food Quality Scheme with a reference product (the zero level) in percentage variation (Fig. 1), followed by its interpretation. Each branch presents the performance of the value chain, averaged across the chain levels (e.g. farms and processors), for one of the systematic indicators. For the environmental indicators for which lower is better, the opposite of the difference (e.g., +20% when the carbon footprint is 20% lower) and the supply chain total – rather than supply chain average – are displayed.

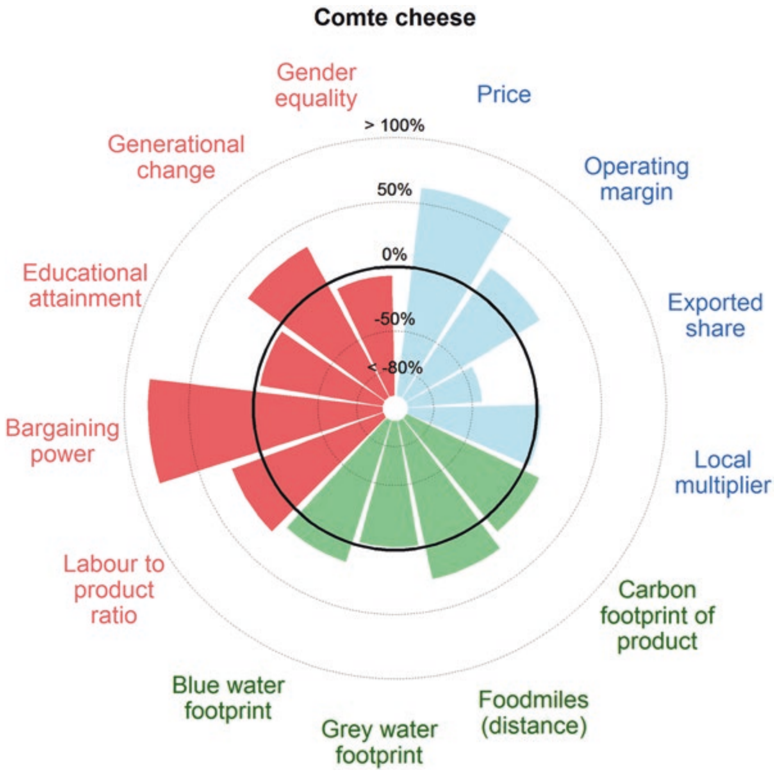

Fig. 1 Sustainability performance of PDO Comté cheese

Reference, Data Collection and Metadata Documentation

Selection of a Reference Product/Case: Elements of Guidance

To provide a basis for comparison, each sustainability indicator has been estimated for the same product category (for example cheese) in two different value chains: specific quality (organic or geographical indication) and generic quality (reference product). In order to define the reference, the following guidance, composed of two objectives and three constraints, was applies. The two objectives are:

- Comparability of contexts: the two cases (food quality scheme and its standard reference) should be produced in territorial contexts (in terms of location) as similar as possible;
- Comparability of the products: the two products/basket of products (food quality scheme and their standard reference) should be as comparable as possible.

These objectives should be sought until one of the three following constraints are met:

- Data resolution limit: data for the reference are only available at a larger scale than for the case studied.
- Confusion of the case and its reference: for example, for an apple under geographical indication (GI), the reference would ideally be the production of 'standard' apples in the same area. Nevertheless, if almost all the apple production of that area is under GI, a reference should be chosen at a larger scale (regional or even national scale).
- The case studied is the only one of its type: with the example of an apple under GI, the ideal reference would be a standard apple of the same variety. Nevertheless, as mentioned for geographic scale, data may be scarce at this detailed level (variety), or even all the apples of this variety may be sold under GI. In this case a suitable reference would be one, or a mix of, the main varieties.

In practice, the choice of a relevant reference by case study conductors will strongly depend on data availability, so that a national average can be used if a more suited reference cannot be documented. Moreover, a mix of specific references and national averages can be used. For example, looking at the Comté cheese, some variables (e.g. price of milk, price of cheese, …) may be specific to Emmental, a non-certified ripened, hard, cow-milk based cheese, while national averages are used for other variables (e.g. quantity of mineral fertilizer per hectare, share of exports over total production, …) for which Emmental-specific data are not readily available.

Note that the use of the reference is primarily to interpret the results from the case so even if the reference presents some peculiarities, this can be accounted for in the discussion of results. Indeed, although we opted for real *relative references* in Strengh2Food, many performance assessments use *normative references*, that is references which correspond to fictive cases or to targets to be reached (Acosta-Alba and Van der Werf 2011).

Data Collection

Two Angles of Prioritization

Two distinctions were made to convey a sense of priority for data collection:

- **Systematic vs complementary indicators**: systematic indicators were to be computed for all case studies while complementary ones could be restricted to a subset of cases which are particularly interesting;
- **Key vs secondary variables**: a reasonable approximation of the indicator can be obtained from key variables data, while obtaining values for secondary variables would create even more precise estimates.

Which Firms Belong to the Value Chain?

When firms are making only part of their turnover from the FQS product – e.g. a freezing plant which is freezing and packaging all kind of fruits, including the FQS (organic raspberries) – criteria are needed to determine whether they belong to the FQS value chain. The key recommended criterion is that the firm makes at least 50% of its turnover from the FQS product. As such, most firms at retail level will be excluded. However, a few systematic or ad hoc exceptions are made:

- The retail level is included for two economic indicators, namely price premium and export;
- A firm/value chain level can be retained on an ad hoc basis when its impact on an indicator is substantial (e.g. impact of freezing on the carbon footprint of frozen raspberries);
- A firm/value chain level can be retained on an ad hoc basis when stakeholders consider it as part of the value chain despite it making less than 50% of its turnover from the product.

In other words, most of the data collection/gathering effort should be spent on *key variables which contribute to systematic indicators*, while the rest should only be provided if data is readily available, and should not be the object of a dedicated data collection effort.

Relying on Existing Sources of Information

In general, given the resource and time constraints, most variables were designed to be common enough to be obtained from existing studies, reports and databases. A good strategy for a comprehensive overview of existing sources, may be to conduct a few (3–5) interviews with key stakeholders in the chosen case study's value chain.

Default Values

In parallel to case-by-case data collection, an effort was made to obtai national average values for as many variables as possible, and cover all the sectors studied (dairy, meat products, seafood/fish, cereals, fruits & vegetables). These values do not refer to specific products but to larger product categories which can be identified in systematic surveys. For this purpose, databases with pan-European coverage, such as the Farm Accountancy Data Network (FADN) and different surveys and datasets available via Eurostat database (i.e. Farm Structure Survey, Structural Business Statistics, Labour Force Survey, etc.) have been explored.

These default values were could be used in three different manners:

- To check that the collected data for the case and/or its reference is of a reasonable order of magnitude;
- To estimate indicators for a "national average" reference product;
- To save time on data collection when there is evidence (e.g. expert judgement) that a given variable is not significantly different from the national average.

This last option was infrequently used and, in all cases, data sources for each variable and product are transparently documented in the data repository (https://www2.dijon.inra.fr/cesaer/informations/food-sustainability-indicators/).

Quality Checks in Data Collection and Indicator Estimation

Principles

Considering the scale and the complexity of the Strenght2Food project (measuring the sustainability level of 44 products using 23 indicators referring to the environmental, economic and social dimensions of sustainability), an organizational model was developed. It consider three operational phases and three different researcher profiles which specific relationship and responsibilities.

The most important principle of the procedure for data collection and indicator estimation is an early and repeated interaction between the case study conductor and the indicator coordinator (Fig. 2). The case study conductor is responsible for collecting the data and ensuring its traceability, which implies creating a repository with all source files and intermediary calculations. The indicator coordinator is responsible for the quality check of the data provided (e.g. verifying, together with the case study conductor, the original source when an order of magnitude seems wrong, etc.) and for providing the case study conductor with the estimated indicator(s). Both are responsible for interpreting the results.

Example of Data Collection Agenda

Based on the experience gained on the three pilots, the following agenda was recommended for data collection:

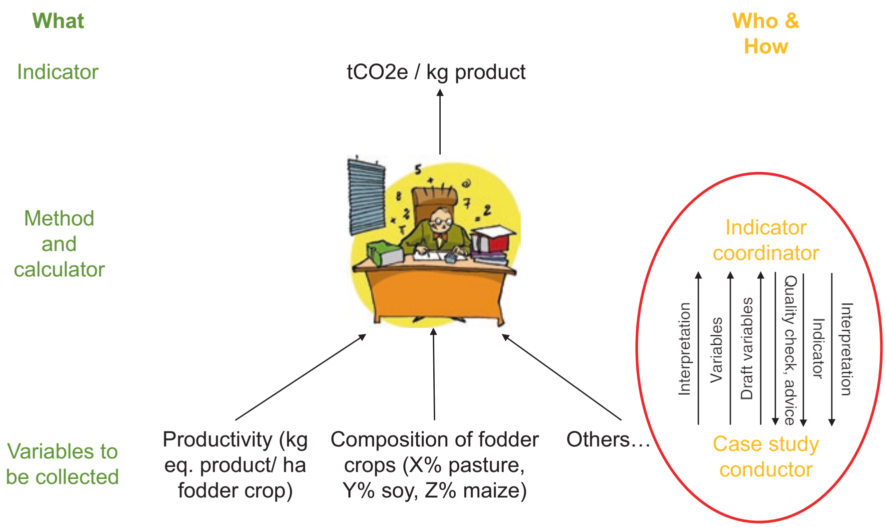

Fig. 2 Organisation of data collection and indicator estimation and interpretation

- Identify 4–6 key stakeholders likely to know of many and diverse sources of information, starting with the product syndicate (Defence and Management Organisation for GIs);
- Send them an e-mail asking for documents;
- Look for variables in the documents, following the prioritization strategy;
- Interview the 4–6 stakeholders, focusing on the key variables still missing and the indicators/variables/levels you are most interested in. And early interview with the product syndicate will likely be helpful for the identification and contact of the other key stakeholders;
- Set up a stakeholder survey if necessary for the variables that could neither be obtained from secondary data nor from expert judgement during the interview;
- Make use of the indicator coordinators throughout the process: to identify possible data source, to request default values, to avoid misunderstandings on the requested variables or on the method to estimate the indicators, …

Tips for Data Collection

In addition to the road-tested example of data collection agenda presented above, here are a few tips for data collection which were used:

- Comparability of sources: to the extent possible, it is preferable to use the same source of data for related values (e.g. fertilizer amount and crop yield). In particular, it is preferable that for a given variable (e.g. price), values for the Organic/GIs and its reference come from the same source where authors have likely put some effort into ensure that the comparison is *caeteris paribus*. Along those

lines, when eliciting expert judgement, it is preferable to ask for the difference between FQS and its reference rather than asking for absolute values.
- Prioritization:
  - Begin with key variables necessary to compute systematic indicators at key levels of the value chain
  - Rely on existing sources of information: existing documents (articles, reports, code of practice/technical specifications, …) and databases
  - Conduct 4–6 interviews to obtain more secondary data and/or primary data
- It may be convenient to focus on key areas of production (e.g. three main regions producing Parmigiano) or key processors (e.g. the three firms making up 80% of market share) to save time. Indeed, regional authorities of key areas may have readily available data which do not exist for smaller areas.
- Metadata documentation: record the source/reference, the type of value (average, min, max, …) and the time period in the excel template and deposit the original documents and, where relevant, the intermediary calculations, in a dedicated repository;
- Access to AMADEUS and/or its national counterpart helps a lot with the processing levels for Ec1 and So1 (and Ec2, to a lesser extent);
- Regulators, auditors and accountants are likely institutions with data on the variables sought.

Metadata Documentation

For each variable value, two metadata were documented:

- the source/reference for the values (e.g., Dupond et al. 2010);
- to which time period the variables values correspond. Time periods should be as recent as possible, and to the extent possible, similar between different variables. When relevant and available, time-series and/or multi-year averages can be used.

In addition, all original documents from which the data are sourced and the intermediary calculations (e.g. excel or word documents) have been stored in an online repository so that both the case study conductor and the inidcator coordinator can go back to them easily to double check some values or interpret the results.

Summarized Description of Indicators and Their Purpose

The indicators used in each case study throughout this book are briefly described in this section. More details of the feature and the computational methodology for each indicator, together with the detailed list of key and secondary variables used to estimate them and the most important data sources, is provided in Bellassen et al. (2016).

Economic Indicators

Price

The price indicator answers to the question whether FQS products benefit from a price premium, testifying that at least some consumers recognize its higher quality and are willing to pay more for it. The prices may be directly available, if not they must be calculated using turnover and quantity.

This indicator is computed for each level of the value chain. Prices should be representative of the value chain, in terms of volume, actors and according to possible seasonal variations, so that ideally they should be average prices weighed by the relative importance of each distribution channel.[1] The main stages of the value chain have to be considered depending on the type of product.

Profitability and Value Distribution

The actual profitability also depends on the costs incurred. Three classic analytical accounting indicators (Gross Value-Added, Gross Operating Margin, Net Result) are computed for each FQS and its standard reference (Chatellier 2002; Chatellier and Delattre 2003; France AgriMer 2011). Intermediate consumption, subsidies and wages are the costs where the most important differences are expected between FQSs and their reference products.

Either these three classical indicators have already been computed and published in an existing documents (i.e. FADN report, AMADEUS, etc.) or they can be computed based on the variables, as presented in Fig. 3.

Indicators are defined per unit of turnover. These indicators are computed at the main stages of the value chain which allows analyzing the distribution of:

- revenues along the value chain
- gross margin along the value chain
- prices along the value chain (computing price premium = (priceFQS – priceReference)/priceReference)

NB: for operators involved in several productions, one must assess whether they are considered as part of the value chain. The key recommended criterion is that the firm makes at least 50% of its turnover from the FQS product (see above).

[1] For example, if 25% of the total volume is sold in national supermarkets at price a, 50% by direct selling at price b and 25% is exported at price c, the average price will be (0.25∗a + 0.5∗b + 0.25∗c). The same logic applies for different presentation and type of products (raw or processed product, packaging, more or less aged, etc.).

Fig. 3 Conceptual model for distribution of costs and margins in a value chain

International Trade Indicators

The ratio of the products exported (volume or turnover) to the total production provides some information on market dynamism. The following indicators are relevant for investigating the contribution of the FQS to the national and European trade balance. These indicators are related to the final product.

$$\%\ \text{export}_{Vol} = \frac{\text{Export Volume}}{\text{Total turnover Volume}}$$

$$\% \text{ export}_{Val} = \frac{\text{Export Volume}}{\text{Total turnover Value}}$$

Local Multiplier

Method to Compute the Indicator

The methodology comprises three steps of analysis and starts from the stage of the product supply chain where the most value added is produced (i.e. downstream supply chain value). This point is named LM1. For FQSs, LM1 should be the producer or processor/manifacturer whose output is the final product in nature before being sold to the wholesaler (e.g., ripened cheese rather than milk, pasta rather than wheat, …).

Definition of the Local Area

The local area for Geographical Indications is the area included in the technical specifications. In the case of organic products the local area is the NUTS2 region surrounding where the firm is located or a circle of 50 km radius around the processor considered in LM1. If administrative boundaries are easier for the interviewer to use, then relevant administrative area summing up to around the same surface (8000 km^2) can be used instead. It is important to give evidence of the criteria employed to define the Local Area.

Collection of the Information

LM1 compilation: this section requires the provision of "balance sheet-type" operative data for the firms at the stage of the product supply chain where the most value added is produced (i.e., processor of the agricultural commodity). In particular, three types of cost categories should be provided:

- Total Payroll (labour costs);
- Total Core Input Costs (CI – cost of the agricultural input to be processed). In the case of Parmigiano Reggiano, for example, it is the cost for the milk to be processed.
- Total Non Core Input Costs (NCI – all costs of the firm except those for labour and the Core Input). These cost items include, for example: electricity, fuel, …;

LM2 compilation: still looking at the costs of the LM1 firms, this part consists in estimating the share of labour and each inputs costs sourced within the local area.

To make the indicator comparable across value chains and robust to organizational arrangements (e.g. number of juridically differentiated intermediaries involved in selling a given input), the firms considered as suppliers are those which are actually changing the nature of the input (e.g. farmers which turn feed into milk rather than intermediaries shipping milk, refineries turning oil into gasoline rather than petrol stations, …).

When the number of processor levels varies between a FQS and its reference product (e.g., raw cheese manufacturer and ripener in the FQS vs a single cheese manufacturer in the reference product), processor levels should be aggregated such that they remain comparable. For example, if breeders constitute one LM2 supplier type in the reference case, they should also represent one LM2 supplier type in the FQS.

LM3: The aim of this section is to calculate the amount of money spent at the local and non local level by the local and non-local employees of LM1 firms, and by local and non-local suppliers of the core input.

Environmental Indicators

Carbon Footprint

Two indicators will be computed for each FQS and its standard reference. Both require to define precisely which is the product in the supply chain considered (e.g. milk or cheese?). This definition needs to be specified by the case study conductor.

Product Carbon Footprint, in tCO2e per kg of Product

This indicator is the most intuitive and common one for product-oriented carbon footprinting (Röös et al. 2014). It corresponds to SAFA indicator E 1.1.3. Under the rather common assumption of fixed demand in quantity for the product, and in our case full substitutability between the FQS version and its reference, one of the advantages of this indicator is to control for carbon leakage (Colomb et al. 2012).

Carbon Footprint of Production Area, in tCO2e per Hectare of Utilized Agricultural Area (UAA)[2]

This indicator is more oriented towards the upstream of the supply chain. The implicit assumption is that the area used to produce the product is fixed and that demand in quantity will adapt to production levels. For example, if the FQS supply chain is less productive on a per hectare basis, this indicator assumes that overall

[2]Adapted for seafood: either irrelevant (for wild fish) or UAA replaced by area of fish/seafood farms.

product consumption decreases as the share of FQS rises. Thus productivity losses are implicitly assumed to be offset by decreased consumption in the overall carbon footprint of the supply chain.

In a way, the implicit economic assumptions behind these two mainstream indicators correspond to two unrealistic extremes: fixed demand and full substitutability (tCO2e/kg of product) or elastic demand and no substitutability (tCO2e per hectare). Hence the usefulness of computing both.

Method to Compute the Indicators

The producer (farmer) is the main part of the supply chain considered in the indicator for three reasons:

- 83–88% of the carbon footprint of the food sector occur at the production stage (Röös et al. 2014; Weber and Matthews 2008). The collection and processing stages are therefore negligible in the general case;
- the relative impact of transportation can be important for alternative products based on roots, cereals and vegetables (Röös et al. 2014). For this reason, the carbon footprint of the collection stage, potentially very different between FQS and non-FQS, will be derived from the foodmiles indicator (see below);
- the difference in energy demand between processes in FQS and non-FQS supply chains is likely negligible.

Based on this rationale, most farm-level variables are classified as "key"[3] while most variables pertaining to other levels are classified as "secondary". An exception is made for vegetal products where process-related or transportation-related emissions may be substancial.

The two indicators are computed using the Cool Farm Tool (Hillier et al. 2011). This method and the Cool Farm Tool allow to follow the Life Cycle Assessment (LCA) principles and to address the key methodological issues of LCAs as listed in JRC (2010):

- Which LCA modelling principle to follow (i.e. attributional or consequential)? - > attributional in our case
- Which LCA method approaches to employ for solving multifunctionality of processes (i.e. allocation or system expansion/substitution)? - > allocation in our case
- System boundaries: the definition and application of system boundaries and of quantitative cut-off criteria (including the question which kind of activities to include in LCA);
- Functional unit definition;
- etc.

[3] Based on expert practice of carbon footprint calculation, some farm-level variables are nevertheless classified as secondary when they tend to represent a negligible fraction of the total footprint.

LCA is however a standardized procedure which is very time consuming when properly implemented. Given the constraints of the project, we cannot conduct a full-fledged LCA on the studied products.

Specific Case of Unfed Seafood and Fish

The emissions sources of seafood and unfed fish are very different from other food products. Accordingly, the key variables to focus on are different, mostly the quantity of diesel for boat operation, the amount of cooling agent used to refrigerate the fish in the boat and the quantity electricity use for depuration and farm operation (in particular sea water pumps). More details are provided in Bellassen et al. (2016).

Extended Food Miles

Two indicators will be computed for each FQS and its standard reference. Several products may be considered throughout the value chain (e.g. wheat upstream, flour downstream). For both indicators, the upstream – from cradle to the processing plant – and downstream – from the processing plant to the end-consumer – parts will be estimated separately as they rely on different data sources and different stakeholders. Case study conductors should prioritize their data collection effort towards the upstream part (collection stage, from production to processing), and also towards the dowstream part when it applies to a product which is mainly exported.

Distance Traveled, in ton.km per Ton of Product

This indicator is the most intuitive and striking for dissemination to the general public and it sticks to the basic idea of the concept of “food miles”. It is estimated by combining the distances between each value chain level and the concentration of the product from upstream to downstream (e.g. if 10 kg of milk are needed for 1 kg of cheese, the distance between breeder and cheese factory is multiplied by 10). However, this indicator is to be interpreted cautiously and need to be complemented by the estimation of the related carbon emissions. A longer distance traveled does not necessarily mean larger carbon emissions. Considering the logistics (transportation modes, volumes carried, and spatial repartition of the different stages) is crucial to assess the environmental impact of transportation.

Carbon Emissions Related to the Transportation Stage, in kgCO2e per Ton of Product

This indicator is more relevant for assessing the environmental impact of products, since not only the distance but also the logistics of the collection stage of raw materials and of the distribution stage of the final product is considered. Moreover, it allows for a more comprehensive and precise estimate of the carbon footprint indicator. This indicator will be computed using the Cool Farm Tool, Transport tab (Hillier et al. 2011).

Water Footprint

The water footprint of a product or a process is the amount of water that is consumed and polluted during all stages of its production. Water footprint, as composed of three metrics, is at the same time an indicator of water consumption and of water pollution. The water footprint of a product is the sum of the water footprints of the processes/steps taken to produce the product during the whole production and within the value chain.

Three indicators compose the water footprint. They require that the main steps in any value chain are taken into account to measure the impact of the whole value chain. If different intermediate products (e.g., milk for cheese) serve the same value chain, calculation should be carefully planned considering the amount of the intermediate product(s) that is employed to obtain the final product. This aspect needs to be specified by the case study conductor.

Blue Water Footprint, in Water Volume per Product Unit (i.e. m^3/kg)

This metric is the most intuitive one as it accounts for the consumptive use of fresh surface or groundwater, the so called blue water, along the whole production chain. It quantifies the water that is withdrawn from surface or groundwater to assist production in all phases, from crop growth to product selling.

Green Water Footprint, in Water Volume per Product Unit (i.e. m^3/kg)

This metric quantifies the volume of water consumed by the crops during their growth through evapotranspiration. It is computed as a balance between the plant evapotranspiration and the volume of effective precipitation and is particularly relevant where rainwater is scarce.

Grey Water Footprint, in Water Volume per Product Unit (i.e. m^3/kg)

This metric indicates the water volume needed to assimilate a pollutant load that reaches a water body. It is an indicator of water resources appropriation through pollution that can be associated to production in the whole value chain. It is computed as the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards. Here, the only pollutant considered is nitrates.

Method to Compute the Indicators and Sources of Data

The green water footprint and the blue water footprint quantify respectively the evapotranspiration of rainfall and the evapotranspiration of irigation water. Their calculation relies on the knowledge of the crop water requirement (CWR) which is the product of the reference crop evapotranspiration (ET_0) by the crop coefficient (K_c): $CWR = K_c \times ET_0$. The reference crop evapotranspiration ET_0 is the evapotranspiration rate from a reference surface, not short of water. The reference crop is a hypothetical surface with extensive green grass cover with specific standard characteristics and therefore the only factors affecting ET_0 are climatic parameters. The effects of characteristics that distinguish field crops from grass (reference crop) are integrated into the crop coefficient (K_c). The product $K_c \times ET_0$ under the condition that the crop water requirements are fully met quantifies the actual crop evapotranspiration (ET_C).

Green water evapotranspiration (ET_{green}), evapotranspiration of rainfall, can be equated with the minimum of total crop evapotranspiration (ET_c) and effective rainfall (P_{eff}).

$$ET_{green} = \min\left(ET_c, P_{eff}\right)$$

In fact when precipitation exceedes the crop evapotransipration the excess rainfall is not used. On the oher hand when precipitation are limited all the rainfall is used by the crop.

When the effective rainfall is less than the total crop evapotranspiration what needed to satisfy plant evapotranspiration must come through irrigation ("irrigation required"). This is the theoretical water needed by the crop and its value is then compared with the amount of water provided to the crop through irrigation. If no irrigation is applied, the blue water footprint is equal to zero, no matter if the crop needs water to balance the lack of rain and compensate for the evapotranspiration. When crops are irrigated the blue water evapotranspiration is assumed equal to the minimum between irrigation required and amount provided through irrigation.

Measuring evapo-transpiration is costly and unusual. Generally, one estimates evapotranspiration indirectly by means of a model that uses data about climate, soil properties and crop characteristics as input. Here we use CROPWAT, developed by the FAO (2010). The climate database CLIMWAT 2.0 provides the climatic data needed in the appropriate format required by the CROPWAT 8.0 model.

The grey component of the water footprint of growing a crop or tree (m^3/ton) is calculated as the chemical application rate to the field per hectare (App, kg/ha) times the leaching-runoff fraction (α) divided by the maximum acceptable concentration (kg/m^3) minus the natural concentration for the pollutant considered (kg/m^3).

$$WF_{grey} = \frac{\alpha \times App}{C_{\max} - C_{nat}} \left(volume / time\right)$$

This value is then and then divided by the crop yield (ton/ha). For the leaching-runoff fraction coefficient (α) no databases are available. We assume 10% for nitrogen fertilizers. As for the maximum acceptable concentration we rely upon ambient quality standards that are available in European directives (50 mg of nitrates per liter). Cnat is considered equal to 0, which underestimates the actual waterfootprint.

For food processing, the amount of water that evaporates during storage, transport, processing and disposal is generally not measured directly, but can be inferred from the difference between abstraction and final disposal volumes. The best sources for blue water consumption in manufacturing processes are the manufacturers themselves or regional or global branch organizations. The Ecoinvent (Ecoinvent 2012) database dedicated to LCA methods provides further information instrumental to calculating water consumption in production processes, with particular attention to the processing, packaging and distribution of the final products phases.

Social Indicators

Employment

Labour-to-Production Ratio, AWU per Ton of Product

Number of annual work unit per ton of product. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001).

Turnover-to-Labour Ratio, € per AWU

The labour productivity is measured as turnover-to-labour ratio. It is expressed as the turnover per annual work unit.

Method to Compute the Indicators

Labour inputs are estimated using the calculation of labour units based on standardised figures, e.g., one Annual Work Unit, abbreviated AWU, for each person between 18 and 65 years who works full-time on the farm(s)/business unit(s). All form of farm labour (farmers, hired employees and unpaid family workers) are included in the calculation. One annual work unit corresponds to the work performed by one person who is occupied on a full-time basis. Full-time means the minimum hours required by the relevant national provisions governing contracts of

employment. If the national provisions do not indicate the number of hours, then 1800 hours are taken to be the minimum annual working hours: equivalent to 225 working days of 8 hours each. As the volume of labour is calculated on the basis of fulltime equivalent jobs, nobody can represent more than one AWU, even if someone works for more than the maximum number of hours defining full-time work in that Member State.
Turnover (turnover) is computed from total sales (see above).

Bargaining Power Distribution

As bargaining power determines the capacity of individual stakeholders to capture value created throughout value chains (Coff 1999, 2010), our indicator is concerned with the repartition of bargaining power among individual actors. Bargaining power is therefore closely linked to several indicators proposed in the SAFA typology, such as those pertaining to fair trading practices (FAO 2013). It is defined as an actor's capacity to influence in its favour the definition of terms and conditions of a contract (Argyres and Liebeskind 1999). If standard microeconomics has essentially conflated bargaining power with market power, such an approach can hardly be applied to the analysis of value chains and for the purpose of Strenght2Food research, bargaining power is not only rooted on market-based factors, but also has to consider transactional and institutional dimensions.

By taking a wider lense than only that of market mechanisms, we adopt a more global conception of bargaining power that is multifactoral and collective because we ascertain the capacity of supply chains actors of different supply chain levels to weigh in on bargaining processes. We thus better ascertain whether FQS supply chains can be considered as socially more sustainable by appraising how they generate and manage possible sources of bargaining power and how it is vertically distributed along supply chains.

Although incomplete and imperfect, the distribution of bargaining power nonetheless gives an indication over the economic and social sustainability of supply chains. (see Touboulic et al. 2014). One may therefore expect that supply chains for which bargaining power is evenly distributed between levels shall be more socially and economically sustainable (Filippi and Muller 2013).

The method proceeds into two main steps:

In a first step, a bargaining power index value BP_l is computed for each level l of the supply chain. It is computed as the average of the following variables, all normalized to be bounded by 0 and 1. Following our argument, variables account for one of the three aforementionned dimensions of bargaining power (market-based, transactional, institutional).

Market-based variables:

- the level of concentration at level l (market share of the two largest firms);
- the number of entities producing similar/substituable products compared with other supply chain levels;

Transactional variables:

- the proportion of transacted volumes that are subject to long-term contracts between value chain level l and its clients (level l + 1);
- whether the level l of the value chain contributes to the differentiation of the product with potential substitutes;
- whether level l of the value chain requires the possession of specific resources (natural, physical, knowledge/skills…) not accounted for in the specifications.

Institutional variables:

- whether firms at level l are involved in a product management consortium;
- whether firms at level l are involved in other professional unions linked to the product;

We then compute a normalized Herfindhal-Hirschmann index on the basis of obtained bargaining power value at each level:

$$HHI = \frac{\sum_{j=1}^{L}\left(\frac{BP_j}{\sum_{i=1}^{L} BP_i}\right)^2 - \frac{1}{L}}{1 - \frac{1}{L}}$$

Where: BP_j is the bargaining power value of level j; L is the total number of levels in the supply chain. By construction, HHI is bounded within a [0,1] interval where the level of inequality increases with the value of the normalized Herfindhal-Hirschmann index.

Educational Attainment

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. Education could be considered as an important cause of many forms of political and social engagement (Putnam 2000). For these authors, a rise of educational attainment has a beneficial effect on trust and social engagement which are themselves key components of social capital. It is specifically the case for empirical political behaviour research which consistently observed a robust and positive relationship between education and political engagement (Hillygus 2005). Educational attainment is also a predictor of political trust and liberal social attitudes (Schoon et al. 2010). The measurement of educational level allows us to indirectly measure some components of social capital. The systematic indicator is the educational level of people who work in the supply chain. A secondary indicator based on average wages is also proposed. It allows to take account indirectly of the vocational education and the skills which is needed for workers. In this sense it will complete the educational attainment and replace it for processing level if the difficulties for collecting data are too strong.

We use The International Standard Classification of Education (ISCED) 2011 to classify educational attainment into five categories:

- Primary education or less/middle school degree or less (level 1 and 2 of ISCED)
- Secondary education or equivalent /high school degree or equivalent (level 3 of ISCED)
- Short cycle tertiary education, post-secondary non tertiary education or equivalent (1 or 2 years after high school, level 4 and 5 of ISCED)
- Bachelors/license or equivalent level, 3 or 4 years after high school (level 6 of ISCED)
- Higher education or equivalent level, at least 5 years after high school (e.g., master degree, PhD, …, level 7 and 8 of ISCED)

If it is not possible we can accept to regroup the last three categories (short cycle tertiary and post secondary non tertiary education, Bachelor/license level and higher education level) into one categorie: tertiary education level or equivalent.

The indicator is then normalized as follows:

$$\left[\begin{array}{l}(\text{prop\_primary})\times 0+(\text{prop\_secondary})\\ +(\text{prop\_short\_tertiary}+\text{prop\_license}+\text{prop\_master})\times 2\end{array}\right]/2$$

For the secondary indicator (average wages), we include the net results at farm level, to account for the non-salaried employees:

$$At\ \text{farm level: wage} = \text{Turnover} * (\%net\ \text{result} + \%\text{wages}) / \text{annual work unit}$$

$$At\ \text{farm level: wage} = \text{Turnover} * \%\text{wages} / \text{annual work unit}$$

Generational Change

Generational change performance at each j^{th} stage of the supply chain is captured the percentage ratio between the number of employees in the 15–35 age bracket and the number of employees in the 45–65 age range:

$$GC_j(\%) = \frac{EMP_{15\div 35;j}}{EMP_{45\div 65;j}} \cdot 100$$

where $EMP_{x-y,j}$ is the share of employees aged between x and y at level j of the value chain.

Gender Equality

This indicator corresponds to SAFA indicator S 4.2.1. and draws on the methodology and – to some extent – data for the calculation of the UNDP Human Development Index (HDI), and its component gender inequality indicator (GII) (UNDP 2018). Because it relies on geometric means, the indicator cannot be calculated whenever 0% occurs for one of the primary variables. Following the indications in UNDP (2018), a minimum value of 0.1% (or 0.001) is employed instead. This composite indicator relies on the following primary variables: gender-based share of employees with an upper secondary education (if available), gender-based share of employees, and gender-based share of entrepreneurship.

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Part II
Cereal and Bakery Sector

Organic Flour in France

Chloé Juge, Elie Langard, Mathilde Le Traou, Agathe Rival, Maëlle Simmen, Valentin Bellassen, Marion Drut, and Matthieu Duboys De Labarre

Introduction

In this chapter, we explore whether organic products (soft wheat, flour and bread) produced in France perform better than their conventional references across the three sustainability pillars. We first describe the characteristics of the organic chain in France, in particular its organization and governance, as well as the technical specifications of the FQS. Then, we discuss the sustainability performance of the case study.

The Cereals Sector

Cereals are the main staple food for billions of humans and animals throughout the world. The world's annual production is around 2.6 billion tons of cereals, of which 400 million tons are traded (FAO 2016). Half of arable lands, i.e. 706 million hectares, are used to produce cereals. Wheat is one of the major crops produced, together with rice and maize. The European Union is the major wheat producing region in the world (Tray 2014). The United States, Argentina, Brazil, Ukraine, Russia, Australia, Canada and France are the main exporters of cereals.

The European Union produces 300 million tons of cereals: 45% of soft wheat, 20% of corn and barley, and other cereals such as triticale, oat, rye or durum wheat

C. Juge · E. Langard · M. Le Traou · A. Rival · M. Simmen
AgroSup Dijon, Dijon, France

V. Bellassen · M. Drut (✉) · M. Duboys De Labarre
CESAER, AgroSup Dijon, INRA, Univ. Bourgogne Franche-Comté, Dijon, France
e-mail: marion.drut@inra.fr

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in much smaller quantities (Eurostat 2018). Half of the European Union farms produce cereals, which demonstrates the importance of cereals production in Europe.

France produces 53.8 million tons of cereals: 52% of soft wheat, followed by 20% of barley and 15% of corn (Passion Céréales 2017). The production is mostly located in a few specialized regions: Nouvelle Aquitaine, Grand-Est and Hauts de France representing 40% of the national production. France is the first European producer and exporter of soft wheat, with 27.9 million tons produced between 2016 and 2017,[1] representing around 20% of the EU wheat production (Eurostat 2018). About 40% of the French soft wheat production was exported in 2016 (Passion Céréales 2017). Other major wheat producers in Europe are Germany, Ukraine and Russia.

The soft wheat market has two main outlets: human food (58%) and animal feed (34%). In 2016, 4.7 million tons of soft wheat were processed into 4.1 million tons of flour. French mills use almost exclusively (96.8%) soft wheat produced in France. The remaining 3.2% (170,000 tons) is imported from European countries (mainly from Germany and Bulgaria). 97.8% of the flour produced is used for human food, and especially (63%) in the bread-making industry (Passion Céréales 2017).

Organic soft wheat represents only 0.26% of total soft wheat production in France. In 2016, 90 thousand tons of organic soft wheat grains have been produced in France and, according to experts, 50 thousand tons of organic grains have been imported.[2] Imports of organic soft wheat grains represent about 35% of the total organic grain volumes and, according to experts, comes mainly from Germany, Romania and Spain. Forty percent of organic soft wheat is used for human food and 60% for animal feed (Agence Bio 2013). According to experts of the organic mill industry, about 110,000 tons of organic flour have been produced in 2016, both from organic soft wheat cultivated in France and imported. About 9% of organic flour is imported (Natura-Sciences 2018) and 7% is exported (ANMF 2016). Half of the flour is then used in industrial or traditional bakery to produce bread, the rest is used in the biscuit industry or directly sold in bags (Agence Bio 2013). For this reason, this case study focuses also further downstream, down to the bread production.

Development of the Organic Sector in France: Drivers and Challenges

From 1985, the French government recognized organic farming as an "agriculture that doesn't use chemical products and synthetic pesticides". European Union in 1991 has adopted the first EU regulation on organic productions. More recently in

[1] Yields for 2016/2017 were particularly low as there has been a long period of drought in the country. Over the last years, the average soft wheat production is about 37 million tons (Passion Céréales 2017).

[2] Updated figures for 2018 indicate about 100 thousand tons of organic soft wheat produced in France, and about 180–200 thousand tons of organic soft wheat milled, namely 80–100 thousand tons of imported soft wheat (i.e. 40–50% of the total organic grain volumes) (Pelletier 2019). These values point a rise in the demand for organic flour based products greater to the rise in the organic soft wheat volumes produced.

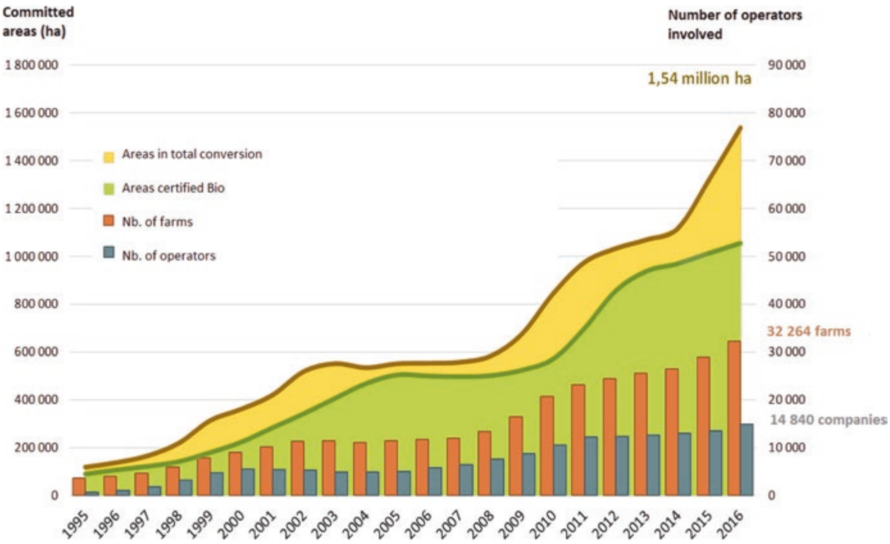

Fig. 1 Trends in organic farming in France. (Source: Agence Bio 2016)

the food sector, the European Union has unified the technical specifications of organic farming (n°834/2007 June 2007; n°889/2008 September 2008; n° 848/2018 May 2018). The cornerstone of technical specifications in vegetal productions such as organic wheat flour is the absence of chemical inputs and genetically modified organisms.

In 2016 in France, organic farming employed 118,000 people in 32,000 farms and 1.54 million hectares are certified or about to be certified (Fig. 1) (Agence Bio 2016). Between 2015 and 2016 the number of farms producing organic cereals raised by 17%, the surface in conversion raised by 54% and the production of organic cereals raised by 20%. The area producing organic cereals increased by 20% between 2015 and 2016, illustrating the dynamism of the sector. However, the organic cereals sector remains small as it covers 266,000 ha, representing only 3% of the area used for cereals (Agence Bio 2017).

The development of the organic industry and in particular of the organic soft wheat sector in France benefits from drivers, mainly economic ones, but faces challenges, mainly technical ones.

On the one hand, better economic perspectives are a strong driver for farmers to move from conventional to organic systems. Organic farming is growing particularly fast since 2015, after new European subsidies from the Common Agricultural Policy (CAP) supporting organic farming were introduced. French farmers can receive CAP payments during 5 years for converting to organic farming,[3] and during another

[3] Although only 2 years, from the beginning of the conversion and the sowing date, are needed to convert from conventional to organic wheat production.

5 years for maintaining organic farming.[4] These subsidies are intended to cover some of the extra costs and yield losses caused by the conversion into organic farming. There are also market incentives to move to organic farming. As indicated in section "Economic Indicators", French farmers sell organic soft wheat grains at a 146% price premium. Organic farmers get on average 5.43 €/kg produced, against 3.47 €/kg in the conventional sector. The growth in demand for organic food products provides market opportunities for the stakeholders of the organic supply chain. Indeed, 82% of French consumers trust the organic label, 26% of them want to consume more organic food and 85% of them think that it is important to develop organic farming (Agence Bio 2016).

On the other hand, the development of the organic soft wheat sector in France is limited mainly by technical issues, and to a smaller extent by consumers' behavior. First, low yields in organic soft wheat production combined by a limited certified area results in grain shortage and the necessity to rely on imports to meet the French demand. The average yield of organic wheat was 2.3 tons per hectare versus 7.6 tons per hectare for conventional wheat between 2013 and 2015 (France Agrimer 2016; Agreste 2013, 2014, 2015). Part of this discrepancy is explained by the location of organic farmers, who tend to be located on poorer soils. Indeed, looking at a single region, the yield difference is lower (e.g. 47% in Occitanie region). The rest of the explanation largely lies in the restrictions imposed by the technical specifications on fertilizer and pesticides use. Furthermore, the protein content is lower in organic grains than in conventional grains. Again, the most likely reason is the restriction imposed by the technical specifications on nitrogen inputs. Given that protein content is the main criterion used to evaluate the quality of the grains and the baking quality of the flour, a low protein content could be an obstacle to the valuation of organic flour in the bakery industry. Farmers have the choice between multiple varieties of soft wheat on a scale from higher protein rates to better productivity. Thus, they make a balanced choice between quality and productivity. The additional compensation for quality seems too low to offset the earnings forgone due to lower productivity, therefore quantity is better paid than quality on a hectare basis (Robin 2017). Both the quantity and the quality of organic soft wheat is reported as a challenge and forces millers to stretch their collection basin and even to import a substantial part of the feedstock.

Available levers to increase yields in organic farming are weak (Robin 2017). However, changing cultivation techniques and wheat varieties may help increase yields or the grain quality. Furthermore, organic breeding can help the development of organic soft wheat production (Divo 2018; Robin 2017). Indeed, feeding animals with temporary pasture allows to increase soil fertility, and therefore protein content in following wheat. In addition, monogastric animals eat protein crops: they can be used as a relay in rotation in organic farming before soft wheat crop.

[4] In France, since 2017, maintenance payments are no more funded by the EU but can be founded by regions, on a voluntary basis.

Second, consumers' interest in organic products does not always translate into a purchasing habit: 90% of French consumers have eaten at least one organic product these past 12 months but only 16% of them eat organic products daily. Another challenge to the development of the organic market is that the price for organic products, which is usually higher than the price for conventional products, is deemed too high for 88% of non-organic consumers. Last but not least, consumers are more interested in organic products such as fruits and vegetables than in soft wheat-based products (Agence Bio 2016).

Technical Specifications

Specifications are proposed by the National Committee for Organic Farming, organized by the INAO and thus part of the Ministry of agriculture. It details practices allowed or not under the organic certification. Table 1 summarizes the technical specifications for organic soft wheat production. First, seeds have to come from organic farming or, with derogation, be conventional seeds without chemicals. Some practices are formally forbidden: use of chemicals, phytosanitary products, hydroponic culture, and Genetically Modified Organisms (GMO). Concerning soil fertilization, specifications foster practices that preserve the organic matter and biodiversity of soils. Moreover, crop rotation is advised, integrating leguminous plants and spreading of manure. Organic inputs and conventional manure can be used to complete the needs of crops. The fight against pest of culture, illness and weeds relies on natural methods like mechanic or thermic weeding, crop rotation or protection of natural predators of insects. Some *natural* products can be used if needed (for example, copper sulfate or copper hydroxide) but are limited in quantity per time unit. Those products are in any case very seldom used on cereals. Finally, farmers have to maintain a book of production, to keep any document that justify the necessity to use inputs, and to keep track of documents from suppliers.

Table 1 Technical specifications for organic soft wheat production

Step/materials	Allowed	Forbidden
Seeds	Seeds from organic farming Conventional seeds without chemicals	Seeds with chemicals
Fertilization	Practices preserving biodiversity of soil Crop rotation Organic inputs	Mineral inputs Chemicals
Protection	Mechanic weeding Thermic weeding Crop rotation Natural predators	Chemicals Phytosanitary products GMO
Administrative duties	Keep track of documents (book of production)	

Source: Ecocert (2015)

Further downstream of the supply chain, the use of organic ingredients is required in the processing of flour and then bread. Only organic grains can be used to produce organic flour. There is no specification related to the origin of the grains. Either stone grinders or cylinder mills can be used in the production process of organic flour. To be labeled as “organic”, products have to contain 95% of ingredients of agricultural origin that are organic. The remaining 5% have to be included in a list of products allowed. The list includes allowed additives and processing aids (e.g. ascorbic acid, lecithin), as well as ingredients of agricultural origin for which organic production is low or nil (e.g. sesame seeds, yeast). In the bread production, the share of 95% is with respect to flour only, and do not concern water or salt that are not of agricultural origin. The flour used (and the bran, when appropriate) has to be 100% organic, a mix with 95% of organic flour and 5% of conventional flour is not allowed. Bread makers have to ask for a proof of organic production for the flour supplied. Moreover, they have to keep separate accounts for their organic production, especially for purchases from suppliers.

Description of the Organic Flour and Bread Supply Chain

The flour and bread supply chain is separated into four levels: production (farmers), processing (millers), collection and storage (mainly grain cooperatives), and distribution including industrial and traditional bakers, as well as supermarkets (Fig. 2). This case study focuses on the bread-making supply chain using soft wheat flour from soft wheat grain production. The value chain diagram is simplified and focuses on the main links between stakeholders of the organic flour and bread supply chain. For instance, direct links between farmers and bakeries also exist, however these links entail marginal volumes.

In addition, the inter-branch organization (FNAB) works with all the stakeholders of the supply chain: farmers, cooperatives, millers and bakers. It has a global view of the supply chain, provides advice to stakeholders, and undertakes lobbying, development and advertising actions on behalf of the value chain.

Farmers

In 2016 3700 farms have produced 90.3 thousand tons of organic soft wheat, i.e. 0.26% of the wheat grains production (Table 2). Forty percent of conventional soft wheat is exported (Passion Céréales 2017), while organic soft wheat production falls short of the demand from the French industry and is not exported.

Forty percent of the organic soft wheat production is used for human food, and half of the flour is then used in industrial or traditional bakery to produce bread (Agence Bio 2013). The quality expected by the bread making industry is mainly a function of the protein rate. The protein rate is expected to be over 11% for organic

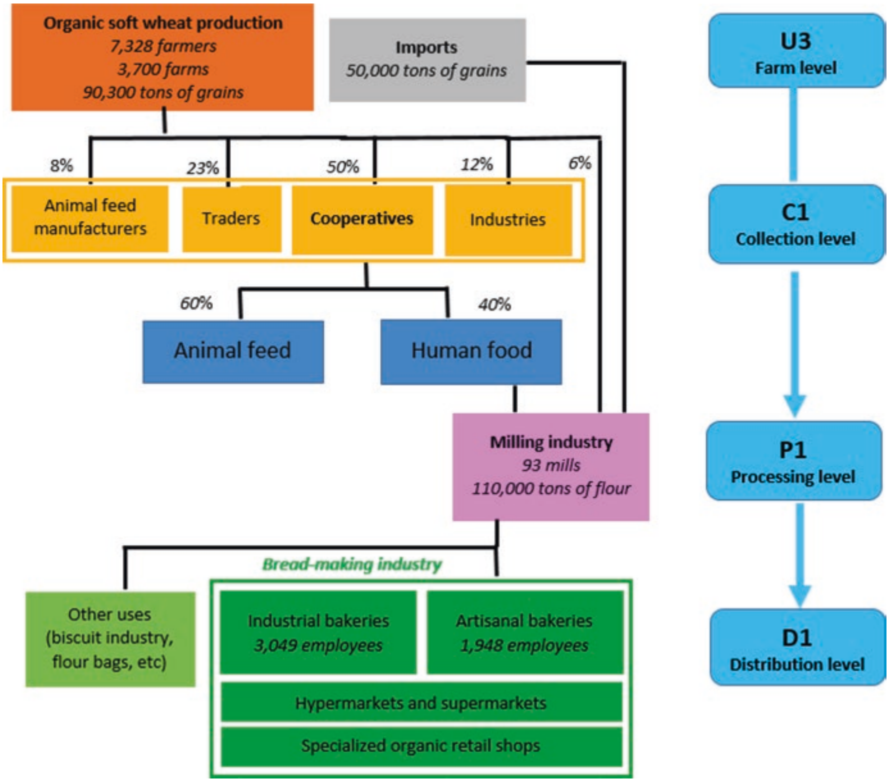

Fig. 2 Value chain diagram for organic flour and bread. (Source: AgenceBio 2017; ANMF 2017; OPM 2017)

Table 2 Organic and conventional production of soft wheat in France (AgenceBio 2016)

	Organic wheat	Conventional wheat
Number of farms	3728	73,740
Production of soft wheat grain (in thousand tons)	90.3	27,900

soft wheat and between 11.5% and 14% for conventional soft wheat (Ethevenot 2017). Wheat lots with lower protein rates can be mixed with lots with higher protein rates – hard wheat – so that the mix can be used for bread flour. For this reason, farmers may receive premiums for high protein rates – around 20 euros per percentage point in the organic supply chain and around 2 euros per percentage point in the conventional supply chain (Pelletier 2018). Due to the generally lower protein rates in organic wheat, lot sorting and subsequent mixings are much more frequent in the organic supply chain.

Collection and Storage

During the agricultural season 2011/2012, half of the organic cereal production has been collected by 48 cooperatives, 23% by 39 traders, 6% by millers, 8% by 10 animal feed manufacturers, and 12% by other industrials (Agence Bio 2013). No data were available to quantify the direct links from soft wheat producers to bakeries.

Grain cooperatives tend to become more and more vertically integrated, in particular in the organic sector. Farmers, collectors and millers are often integrated into a cooperative structure. Vertical integration usually implies cost reduction. When millers and farmers are part of the same entity, transaction costs are likely to be reduced. However, due to the increased bargaining power of large and vertically integrated structures, this cost reduction may translate in higher margins for cooperatives rather than in reduced prices for consumers.

As members of cooperatives are mostly farmers and, in some cases, also millers, this level has not directly been investigated (except for the foodmiles indicator for which distances were provided from the collection stage to the milling industry, and except for the bargaining indicator which analyses cooperatives as farm level). Indeed, data collection focuses on farmers, millers and retailers, and as such covers indirectly the collection and storage stage, according to the composition of cooperative structures.

Milling Industry

The milling industry corresponds to the transformation level. There are 416 mills and 93 of them grind organic soft wheat (partly or in full) (ANMF 2017; Agence Bio 2016). The milling sector is characterized by a few big companies specialized in organic flour production and a lot of small companies located throughout the country. In 2016 90.3 thousand tons of organic soft wheat were ground to produce 68.3 thousand tons of flour, which represents 1.5% of the national production of soft wheat flour (Pelletier 2017; ANMF 2017).

Bread Making Industry

Although it also entails a transformation from flour to bread, the bread making industry is considered here as the distribution level, since usually both processing and distribution of bread takes place at the same location. The organic bread making industry, as well as the conventional industry, is composed of industrial and traditional bakeries.[5] Organic production has to be separated, in space (specific premises) or time (specific hours), from conventional production. Indeed, organic production requires the use of organic cleaning products. However, a given industry can process both conventional and organic breads, as long as the line of production is clearly different. Organic industrial bakeries and traditional bakeries employ 3409 and 1948 people respectively. There are 2459 traditional bakeries that produce organic bread, some are specialized but most of them are mixed with conventional bread (OPM 2017). The number of retail points selling organic bread is increasing as the demand for organic products is growing. Organic bread from industrial bakers is found in regular hypermarkets and supermarkets and in organic supermarkets too.

Governance of the FQS

As the organic flour and bread case study does not concern a small geographically limited area but France as a whole, it is more difficult to provide concrete elements of governance. For this reason, we will stick to the control of organic products in France, and elaborate more on the role of cooperatives in the supply chain.

Controls of Organic Production

The governance of the organic label in France implies different steps and involves various organisms. Regulation for organic agriculture (RCE 834/2007 and 889/2009) has been introduced by the ministry of agriculture in agreement with the INAO (National Institute of Quality and Origin).

In order to sell products under the organic label, the producer or processor has to be controlled by an independent public certifying body approved by the INAO and recognized by the French accreditation committee (COFRAC) (Agence Bio 2008). Today there are nine approved certifying bodies providing certification for organic farming and performing yearly mandatory and unforeseen controls: Ecocert France, Certipaq bio, Bureau Veritas, Certisud, Certis, Bureau Alpes controles, Qualisud, Biotek Agriculture, and Eurofins Certification (Agence Bio 2018). The producer or processor deals with the certifying body of his/her choice and has then to register his/her activity to the Agence Bio. It takes 2 years in soft wheat production to obtain

[5] According to the collective agreement of the bread making industry, bakeries that produce less than 5400 quintals of bread yearly, have fewer than 50 employees and rely mainly on direct sale to final consumers are considered as traditional or artisanal. To the contrary, bakeries that produce more than 5400 quintals of bread yearly, have more than 20 employees and a baking area larger than 30 sqm, earn less than 30% of their turnover with retail sale of bread, and produce and sell unfinished products, such as partially baked or pre-baked bakery wares are considered as industrial.

the organic certification: this is a way to guarantee that most of the chemicals from previous conventional crops have drained away from the topsoil. Any irregularity has to be corrected, otherwise the certification can be suspended for this activity. If the offense is serious, products are not allowed to be commercialized under the organic label.

Role of the Cooperatives

Cooperatives have a key and dominant position in the organic flour and bread supply chain. They represent central players between farmers and millers, since most organic grains are collected and stored by cooperatives. In principle, this allows for a more balanced bargaining power between farmers and other supply chain levels by limiting the number of entities at production level (see section "Bargaining Power"). The benefits are redistributed to the farmers who are members of the cooperative and each farmer has a voice at the general assembly, no matter the size of his farm.

However, the vertical integration of cooperatives threatens the bargaining power of independent millers. As cooperatives grow, they may become a necessary partner for both level n − 1 (farmers) and n + 1 (millers or bakeries). And even if they do not become necessary, their vertical integration can create a distortion, as farmers and millers will be part of the same entity, whereas for independent mills, farmers are independent suppliers. The second threat perceived by millers is that large cooperatives may create more milling capacity than necessary, temporarily driving flour prices down. And while cooperatives are large and diversified enough to survive a price shock, independent millers may be driven out of business.

Evaluation of the Sustainability Based on the Indicators

The aim of this section is to assess the sustainability of the French organic soft wheat sector, comparing the results of the indicators applied to the French conventional soft wheat flour supply chain and to the French organic soft wheat flour supply chain, using the Strength2Food method (Bellassen et al. 2016). Data come from published articles and reports and from interviews with stakeholders of the value chain.

Considering the three pillars of sustainable development, the diagram (Fig. 3) shows that organic flour and bread are globally more sustainable than their references. The comparison shows that organic flour and bread perform better on most of the economic, social and environmental indicators explored by the Strength2Food project. This case study performs worse only on the exported share, the local multiplier and the water footprint.

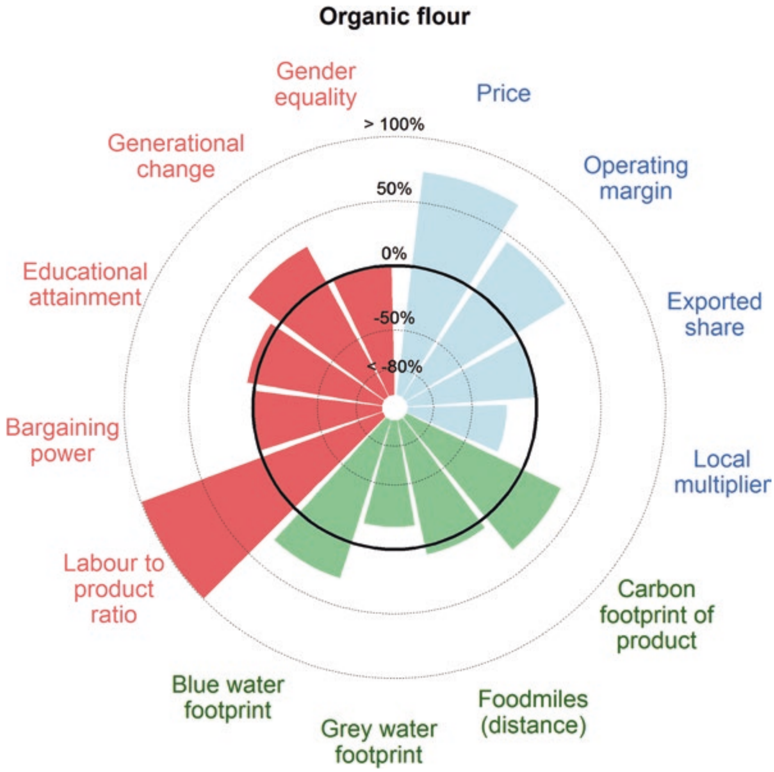

Fig. 3 Sustainability performance (Each indicator is expressed as the difference between the FQS and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower)) of French organic flour and bread (supply chain averages)

Economic Indicators

There is a price premium at each level of the value chain: 146% at farm level, 19% at milling level and 56% at bakery level (Table 3). This means that intermediaries and consumers at all levels of the value chain perceive the organic label as more valuable. The much lower premium at milling level than at farm level is somewhat surprising and may put the profitability of millers at risk. At farm level, given that long agronomic rotations are necessary in organic farms, this high premium may however be partly offset by lower premiums on other crops than wheat.

At farm level, both the gross value added and operating margin are higher for organic production. The weight of intermediate consumption is very high for conventional flour. Subsidies lead to an increased difference between organic and conventional cereal farmers. Indeed, farmers receive additional subsidies for organic farming.

Table 3 Economic results for organic and conventional flour and bread production

	FQS	Reference	Difference
Price (€ kg^{-1})			
Farm level	0.37	0.15	**+146%**
Processing level	0.51	0.43	**+19%**
Retail level	5.43	3.47	**+56%**
Gross value-added (% of turnover)			
Farm level	72.9	58.3	**+25%**
Processing level	24.6	26.4	**−7%**
Gross operating margin (% of turnover)			
Farm level	107.1	82	**+31%**
Processing level	11.8	7.4	**+60%**
Net result (% of turnover)			
Processing level	9.0	3.1	**+190%**

At processing level, due to a higher percentage of intermediate consumption for FQS product, the gross value added is smaller for this product than for reference product. The other profitability indicators are rather weak, but more favorable for the FQS product than for the standard product.

The export shares have been rebuilt and aggregated along the supply chain (wheat, flour and bread). The conventional chain relies more heavily on exports (50%) than the organic chain (16%).

The local multiplier effect of organic flour is 23% lower than its conventional reference: each euro of turnover for organic flour triggers 65 cents of respending in the same administrative region versus 1.15 euros for the reference. The main driver of this difference is the location of wheat producers: only 33% are within the same region as the mill in the organic case, versus 85% for the reference. This relates to the overall shortage of organic wheat producers in France as a whole. Under the hypothesis that wheat grain originates from outside the local area, the local multiplier would reduce to 1.3 for both the organic product and the conventional one.

Environmental Indicators

The three environmental indicators computed are the carbon footprint, the food miles and the water footprint. These indicators have many variables in common such as yield and input amounts for carbon and water.

Carbon Footprint

The carbon footprint (without transport) of organic bread is 34% lower than the reference (162 *vs* 246 $kgCO_2e$ ton of bread^{-1}). The difference in per hectare emissions is even higher, mainly due to the absence of mineral fertilizers, but the much higher yield of conventional wheat (4 *vs* 7.6 tons ha^{-1}) partly offsets this benefit.

On a per hectare basis, the difference would likely be even higher if one accounts for emissions at rotation level, which must include low-carbon legumes in the case of organic wheat. These results are consistent with Meisterling et al. (2009) which also finds a better carbon footprint for organic flour. Note that the carbon footprint we find for conventional bread is almost equal to the value reported by Meisterling et al. (2009) and slightly lower than Espinoza-Orias et al. (2011).

Food Miles

Over the entire supply chain, from farms to distribution units (or actually often from cooperatives to distribution units), organic products (soft wheat, flour and bread) travel 11% shorter distances (1964 *vs* 2214 t.km t^{-1}) and release 10% less emissions (109 *vs* 121 kg CO_2e t^{-1}) than conventional products (Table 4). This difference is mainly driven by the smaller share of exports of the FQS (16% *vs* 50%) that implies shorter distances and less emissions than for the reference product. However, the larger share of imports of raw products (cereals) (35% *vs* 3%) and the larger catchment area of mills handling organic soft wheat (340 km *vs* 50 km) offset part of the benefits (although not all), as they contribute to add kilometers and emissions to the bill. The distribution level, from millers to bread-makers (P1-D1), concentrates most of the kilometers embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 60% for the organic chain and up to 95% for the conventional chain).

Regarding foodmiles indicators, we can conclude that organic bread is more sustainable than its reference in terms of distance traveled (−11%) and emissions released at the transportation stage (−10%).

Water Footprint

The grey water footprint – water pollution by nitrates – is 17% higher for organic bread than for conventional bread (Table 5). Indeed, although organic wheat requires less nitrogen (no mineral fertilizers and 100 kgN/ha from organic sources versus a

Table 4 Food miles for organic and conventional flour and bread production

	FQS	Reference	Difference
Distance traveled (ton.km ton^{-1})			
Processing level	676	115	**+488%**
Retail level	1288	2099	**−39%**
Value chain	1964	2214	**−11%**
Carbon emissions related to the transportation stage (kg CO_2e ton^{-1})			
Processing level	36	8	**+350%**
Retail level	73	113	**−35%**
Value chain	109	121	**−10%**

Table 5 Water footprint for organic and conventional flour and bread production

	FQS	Reference	Difference
Green water footprint (total water consumption) (m^3 kg^{-1})			
Farm level	0.633	0.336	**+88%**
Grey water footprint (water pollution) (m^3 kg^{-1})			
Farm level	0.231	0.197	**+17%**
Blue water footprint (surface and ground water consumption) (m^3 kg^{-1})			
Farm level	0.012	0.043	**−72%**
Processing level	0.064	0.064	**0%**
Overall	0.94	0.64	**+47%**

total of 161 kgN/ha for the reference), its lower yield more than offsets this benefit when the indicator is expressed on a per ton basis. However, one may consider that for water pollution, the indicator expressed on a per hectare basis is more relevant, in which case organic flour outperforms its reference by 48%.

As for the blue water footprint – use of surface and ground water, the bulk of it is generated by the production of fertilizers and pesticides – which mostly occurs in the conventional case – and at baking stage which requires the same amount of water in both value chains. Hence the overall 30% lower value is driven by organic bread.

The green water footprint – use of rainwater by the crop – mainly stems from the difference in yield and is not very relevant in most of France where rainwater scarcity is not an issue.

Social Indicators

The social indicators computed are distributed into four components: employment, bargaining power, educational level and gender equality.

Employment

The allocation of labour to production is higher for organic products than for their non-organic references (Table 6). At the farm level, it takes 4 hours of work to produce a ton of cereals when the reference product requires only 3 hours. The difference (+65%) clearly indicates that the organic product generates more jobs than the reference system. The organic sector employs more people at the processing level (+120%). It takes 6 hours to produce one ton of organic flour compared to 3 hours for conventional flour. The relative difference is of the same order for retail level, but with greater absolute difference since the sale of one ton of processed products requires 141 hours of work compared to 66 hours for conventional products.

Table 6 Employment for organic and conventional flour and bread production

	FQS	Reference	Difference
Labour-to-production ratio (AWU.t^{-1})			
Farm level	0.002	0.001	**+65%**
Processing level	0.004	0.002	**+120%**
Retail level	0.078	0.037	**+114%**
Turnover-to-labour ratio (€.AWU^{-1})			
Farm level	158,095	105,181	**+50%**
Processing level	142,623	264,179	**−46%**
Retail level	59,362	60,498	**−2%**

The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 50% higher in organic farms than in conventional ones. The productivity ratios are better for non-organic firms at the processing and retail levels, with a greater difference for processing. These differences are mostly due to the farms/firms structure (organic millers have smaller structures than conventional ones and thus benefit less from economies of scale), the technical specification of the product (the higher difficulty to find feedstock and the necessity to sort and assemble lots based on their protein content require more labour in the organic chain (see section "Farmers")) and for a part to the geographical conditions (the supply basin of organic soft wheat is large and dispersed, which generates longer distances traveled to address the market demand).

Bargaining Power

The bargaining power is very evenly distributed among levels in both value chains (Table 7), although one can witness a small advantage of the farm level of wheat producers over other levels. By way of contrast, distribution (mostly industrial and craft bakeries) suffers from the weakest position. Discrepancies in bargaining power may be explained by the fact that retail level counts a very high number of independent bakeries in comparison with processing level (flour mills) and farm level (grain coops), although no market leader clearly emerges at the latter level. Indeed, half of the organic production is collected by 48 grain cooperatives. The advantage of cooperatives over other levels may also be explained by their capacity to mobilize highly specialized resources (wheat not easily replaceable by foreign wheat), and is reinforced by their vertical integration. Cooperatives often integrate the farming, collector and miller levels. This is particularly visible in the organic sector because the shortage of organic wheat compared with flour demand reinforces the bargaining power of farming level. However, vertical integration is not considered in this indicator, as it concerns a limited number of stakeholders.

There is no difference between organic and conventional chains as regards bargaining power. Indeed, the organization of these value chains is similar: both include producers level as cooperatives, both have less millers than bakeries and

Table 7 Bargaining power for organic and conventional flour and bread

	FQS	Reference	Difference
Bargaining power			
Farm level	0.67	0.67	**0%**
Processing level	0.56	0.56	**0%**
Retail level	0.38	0.38	**0%**
Bargaining power distribution			
Value chain	0.024	0.024	**0%**

more millers than cooperatives. The lower price premium of organic at miller level is therefore not obviously linked to a lower bargaining power although again, vertical integration may blur an existing lower bargaining power at miller level.

Educational Attainment

This education level indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases: it is slightly in favour of organic production at farm level (Table 8). This is explained by a higher proportion of staff who have reached an upper education degree (probably short tertiary diplomas rather than bachelors or masters): 50% compared to 42% among conventional producers. At the same time, the share of primary education is a bit higher in organic farms (28% versus 24%). However, this result has to be tempered by the data: these different values come from a small sample of producers, which may not be representative. On the other hand, the reference takes into account only farmers under 50 years with a higher educational attainment than the global population of farmers. According to this, the difference between organic and reference likely remains meaningful.

Similarly, wages – which include the revenues of self-employed farmers at farm level – are higher for organic farmers than for conventional farmers in the soft wheat industry. The idea that a higher educational attainment leads to higher wages is therefore confirmed in this study.

Generational Change and Gender Equality

Regarding generational change and gender equality, the organic supply chain was compared to the conventional supply chain from the farming to the retail stage. However, due to data availability in the organic chain, results can only be compared at farm level.

At the farm level, organic soft wheat production appears to be more sustainable than the conventional one (Table 9), both in terms of Generational Change (33% *vs* 25%) and Gender Inequality (0.18 *vs* 0.30). However, because the generational change indicator is much smaller than 100%, the farm stages of both supply chains

Table 8 Educational attainment for organic and conventional flour and bread

	FQS	Reference	Difference
Educational attainment			
Farm level	0.61	0.58	**+6%**
Wage level (€/AWU^{-1})			
Farm level	22,639	9382	**+141%**

appear somewhat endangered in their sustainability prospects due to a rather limited employment of 15–35-year-old, compared to 45–65-year-old. Moreover, what drives the difference regarding the gender inequality is the higher level of female entrepreneurship at the farm stage of the organic supply chain, compared to the conventional one.

At the processing stage, there is less age imbalance in the reference value chain although the indicator remains lower than 100%.

The retail stage seems very well poised in terms of sustainability because the generational change indicator is much larger than 100% (i.e. allowing for generational renewal) and the gender inequality indicator is very close to 0 (i.e. absence of inequality). The very small value of the gender inequality indicator is driven by employment being 50% male and 50% female as well as by very similar gender-based educational achievements by the workforce. A marked difference in gender-based ownership of retailing firms is the only source of inequality.

Overall, the supply chain for conventional flour and bread is sustainable in terms of generational change (108%), but only because the retail stage largely allows for generational renewal.

Limits of the Study

The results are to be nuanced due to the data collection and the limited actors interviewed. Only three organic millers (representing 23% of the total organic flour production in France) and one conventional miller (which represents 2.79% of the total conventional flour production in France) have been interviewed. Furthermore, data sources are often heterogeneous in sample size and collection method: for example, the price of flour in the conventional sector is robustly collected by FranceAgrimer while its organic counterpart relies on three interviews.

Another limit is the difficulty (almost impossibility) to measure the conviction of actors. Our proxy for this, educational attainment, is not deemed relevant by organic stakeholders who report that the educational attainment of their employees is of lower importance than the fact that they share a common "vision" of the values implied by organic production.

Last but not least, it would have been interesting to account for impacts on soil quality, on use of renewable resources and on biodiversity in this case study. Indeed, organic farming is expected to limit soil degradation and loss of biodiversity.

Table 9 Generational change and gender equality for organic flour and bread

	FQS	Reference	Difference
Generational change (%)			
Farm level	33	25	**+32%**
Processing level	–	61	–
Retail level	–	239	–
Value chain	–	108	
Gender inequality (%)			
Farm level	0.18	0.30	**−40%**
Retail level	–	0.09	–

The environmental indicators investigated in this project are not exhaustive and set aside aspects that are crucial when considering organic farming and processing – and that even justify the very existence of the organic industry.

Conclusion

This chapter aims to assess the sustainability of the French organic soft wheat supply chain, in comparison with the conventional soft wheat chain. This study is based on a literature survey and on interviews with key stakeholders of the supply chain.

The results show that the organic chain is globally more sustainable than its reference as regards the economic, social and environmental aspects investigated here. From an economic point of view, the organic system is more profitable. Each level of the organic supply chain exhibits higher benefits, price premium, than the conventional chain. However, at farm level, given that long agronomic rotations are necessary in organic farms, this high premium may be partly offset by lower premiums on other crops than wheat. From a social point of view, results show that the organic chain creates more jobs at both farm and processing levels, as more labour is required to produce a given final unit, a ton of wheat or a ton of flour. From an environmental point of view, the carbon footprint and the foodmiles indicate that the organic flour and bread supply chain performs better than the conventional chain. Regarding water pollution, the conventional chain outperforms the organic chain on a per ton basis thanks to higher yields, but the merit is reversed on a per hectare basis, justifying the subsidies for organic farms around water catchments. Last but not least, other environmental aspects are not assessed in this study (biodiversity, use of non-renewable resources, soils, pesticides in water, etc) and are expected to perform better in organic than in conventional farming.

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Organic Pasta in Poland

Edward Majewski and Agata Malak-Rawlikowska

Development of the Polish Organic Food Market

Polish Regulations and Institutions for Organic Production

Organic production in Poland is regulated by the Organic Farming Act of 25 June 2009 (Official Journal. No 116; 975) and implementing regulations of the Minister of Agriculture and Rural Development. The Act is based on the EU Council Regulation (EC) No 834/2007 of 28 June 2007 (EU OJ L 189 of 20.07.2007) concerning organic production and labelling of organic products. Implementation of this Council regulation was laid down in the Commission Regulation No 889/2008 of 5 September 2008 (EU OJ L 250 of 18.9.2008) and No 1235/2008 of 8 December 2008 with later amendments.

In Poland, as in most other EU countries, the system of organic production certification is based on private certifying organizations that are accredited by the Polish Centre for Accreditation supervised by the designated authorities. In the Polish system these are public institutions: The Ministry of Agriculture and Rural Development – which authorizes certification bodies to carry out inspections and issue and revoke certificates of conformity in organic farming, and Agricultural and Food Quality Inspection (GIJHARS) – which supervises certification bodies and compliance with standards of organic production. In this function GIJHARS cooperates with the following institutions:

- Office of Competition and Consumer Protection – the trading of live or unprocessed agricultural products and processed agricultural products intended for human consumption;

E. Majewski (✉) · A. Malak-Rawlikowska
Faculty of Economic Sciences – Warsaw University of Life Sciences – SGGW, Warszawa, Poland
e-mail: edward_majewski@sggw.pl

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- Veterinary Inspection – feed for animals;
- Main Inspectorate of Plant Health and Seed Inspection –vegetative propagating material and seeds for cultivation;
- Polish Centre for Accreditation – accreditation of certification bodies.

Under this umbrella in 2018 there were 12 certification organizations in Poland authorized by the Minister of Agriculture and Rural Development to carry out inspections and issue and revoke certificates of organic farming.

Government Support

Since Poland joined the European Union in May 2004, Polish organic farmers have received a per hectare subsidy for organic farming under the European Union's Rural Development Programs. However, in 1998 the Polish government had already introduced subsidies compensating the costs of organic farm inspections, and per hectare payments for organic crops during the two-year period of conversion to organic production (Kociszewski 2010).

Production

In 2017, there were 21,400 organic producers including 20,257 organic farms, both certified and under conversion. Compared to the year 2004 the number of producers has increased over five times (GIJHARS 2005, GIJHARS 2011, GIJHARS 2011b–2018). The average organic farm size in Poland (about 24 hectares) is almost twice as large as the national average for the farming sector.

The area of organic agricultural production in Poland accounted for 5.2% of the organically farmed land in the EU28 in 2015 (Kobuszynska 2017). The total organically farmed area amounted to 494,978.66 ha in 2017 (GIJHARS 2018) which accounted for about 3.4% of total cultivated land in Poland. The share of land fully converted into organic farming was 77.4% of total organic agricultural land in Poland.

According to GIJHARS, in 2016 the vast majority of farms were specialized in crop production (83.2%). In 2016, almost 58% of the land was allocated to fodder crops (including permanent grassland). Cereals accounted for 18.9% of the land, while fruits 9.7% and vegetables 6.6% (GIJHARS 2017). The production of organic grains in 2016 amounted to 173 thousand tons and has been growing steadily.

The food processing industry is a significant factor in the functioning of organic farming in Poland (Pilarczyk and Nestorowicz 2014; Kociszewski 2010). In 2017, there were 795 certificated processing plants in Poland. Their number has doubled since 2013, and was 14 times larger than in 2004. Most of the total number of organic processing plants operating in 2016 (720 processors), were involved in fruit and vegetable processing (31.1%), and products from milling grains (17.6%). Fewer processors dealt with meat (6%); coffee and tea (4.9%) and milk (4.9%). About 30.8% of processing plants produced other food products, such as spices, beverages, cocoa, chocolate and confectionery, ready meals (GIJHARS 2017).

The Market

Characteristic features of the organic food market in Poland are its significant dispersion and the mismatch between the location of production and location of the market demand. Most of the organic food consumers willing to pay a premium price are located in large cities, where personal income and awareness of the advantages of organic food are greater.

On the production side there are many relatively small organic farms scattered across the country, often located in remote areas distant from the main markets. For this reason, supply chains for organic food are underdeveloped in Poland, which impinges on the development of the organic farming sector, despite a steady increase of the number of organic farms. Due to this, part of the organic production goes to consumers through the same sales channels as conventional food (without a price premium) especially in the case of animal products (Grzybowska – Brzezińska 2008). Wholesale organic food is dominated by small-scale wholesalers, mainly regional companies and only few operating nationally (Zuba 2012). Only farmers located relatively close to the large markets can effectively use short supply channels. This results in the relatively weak bargaining power of organic farmers on the Polish market, as well as intermediaries capturing large shares of the operating margins.

At the retail level, organic food in Poland is being sold at specialized grocery stores (e.g. shops with natural, or so-called "healthy" food), stands on traditional marketplaces and directly by farmers. However, there is growing involvement of hypermarket chains, supermarkets and delicatessen chains in the sale of organic food. There are also wholesalers like Organic Health, Organic Planet, Vita, who participate in the supply chain not only as intermediaries but they may also have their own retail outlets in shopping malls.

The demand for organic food is slowly, but rather steadily, growing in Poland due to the changing behaviour of the increasing numbers of better-off consumers. The reasons for the growing interest of consumers in organic food may be the promotion of healthy lifestyles (mainly by mass media and in the Internet), as well as higher incomes, which make value-added products more affordable. To some extent demand for organic food is determined by beliefs about the wholesomeness of these products, and to a much lesser extent by environmental awareness, much lower in Polish society compared to other EU countries (Eurobarometer 2017).

Consumer behaviour is strongly driven by economic factors. The relatively low income of the majority of Polish consumers and the higher price of organic products compared to conventional food are limiting factors. The majority of consumers that face household budget constraints are unwilling to pay noticeably higher prices (Healy and Figurska 2013; Kobuszynska 2017).

Nevertheless, the Polish market for organic products is perceived as still growing largely thanks to the increase in supply from subsidized production, but also the greater demand from the growing number of organic food consumers. Improving existing distribution channels, reducing costs of delivery to the marketplace and increased "visibility" and accessibility of organic food become essential factors in the development of organic farming in Poland. It is expected that there will be an increase in the domestic product range due to the increasing number of processors and better organization of the supply chain. Fresh products will become more widely available and the sales of organic fresh production will increase (Vaclavik and Szeremeta 2008; Kilcher et al. 2011).

The organic pasta value chain, which is the object of the case study, may be considered an exceptional example of the successful cooperation of a group of wheat farmers with a pasta producer, who integrates levels in the supply chain.

Organic Pasta Value Chain

Value Chain and Its Components

The chain of organic pasta may be considered an Integrated Supply Chain coordinated by Mieczyslaw Babalski, President of the "Bio-Babalscy" company and at the same time an organic farmer. The chain is an example of the very successful integration process that was the outcome of strong organizational and financial synergy. Cooperation within the chain is largely based on mutual trust and friendly relations between farmers (grains suppliers) and the processor. Figure 1 presents the organic pasta value chain.

Within the chain the key functions are integrated:

- Breeding of rare (even ancient) varieties of wheat on Babalski's farm. Seeds produced at his farm are distributed to other organic cereals growers, who supply the processing company with grains;
- Milling and pasta production;
- Distribution of pasta, with a growing share of own sales channels (wholesale, farm shop, internet deliveries to wholesalers and to final consumers).

U3 represents the organic farmers The study has been conducted on a sample of 14 organic farms, members of the EKOLAN association (Association of Organic Producers in Cuiavia and Pomerania, http://eko-lan.pl/) [1] and suppliers of the "*Bio*

[1] The Association has about 100 members, mostly farmers certified as organic producers. The main aim of the Association is to promote organic farming and its products.

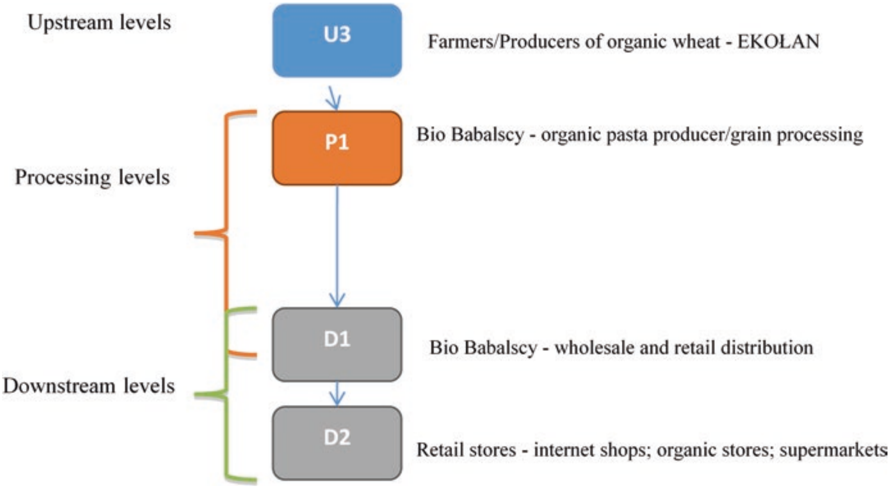

Fig. 1 Organic pasta value chain

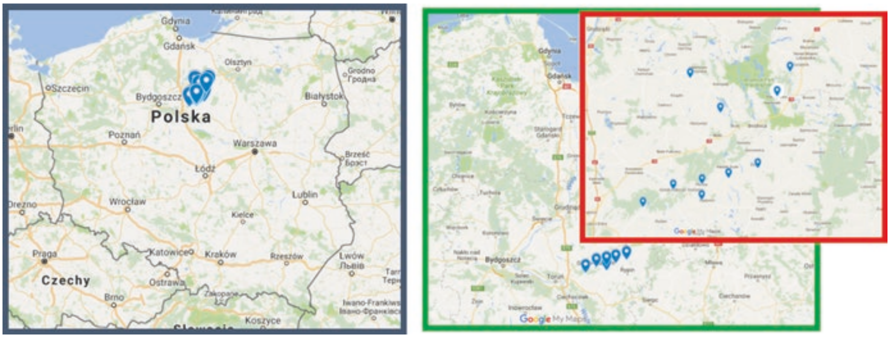

Fig. 2 Geographical location of farmers and the processor on a map of the region

Babalscy" pasta processing company. All farms in the chain are certified as organic by the Agrobiotest.[2]

Farms are located in Brodnica County. Figure 2 shows their geographical distribution on the map of the region. The average size of the farms in the sample is 19.37 ha, which is an above average farm size for Poland (10.56 ha in 2016) and also in kujawsko-pomorskie voivodship (15.51 ha). All farms can be classified as mixed: with cereals and animal production, cereals and vegetables, and with all these categories of products.

Farmers supply the processor with grains, mainly different varieties of wheat (spelt, einkorn wheat, emmer wheat, spring wheat), and supply other cereals (rye, oats, barley) in smaller quantities. Thanks to Babalski's passion and enthusiasm in

[2] Agrobiotest certificate: PL-EKO-07-90001.

Fig. 3 The organic pasta producer "Bio Babalscy". (Source: https://biobabalscy.shoparena.pl [access: 18.08.2017].)

propagating ancient wheat varieties, the specific feature of this supply chain is the breeding of rare varieties to produce grains that are the basis for the processing into flour and pasta. Most of the seeds used by EKOLAN farmers are provided by Babalski who cooperates closely with the Gene Bank at the Institute of Cultivation and Acclimatization of Plants in Radzików, as well as with individual breeders from some European countries (Greece, Austria, Germany). Starting several years ago with small quantities, up to 100 grains, Babalski reproduced enough seeds to allow for a steady supply of cereals to his processing company. Each year on the plots on Babalski's farm in Pokrzydowo (see the map) about 70 old species and varieties of cereals are cultivated. The best species and varieties are promoted. A hundred seeds are enough to cover one hectare of land after 5–7 years of reproduction, and can be supplied to other farmers for reproduction.

The P1 level refers to processing – the organic pasta producer The company "Bio Babalscy" was established in 1985 and produces different kinds of organic flour and pasta (Fig. 3). The mission of the "Bio Babalscy" company is to "provide high quality organic food to the consumers. Healthy, tasty and in harmony with nature!".[3]

Aleksandra and Mieczysław Babalski (photograph above) are the pioneers of organic farming in Poland. Today, they are the most well-known producers of organic food in Poland as well as in the European ecological farming community. Mieczysław Babalski inherited the farm which was run by his ancestors – his grandfather and then his father. At the beginning of the 80s Babalski decided to cultivate the land using ecological methods, based on his experience on organic farms in Switzerland, Austria and Germany.

Babalski started farming on an area of 9 hectares of agricultural land. After conversion, his farm was certified by the Agro Bio Test Certification Body (PL EKO 07 90001) as the first certified organic farm in Poland. In 1991, a plant for pasta production was built, which operates alongside the farm.

[3] Bio Babalscy: *O Firmie,* https://biobabalscy.shoparena.pl/o-firmie [access: 18.08.2017].

The main product is a wholegrain pasta, which is made from grains ground only once. The flour used for making pasta at "Bio Babalscy", unlike standard flour, contains remnants of shells and peels which provide healthy fiber. Most of the products are manufactured using ancient, and rich in health-promoting ingredients, well suited to ecological cultivation cereal species, such as spelt, flatfish and samarium.

Babalski is a small scale pasta producer who uses rather simple, traditional and labour intensive technologies. Initially, pasta was produced on an old-fashioned Swiss machine. A number of old, second-hand machines are still used for processing grains and making pasta.

In total, over 400 tons of grains are processed annually, and the annual sales of end products amounts to about 250 tons. In addition to pasta, wholemeal flour, bran, and even spelt coffee are produced. The processing company's products are also certified as organic.[4]

Despite a growing interest in their products, the owners are unwilling to increase the scale of production because they believe that mass production would lead to losing control over some processes, what may result in a loss of quality. At present, the factory is a reminiscent of a plant in which the most of the work is done by hand.[5]

The D1 level refers to wholesale and retail distribution, which in this instance is carried out by the same pasta producer "Bio Babalscy"

In 2016, about 60% of pasta and related products were sold to wholesalers, and 32% to end consumers through the online shop. The remaining amount was sold directly to consumers from the farm shop (5%) and exported (3%), mainly to EU countries (UK, Germany, France, Greece and Norway) delivered in small packages mainly for individual Internet orders. The company is increasingly developing their online sales [www.biobabalscy.shoparena.pl] managed by Aleksandra Babalska. In the year 2018 direct Internet sales doubled to about 60% of total sales. This distribution channel is gaining popularity among consumers and is also more profitable for the producer.

Products sold to wholesalers are further distributed to small food stores, mainly those specialized in organic foods. Some wholesalers also run their own online stores offering organic products [e.g. www.tobio.pl, www.ekosfera24.pl, www.biosklep.com.pl, www.ponature.pl].

Wholegrain pasta with Bio Babalscy brand, especially that made of spelt wheat, can cost 50% more than conventional pasta. Nevertheless, the number of consumers who believe in the quality of Bio Babalscy products is growing, assuring good prospects for the future of the company and the entire integrated supply chain.

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[4] Agrobiotest certificate: *PL-EKO-07-04194*.

[5] From the interview with Mieczysław Babalski for Biokurier in article *"Wizyta w Wytwórni Makaronu BIO – odwiedzamy pionierów ekorolnictwa„* from 19.03.2015 avaliable online: http://biokurier.pl/jedzenie/wizyta-w-wytworni-makaronu-bio-odwiedzamy-pionierow-ekorolnictwa/.

In 2010, Babalski's farm won the competition for Best Ecological Farm in the category Ecology and Environment (first provincially and later nationally). The company is a member of the Regional Network called "Dziedzictwo Kulinarne Kujawy i Pomorze" *["Culinary Heritage of Kujawy and Pomerania"]* and since 2012, has been engaged in the activities of the Association for Old Varieties and Breeds, and the Cuiavia and Pomerania Association of Ecological Producers EKOŁAN. The organic farm and processing plant Bio Babalscy have about two thousand visitors every year. The visitors are groups of young people, students, farmers and consumers from all over Poland and also from abroad – who want to see and learn how to successfully run a model eco-farm.[6]

Bargaining Power of Farmers and Intermediaries

For several reasons EKOLAN farmers have a unique relationship with the pasta producer. Babalski is an authority in his field being a pioneer of organic farming in Poland, and respected for his expert knowledge of ecological production methods. He is also a trustworthy businessman. Babalski supplies seeds and advice to farmers; always offers his suppliers a good price for grains, and all the support they may require. For this reason the relationship between farmers and suppliers of grains to the Bio Babalscy company, and the processor (Babalski) may be described as a close partnership rather than a buyer – seller relationship. Hence, both parties have almost equal bargaining power due to all partners in the chain being mindful of each others' interests.

Farm survey results show that the opinion of farmers of their relationship with the Bio Babalscy company is almost "enthusiastic". Farmers appreciate assured payments and the good prices offered by the processor, but also the possibilities of the sale of large quantities of produce. Farmers declare that they "simply" like to sell to this channel.

Organic Pasta Quality Attributes and Technical Specifications

In the Table 1 the key technical specifications of the Organic Pasta value chain are presented.

[6] Farma Zdrowia: http://organicmarket.pl/pionierzy-ekologicznych-upraw-zboz/, [access: 18.09.2017].

Table 1 Technical specifications of the organic pasta value chain

Territory	
Geographical area	Region of Brodnica, located in the Middle-North part of Poland in kujawsko-pomorskie voivodship (see Fig. 2)
Varieties/ breeds	Cereals cultivated for "Bio Babalscy" are mainly old varieties of wheat, including ancient triticum monococcum ("samopsza" in Polish), emmer wheat, triticum spelt, flatfish which are no longer grown in conventional production
Farming practices	
Fertilization	In organic production, the use of mineral fertilizers is forbidden. Fields are fertilized organically with the use of manure from cattle and hens as well as green manure from the intercrops
Plant health	Weeds are usually suppressed by manual treatment; the use of herbicides is not allowed. This also applies to the use of other chemical pesticides
Field operations	Typical for cultivation of cereals
Other	Most of the seeds of old wheat varieties are provided by the processor (Babalski)
Processing	
Processing stages	The three main stages of processing: Purifying (cleaning) and sorting grains (including removing husk from some types of wheat); Milling into flour Processing into pasta (includes drying and packaging) Leftovers from cleaning grains are used as feed for animals
Transportation	Organic grains are usually transported from U3 to P1 level in small vehicles: trucks (up to 5 tonnes), vans and tractors. Transportation from P1 to D1 and D2 is done mainly by courier companies that use vans (for shorter distances) and large trucks for long distance transport

Source: own elaboration

Sustainability Assessment of the Bio Babalscy Organic Pasta Value Chain

In order to estimate the sustainability of the organic pasta chain the specific methodology of Strength2Food (Bellassen et al. 2016) was applied. For benchmarking purposes, conventionally produced pasta was used as the counterpart. At the farm level the counterpart was the set of model conventional farms with the same system of production as our organic farm case-study, but assuming conventional production methods, including mineral fertilization and the use of pesticides. Additionally, we used secondary sources from the FADN and the Polish Main Statistical Office.

Comparisons at the processing level are based on data from a conventional pasta producer who provided the required technical and economic data. We also extracted some data from secondary sources (Main Statistical Office and market reports). The key indicators of performances are shown in Fig. 4.

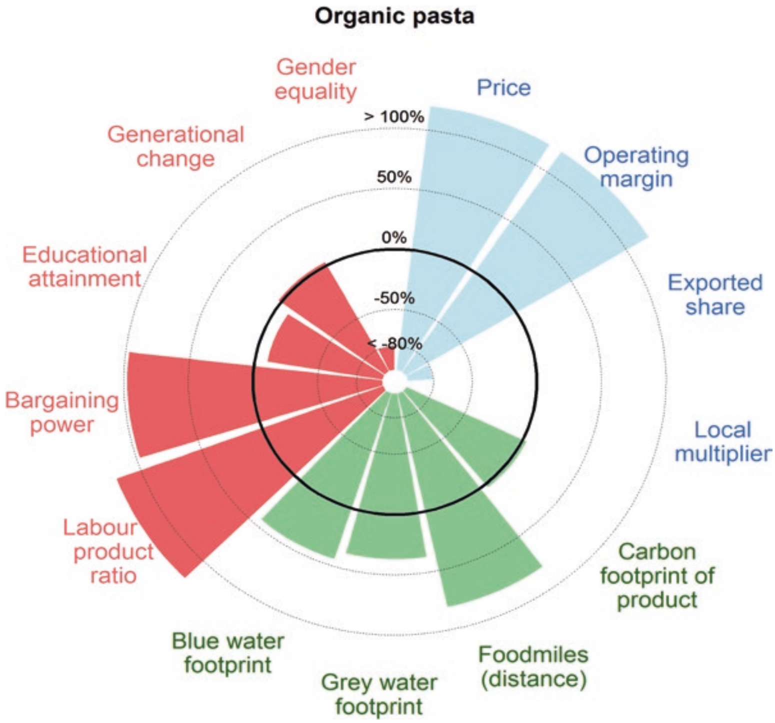

Fig. 4 Sustainability performance of organic pasta chain

Table 2 Economic sustainability indicators

Short indicator name	Chain level	FQS	Reference	Difference %
Price	Farm	0.43	0.22	95
Price	Processor	1.89	0.50	278
Price	Retail	4.28	0.71	503
GVA	Farm	73.8	50.1	47
GVA	Processor	38.8	13.9	179
Net result	Farm	99.5	57.1	74
Net result	Processor	24.3	2.6	835
Export share	Processor	3%	13%	−69

Economic Sustainability

The indicators of economic performance are presented in Table 2. Price premium for organic pasta production is high at both farm and processing levels, with values of 95% and 275% respectively, and reaches 500% at the retail level. The FQS wheat price (0.43 €/kg) compared with 0.22 €/kg of conventional wheat indicates a high premium for the organic produce. This premium is relatively high because of the old varieties of wheat used by the organic pasta producer which tend to have lower yields. The close relationship between pasta producer and farmers is unique, and there is an extra premium for supplying very specific products to the processor.

Profitability indicators are also better for organic pasta compared to conventional pasta. At the farm level intermediate consumption values are similar in absolute terms but have a smaller share in the turnover from organic wheat due to the fact that its price is much higher compared to the price of conventional wheat.

Although wages are higher in the production of organic pasta, higher prices and subsidies mean greater profitability for organic wheat, regardless of the value of the economic indicators (GVA, GOM or Net Result).

At the processing level, the high prices offset the additional costs of organic production, and profitability is greater for organic pasta both in relative and absolute terms.

As for export share, organic pasta is mainly destined for the national market. Export share in total production is about 3%. Sixty-seven percent of this share is exported to EU countries (Germany, UK, Greece, France) and 33% to non-EU partners (USA and Norway). In the case of the conventional pasta company exports are much higher and account for 13% of production. Export is mainly destined to Eastern European countries (75%) and China.

Environmental Sustainability

Environmental sustainability was assessed with the use of two indicators: Carbon footprint (Table 3) and Food Miles (Table 4).

Table 3 Carbon footprint (CFP) indicators

Indicator	Chain level	FQS	Reference	Difference %
CFP per tonne (kg CO_2eq t^{-1} of wheat)	Farm	268.79	345.78	−22.27
CFP per tonne (kg CO_2eq t^{-1} of pasta)	Farm + processing	804.17	868.23	−7.38
CFP per tonne (kg CO_2eq t^{-1} of pasta)	Farm + processing + transport	880.36	934.017	−5.74
CFP per ha (kg CO_2eq ha^{-1})	Farm	501.38	1004.64	−50.09
CFP per ha (kg CO_2eq ha^{-1})	Farm + processing	853.79	1917.19	−55.47
CFP per ha (kg CO_2eq ha^{-1})	Farm + processing + transport	934.697	2062.46	−54.68

Table 4 Green, grey and blue water footprint indicators [m^3/kg]

Indicator name	Chain level	FQS	Reference	Difference %
Green WF	All	1.582	0.764	107.1
Blue WF	All	0.012	0.022	−45.5
Grey WF	All	0.175	0.273	−35.9
Total water footprint	All	1.768	1.059	66.9

Carbon Footprint

If all sources of GHG emissions are taken into consideration (farm operations – processing – transportation) organic pasta generates 5.74% lower emissions per tonne of the final product compared to the reference. Excluding transport, the carbon footprint per tonne of organic pasta is 7% lower than its reference (0.80 and 0.87 tCO_{2eq} ton^{-1} of pasta respectively). Most of this difference is driven by the absence of mineral fertilizers and pesticides in the cultivation of organic wheat. However, the lower yield of organic wheat partly offsets these benefits. Processing represents 47% of the emissions of organic pasta. The use of energy per ton of output is higher in the case of organic pasta, due to a smaller scale of production and the use of traditional technologies. However, the reference pasta generates higher emissions because of the greater share of electricity in total energy input, which is coal-based in Poland. Both products are within the range found in the literature regarding values of carbon footprint in pasta production: 0.9 (Fritsche and Eberle 2009), 1.3 (Ruini et al. 2013) or 0.5 (Röös et al. 2011) tCO_{2eq} ton^{-1} of pasta. The farm-level footprint is similar to (Röös et al. 2011) and at the lower end of the range (Ruini et al. 2013), which can be explained by the relatively low amount of mineral fertilizer use.

Differences in the emissions of CO_{2eq} per hectare are influenced by the level of wheat yield, that is 56% higher in conventional production. The other factor is final product (pasta) to raw product (wheat) ratio, noticeably higher in conventional production (76% vs. 57%). Generally, emissions per hectare suggest that the organic pasta chain is more sustainable in terms of land use. This conclusion may be considered misleading since much more land is needed in the organic chain to produce the same amount of pasta as in the reference product. Thus, the emissions per tonne of pasta are a more appropriate indicator of sustainability. The CFP of organic pasta is 5.74% lower than the reference product.

Food Miles

Over the entire supply chain, from farms producing cereals to distribution (U3-D1), organic pasta travels 3 times shorter distances, but generates 20% more greenhouse gas emissions (115 vs 100 kg CO_{2eq}) than conventional pasta. The difference in terms of distances is mainly explained by the shorter journey of FQS pasta on the domestic market, which concerns most of production (97% for FQS, 87% for the reference chain). A relatively large amount of conventional pasta is exported (13% of production), including shipment to China. Despite shorter distances travelled by organic pasta, in the reference chain mostly heavy goods vehicles, as well as big containers are used for transportation of large quantities of produce. As a consequence, CO_2 emissions per unit transported are lower. We may conclude that the organic pasta chain is more sustainable than its reference in terms of distance travelled, but less sustainable in terms of greenhouse gas emissions released at the transport stage (+18%).

Green, Grey and Blue Water Footprint

Table 4 reports a summary of the values obtained for the components of the indicator water footprint for organic pasta (FQS) and its reference product. They are provided as m^3/kg of product.

The reference product performs better than organic pasta for **green water footprint**. The only drivers that played a role in determining the difference in green water footprint were the yield and final product ratio that relates wheat to pasta (0.57 FQS, 0.76 for the reference product). The difference in the value of these two parameters alone accounts for the differences in the green water footprint in favour of conventional pasta.

FQS production shows a better performance for **grey and blue water footprint**. Although yield is still a factor that tends to increase the water footprint for FQS, nitrogen-based fertilizers used in breeding conventional wheat increase the grey water footprint above the level of the FQS. Specifically, it is the surplus of mineral nitrogen which determines the difference in the grey water footprint. Phosphorus-based fertilizers are also used in the production of the reference product, but the literature shows a tendency to focus on nitrogen only in the computation of the grey water footprint, because it makes comparisons much easier.

However, we also considered phosphorus fertilizers in the LCA approach in the blue water footprint calculation. Blue water is the water needed to support agricultural production as it is used to produce fertilizers, pesticides, diesel fuel, electricity and other means of production for agriculture. Since in both production systems there was no irrigation, it was not considered in the blue water footprint calculation. Organic pasta performs better than the conventional one in this respect because of the ban on the use of fertilizers and pesticides in organic production.

Processing requires a relatively low amount of water compared to agriculture. It accounts for 1% of total water footprint for FQS and 2% for the reference product.

The water required by the reference product in the processing phase is higher than the amount required by the FQS. This is due to the higher amount of electricity and fuel (although FQS uses also coal as source of energy) but, above all, to a much higher water consumption for FQS.

Social Sustainability

Labour Productivity and Educational Attainment

The labour to production ratio (Table 5) is noticeably higher for the entire organic pasta chain compared to the reference. At the farm level the difference (39%) is due to lower yields. Organic pasta production is even more labour intensive than conventional (896%) because of the more laborious technologies used in the organic pasta processing plant.

Table 5 Labour productivity and educational attainment indicators

Short indicator name	Chain level	FQS	Reference	Difference %
Labour to product ratio	Farm	0.110	0.079	39
Labour to product ratio	Processing	0.055	0.006	896
Turnover to labour ratio	Farm	3,784.9	2,802.9	35
Turnover to labour ratio	Processing	40,293.0	90,685.7	−56
Educational attainment	Farm	0.53	0.53	0
Educational attainment	Processing	0.48	0.60	−20

The turnover-to-labour ratio indicator provides more insight into labour productivity. The average turnover per employee is 35% higher in organic farms. The difference can be explained by the much higher prices obtained by organic wheat farmers that contain not only a premium for using ecological farming methods, but also an incentive for cultivating special, even ancient varieties of wheat. As opposed to the farm level the productivity at the processing stage is more than twice as high in the reference processing plant. The difference is due to the large-scale production of conventional pasta producers and high mechanization of production processes compared to the almost handmade pasta of organic companies.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. There is no difference in the profile of education levels between producers of organic flour, at farm level, and those in the conventional sector. The level of education is dominated by secondary education (80–84%). In the case of processing, the level of education is slightly higher in for producers of conventional pasta than organic and can be explained by the case-specific structure of employment. It can be different in other companies.

Bargaining Power

Bargaining power (Table 6) is very evenly distributed among levels of the FQS, as evidenced by the very low value of the bargaining power distribution index (0.01). However, one may detect a small bargaining power advantage of the downstream level of pasta processing (P1), at the expense of the upstream level of wheat production. Key to this advantage are factors pertaining to the competitive environment at P1 level, especially the existence of a strong market leader who can hold weight in potential negotiations. On the other hand, this advantage of the P1 level is partially offset by the fact that the U3 level can rely on a better position than P1 players in terms of transaction costs: they mobilize specific resources in their activity, their contribution is key to the specificity of the end product and they are, on the other hand, not bound by a long term contract with downstream levels.

However, the bargaining position of the FQS supply chain can be considered relatively weak. The weakest is at farm level (U3), with the bargaining power scoring 0.40. Although this level may rely on strong transactional factors to sustain their

Table 6 Bargaining power indicators

Short indicator name	Chain level	FQS	REF	Difference %
BP score U3	Farm	0.40	0.10	−325.0
BP score P1	Processing	0.50	0.44	−12.5
BP score	Total	0.90	0.54	−67.6
BPD share U3	Farm	0.45	0.18	−153.5
BPD share P1	Processing	0.55	0.82	32.9
BP distribution	Total	0.01	0.42	−97.4
BP score competitiveness	Farm	0.25	0.00	
BP score competitiveness	Processing	0.75	1.00	
BP score competitiveness	Total	1.00	1.00	
BP score transaction costs:	Farm	0.78	0.22	
BP score transaction costs:	Processing	0.67	0.33	
BP score transaction costs:	Total	1.44	0.56	

position, this weakness mainly results from a nil score obtained at both levels for the institutional factors. This means that the institutional environment is insufficiently developed for supporting vertical relations within the supply chain. The overall weakness observed at the supply chain level may indicate that FQS are likely to be quite weak against major changes affecting the supply chain (entry or exit of actors, change in the market conditions, etc.). This is very true with reference to the specificity of relations between farmers and the owner of the processing plant, who may be seen as a person whose main focus is on achieving his mission, not necessarily maximizing profits from his business activity.

By way of contrast, bargaining power is very unevenly distributed in the reference product supply chain. In this case, the supply chain is characterized by strong domination of the P1 level. Due to the existence of a very weak institutional environment (institutional variables have 0 values at both levels), this domination is mainly explained by the strong competitive position of P1 players: there are significantly fewer of them than U3 farmers. Another key factor comes from the domination of the market leader at the P1 level.

The reference supply chain is also very weak, as evidenced by the very low score obtained, at the U3 level (0.1). This very low score is due to the existence of a very weak institutional and competitive environment (the average score of those factors is 0), combined with a poor performance in terms of transaction costs (average score of 0.22). This supply chain can therefore be considered highly vulnerable to any changes likely to negatively affect the chain.

All in all, the organic pasta supply chain can be considered more sustainable than the conventional one, at least as long as the mutual interest of farmers and the processor are a factor ensuring balance in relations between these two stages of the chain.

Table 7 Generational change and gender equality indicators [%]

Short indicator name	Chain level	FQS	REF	Difference %
Generational change	Farm	25	38	−34.2
Generational change	Processing	140	100	40.0
Generational change	**Total**	**83**	**69**	**20.3**
Gender equality	Farm	0.09	0.85	−89.4
Gender equality	Processing	0.10	0.07	42.86
Gender equality	**Total**	**0.09**	**0.46**	**−80.43**

Generational Change Index and Gender Equality Index in Employment

The indicators, that have been calculated for the farming and processing stages (Table 7), show that there are no significant differences between both supply chains.

The evidence observed suggests that at the farm stage the reference product appears to be slightly more sustainable than the FQS one regarding the generational change since the value of the indicator for the FQS is 34% lower. The indicator at the farm stage is both for organic and conventional pasta much below 100%. This suggests that both chains may be endangered in their sustainability prospects due to a high share of 45–65-year-old employees, compared to 15–35-year-old.

At the processing stage, the organic chain is more sustainable than the reference due to a greater share of young employees. The conventional pasta chain is balanced in terms of the generational change, considering that the same number of young and older staff is employed at this stage of the supply chain. Because the value of the generational change indicator for both chains is greater or equal to 100%, it has a positive impact on the social sustainability of the processing stage. The overall score for generational change in both chains (below 100%) indicates a low sustainability level, although slightly higher (20%) in the organic pasta chain.

The gender equality indicator, which accounts for gender differences in entrepreneurship and employment levels, at the farm stage is very low for the organic pasta chain (0.09), suggesting that the reference chain is much more sustainable (0.85). It should be emphasized however, that the comparison concerns a small sample of organic farms (14) and the country population of conventional farms as the reference. All organic farms in the sample were managed by men, whilst in the country population of conventional farms 20.4% of farm managers were women.

The share of women farm managers in the whole population of organic farms in Poland is even higher accounting for 26% (GIJHARS 2018). Thus, if the populations of organic and conventional farms were compared, the difference in the value of the gender equality indicator would be much smaller.

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PGI Hom Mali Thung Kula Rong-Hai Rice in Thailand

Orachos Napasintuwong

Abbreviations

ACFS	National Bureau of Agricultural Commodity and Food Standard
CB	Certification Body
COP	Code of Practice
DIP	Department of Intellectual Property
GI	Geographical Indication
KDML105	Khao Dawk Mali 105
PGI	Protected Geographical Indication
RD	The Rice Department of Thailand
THB	Thailand Baht
TKR	Thung Kula Rong-Hai
TRIPS	Trade-Related Aspects of Intellectual Property Rights
WTO	World Trade Organization

Quality aspects of Khao Hom Mali Thung Kula Rong-Hai

Khao Hom Mali can be literally translated as Jasmine rice. Jasmine rice is one of the prominent varieties of aromatic rice on the international market. Because however the term "Jasmine rice" became generic and is used by several countries e.g. Vietnam, another main rice exporter, the term Hom Mali is currently used instead of Jasmine rice from Thailand. Under Thailand's Hom Mali rice standard, two varieties can be considered Hom Mali rice: Khao Dawk Mali 105 (KDML 105) and RD15.

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O. Napasintuwong (✉)
Department of Agricultural and Resource Economics, Faculty of Economics,
Kasetsart University, Bangkok, Thailand
e-mail: orachos.n@ku.ac.th

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RD15 has similar traits to KDML105 but ripens about 2 weeks earlier and has higher yield potential. Both varieties are non-glutinous, photoperiod sensitive, and commonly cultivated in Northeast and certain Northern provinces of Thailand.

Hom Mali rice from Thailand has gained a reputation on the international market for its soft texture, nutty flavor, and naturally rich aroma similar to that of pandanus leaves. Its low amylose content and low gelatinization temperature contribute to soft and sticky characteristics which are different from those of Basmati rice, another well-known aromatic rice from India and Pakistan. Thailand was the market leader of high quality frangrant rice, and the preference of Thai consumers towards Hom Mali rice has profoundly shaped the preferences in Southeast Asian countries (Custodio et al. 2016). Hom Mali rice from Thailand is generally highly desired in several rice consuming countries, particularly China, Hong Kong, and Singapore, and in countries such as the U.S., where Asian consumers demand large quantities of aromatic rice (Goodwin et al. 1996a, b; Suwannaporn and Linnemann 2008; Suwansri et al. 2002).

The Development of Thung Kula Rong-Hai and How It Gained a Reputation for Hom Mali Rice Production

The KDML 105 rice variety was created in Chonburi province in 1945, and brought to Chachoengsao province in Central plain of Thailand for experimental research by the Rice Department (RD). During 1950–1951, varietal selection continued, and after trials at several RD research stations throughout the country, KMDL 105 was certified by the RD in 1959. The Northeastern area, particularly in the TKR area, was identified as suitable and providing distinct aroma and quality for KDML 105. After completing the seed exchange project for glutinous rice in 1979, which encouraged farmers to replace seed they had stored for good quality seed, KDML 105 became widespread in the Northeast area where glutinous rice was traditionally preferred to non-glutinous rice for household consumption.

The name "Thung Kula Rong-Hai" literally translates into Kula, an ethnic group, weeping, because when they travelled through this area, they were exhausted by the heat and dryness, and wept ('Rong-Hai' in Thai) because they could not reach the other side. In 1955, King Bhumibol visited the Northeast area and initiated a development project focusing on developing the practice of irrigation. In 1981, the Department of Land Development initiated the development plan for TKR area. The serious floods in the Northeast region in 1993 left the area of TKR under water for an extended period of time. As a result, the irrigation plan and the boundary of TKR area was specified covering a total of 337,230.40 ha extending across five provinces, namely Roi-Et, Mahasarakam, Surin, Yasothon and Srisaket. Since then several development projects have been carried out in the TKR area, including collaboration with the Australian government for irrigation, the development of the Khao Hom Mali Thung Kula Rong-Hai cluster, large field rice production, and Good Agricultural Practice (GAP) rice production, for example.

Causal Link Between Thung Kula Rong-Hai and a Specific Quality, the Reputation or Other Characteristic of the Khao Hom Mali PGI

Extrinsic Quality Attribute

The aridity and salinity of the TKR area are the conditions for good aromatic rice production, but the area also has low soil fertility, and farmers are generally poor and run small operations, compared to other parts of the country. Like most of the areas in the Northeast region, where irrigation covers only about 10% of the area for rice cultivation, TKR agriculture in the main cropping season is rain-fed and rice cultivation can be carried out only once a year (Office of Agricultural Economics 2017). Severe flooding occurs in the TKR area during the rainy season. Harvesting takes place in the cold season when the weather is cold and dry, after the end of the rainy season. Slightly saline soil and the coolness and dryness of the area cause KDML 105 and RD 15 to produce their typical volatile compound which gives the aromatic to the rice. The TKR area is known among Thai consumers as the prime area for high quality Khao Hom Mali production. Yoshihashi et al. (2004) found that Hom Mali rice produced in the rain-fed area of TKR has a higher concentration of the volatile compound (2-Acetyl-1-pyrrolime or 2AP) than the same rice produced in other areas. Furthermore, the knowledge of local farmers contributes to the quality of Hom Mali rice growing practices. For example, a flooded paddy field needs to be drained about 10–15 days before harvesting to in order to obtain rice of good physical quality, with long, slim, clear and sturdy grains and strong aroma.

Specific Rules in Production, Harvesting, Processing and Packaging That Must Take Place in the Identified Geographical Area

The whole of the production cycle (sowing, cultivation, harvesting) must take place in the defined TKR geographical area to ensure that it is conducted entirely under the geomorphological conditions specific to that area. Harvesting is governed by special rules which cover the dates, phenological stages and grain moisture to guarantee the hygiene and safety of the product and complete traceability of the rice to the region of origin and even, in many cases, to the farmers who have grown it. The processing and packaging take place in Roi Et, Surin, Sisaket, Mahasarakham, and Yasothon Provinces, which are the five provinces of the TKR area. This is to give consumers an effective guarantee of the origin and quality of the rice. Repackaging is not allowed, in order to minimise possible dilution in the concentration of the volatile compound, which would undermine its distinctive aroma, and to prevent any possible contamination or alteration of the product.

Historical Background

Under the WTO Trade-Related Aspects of Intellectual Property Rights (TRIPS) a GI product has to be protected in its country of origin before it can be protected in other WTO member countries. The Geographical Indications Protection Act of Thailand was passed in 2003. Under this Act, Thung Kula Rong-Hai Khao Hom Mali Rice was registered on 28 April 2006 (Department of Intellectual Property 2007). The initial registration allows the processing and packaging in Central plain and in the Northeast of Thailand where the quality, quantity and traceability control can be managed by the five provinces of TKR. Before 2008, Thailand was the only country exporting Jasmine-type rice. Since Vietnam and Cambodia started to export Jasmine-type rice, the market share of Hom Mali rice from Thailand has fallen. Although Thailand has used the label "Thai Hom Mali Rice" certified by the Department of Foreign Trade since 2005, the recognition of high quality Jasmine-type rice was unable to compete with lower price competitors. In the hope that PGI could provide better recognition in the international market, Thung Kula Ronghai Khao Hom Mali Rice was submitted for PGI registration to the European Union on November 20, 2008, and registration announced on June 29, 2010 (Official Journal of the European Union 2010). However, five countries — Belgium, France, Italy, the Netherlands, and the UK — objected that Thailand could not use the phrase "Jasmine rice" or "Khao Hom Mali Rice" given that name had already become generic under TRIPS. They also questioned whether the rice was packed in the TKR area. As a result, the registration of Thai GI Thung Kula Rong-Hai Khao Hom Mali Rice was updated on 20 July 2012 to limit processing and packaging to the five provinces of the TKR (Department of Intellectual Property 2012). Finally, on 11 February 2013, Khao Hom Mali Thung Kula Rong-Hai was registered as PGI (Official Journal of the European Union 2013).

Territory

Thung Kula Rong-Hai is a large plain in Northeast Thailand, extending across five provinces, namely RoiEt, Mahasarakam, Surin, Yasothon and Srisaket. It covers a total of 337,230.40 ha (2,107,690 rai). The geographical area where all operations take place (sowing, cultivation, harvesting, milling, packaging and labelling) is Roi Et, Mahasarakam, Surin, Yasothon and Srisaket. The cultivation area (Fig. 1) lies in:

- Thung Kula Rong-Hai in **Roi Et** province consisting of 157,889.12 ha (986,807 rai) of land in districts (tambons) on the Thung Kula Rong-Hai Plain in *Kaset Wisai, Suwannabhumi, Pratumrat* and *Phonsai* districts and *Nong Hee* subdistrict.
- Thung Kula Rong-Hai in **Surin** province consisting of 92,158.88 ha (575,993 rai) of land in districts on the Thung Kula Rong-Hai Plain in *Ta Tum* and *Chumpol Buri* districts.
- Thung Kula Rong-Hai in **Sisake**t province consisting of 45,920 ha (287,000 rai) of land in districts on the Thung Kula Rong-Hai Plain in *Rasi Salai* district and *Silalat* subdistrict.

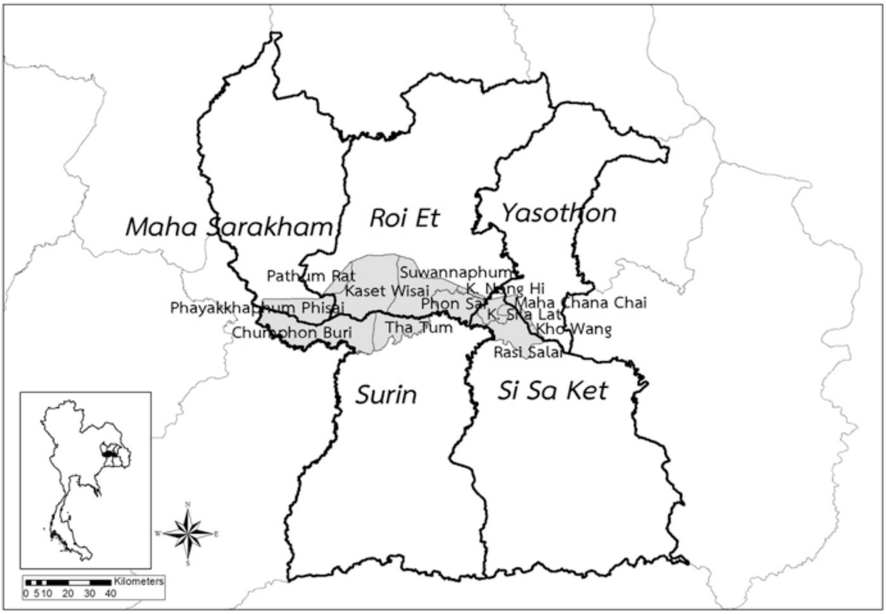

Fig. 1 Thung Kula Rong-Hai geographical area. (**Source:** The author. **Note:** The thicken lines indicate boundaries of five provinces, and the shaded areas indicate Thung Kula Rong-Hai)

- Thung Kula Rong-Hai in **Maharasakham** province consisting of 31,022.4 ha (193,890 rai) of land in districts on the Thung Kula Rong-Hai Plain in *Phayakaphum Pisai* district.
- Thung Kula Rong-Hai in **Yasothon** province consisting of 10,240 ha (64,000 rai) of land in districts on the Thung Kula Rong-Hai Plain in *Maha Chanachai* and *Kor Wang* districts (Table 1).

Table 2 shows the area of production, output and yield of rice cultivation in 2015/2016 (rainy) cropping season. Hom Mali rice accounted for about 42% of total rice cultivation area of the country. As the data on Hom Mali rice cultivation are not available at the district level, in the main cropping season in the TKR area, it is assumed that most of rice cultivation in this area was attributable to Hom Mali rice. In addition, TKR does not cover all the districts of the five provinces, and not all subdistricts of 12 districts are considered TKR area. The data in Table 2 may overestimate the area and quantity of production but they are the closest information available. In the 2015/2016 rainy cropping season, rice planted area in TKR area was about 357 thousand hectares, accounting for less than 4% of total rice area and production of the country. Almost all the TKR area was used for Hom Mali rice production. About 866 thousand tons of rice was produced in the TKR area, or less than approximately 10% of Hom Mali rice production of the country. Table 2 also shows that Surin and Srisaket provinces have a larger area of Hom Mali rice production, but Roi-Et is the largest province producing Hom Mali rice in TKR. Annex I provides more details of the rice production in five provinces constituting TKR.

Table 1 Khao Hom Mali Thung Kula Rong-Hai specifications

Territory	
Geographical area	Thung Kula Rong-Hai covering 337,230.40 ha of five provinces, namely Roi-Et, Mahasarakam, Surin, Yasothon and Srisaket. The growing area covers 9.714% of total area of five provinces. The processing and packaging area covers 3,471,682.8 ha
Varieties/ breeds	KDML 105 and RD 15 rice varieties
Season	Rainy season (main rice cropping season)
Arable farming practices	
Other	GAP or organic under the rules of Ministry of Agriculture and Cooperatives standards required by National Bureau of Agricultural Commodity and Food Standards

Source: Department of Intellectual Property (2012); National Bureau of Agricultural Commodity and Food Standards (2014); Official Journal of the European Union (2010)

The specification of PGI and Thai GI "Khao Hom Mali Thung Kula Rong-Hai" does not explicitly require any particular production standards, but states that production should follow good agricultural practice. The GI rice standards of the National Bureau of Agricultural Commodity and Food Standards, however, require that for GI rice products to be certified, growing has to be either certified organic or certified GAP (National Bureau of Agricultural Commodity and Food Standards 2011). In fact, farmers who produce certified Khao Hom Mali Thung Kula Rong-Hai are usually members of farmers' groups or agricultural cooperatives that receive support from the RD, other public institutions or NGO, in terms of perhaps training and supply chain management, which enables them to produce organic or GAP rice.

Value Chain

This section discusses the value chain of the certified Khao Hom Mali Thung Kula Rong-Hai. Although most, if not all, of the farmers in the TKR area produce Hom Mali rice during the rainy season, the season required for GI certified rice, not all Hom Mali rice farmers are GI certified. There are two possible reasons. One reason is that their production does not follow the Code of Practice (COP) of the GI specifications. The other reason might be because they have not applied for or cannot afford the certification by an external certification body (CB).[1] Certified GI Khao Hom Mali Thung Kula Rong-Hai rice farmers almost always belong to farmers groups such as community enterprises and community rice centers receiving

[1] Bioagricert is the only certification body authorized to certify PGI products under EU regulations. In 2017, the cost of annual certification service by certification body was about 1000 euros for a processor excluding fees for certification of products and the use of certification seal (Bioagricert) which ranged between 0.3% to 1% of the, and depending on the, turnover of certified exported products.

Table 2 Area of Hom Mali rice production in Thung Kula Rong-Hai, 2015/2016 cropping season

Province	Harvested area ('000 ha)	Output ('000 ton)
Whole country		
All rice	8,815	24,312
Hom Mali rice	3,768	8,783
% Hom Mali rice	0.43	0.36
Yasothon		
All rice	198.52	438.81
Hom Mali rice	101.83	230.49
Yasothon_TKR all rice	37.01	93.91
%TKR to Hom Mali rice Yasothon	0.36	0.41
%TKR to all rice Yasothon	0.19	0.21
Srisaket		
All rice	461.77	1,043.15
Hom Mali rice	422.07	948.99
Sisaket_TKR all rice	42.81	109.14
%TKR to Hom Mali rice Sisaket	0.10	0.12
%TKR to all rice Sisaket	0.09	0.11
Surin		
All rice	474.61	1,145.71
Hom Mali rice	468.30	1,129.88
Surin_TKR all rice	85.10	217.42
%TKR to Hom Mali rice Surin	0.18	0.19
%TKR to all rice Surin	0.18	0.19
Maharasakham		
All rice	314.04	716.29
Hom Mali rice	157.76	360.00
Makasarakham_TKR all rice	29.96	0.00
%TKR to Hom Mali rice Mahasarakham	0.19	0.161
%TKR to all rice Mahasarakham	0.10	0.08
Roi Et		
All rice	454.62	1,080.71
Hom Mali rice	329.43	774.59
Roi Et_TKR all rice	162.15	388.41
%TKR to Hom Mali rice Roi Et	0.49	0.50
%TKR to all rice Roi Et	0.36	0.36
TKR all rice	357.02	866.93
%TKR to national Hom Mali rice	0.10	0.10
%TKR to national all rice	0.04	0.04

Source: Office of Agricultural Economics (2017)

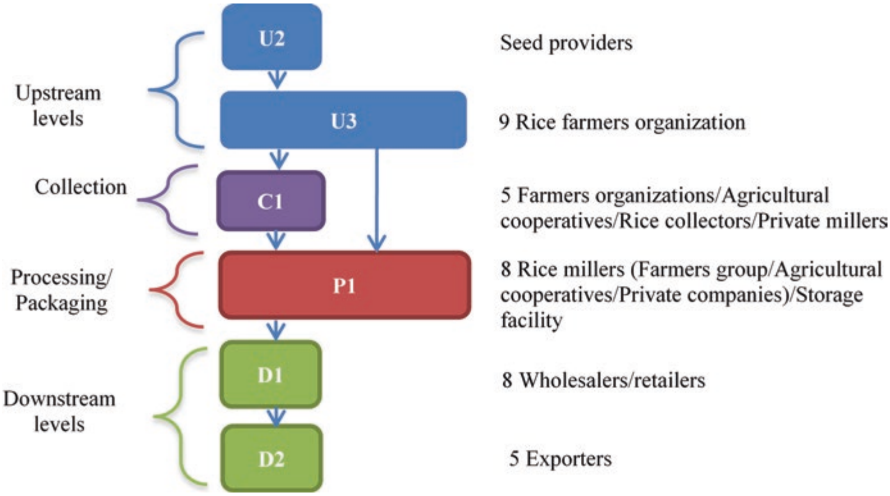

Fig. 2 Certified GI Khao Hom Mali Thung Kula Rong-Hai value chain

support from the Department of Intellectual Property or the RD for rice production standards i.e. GAP. In the past few years, the cost of the GI certification of Khao Hom Mali Thung Kula Rong-Hai by the certification body was almost entirely subsidized either by the Department of Intellectual Property or the RD. Out of 46 agricultural cooperatives located in TKR area, only three of them are certified GI Khao Hom Mali Thung Kula Rong-Hai collectors, and one out of these three is also certified as a GI Khao Hom Mali Thung Kula Rong-Hai processor (Napasintuwong 2017).

Structure of the Supply Chain

Figure 2 shows the main stakeholders along the value chain of certified Khao Hom Mali Thung Kula Rong-hai. Information regarding the seeds providers is not included. Nevertheless, seeds are the only single key input of breeding Khao Hom Mali Thung Kula Rong-Hai rice. Farmers are required to obtain the seeds from reliable sources such as the RD Seeds Centers or farmers seeds associations to ensure that the seeds are of KDML 105 or RD15 varieties.

As of 2017, the certified GI Khao Hom Mali Thung Kula Rong-Hai stakeholders are as follows:

– 9 farmers' organizations, 3 of them are also processors (millers) and also wholesalers/retailers. As noted above, certified GI farmers currently belong to farmers' organizations. The groups also frequently produce rice seeds themselves, particularly those that are certified organic. The groups buy registered seeds from the RD, commercial seeds, and use them among group members in subsequent cropping seasons.

- 2 collectors (agricultural cooperatives). They are also wholesalers/retailers but their processed products are not certified GI. In some cases, they only collect and transfer rice to other processors. There is no processing at point of sale. This is because of the wide area of production. There can be a great distance to millers, so that farmers have no incentives to deliver the paddy. The collector is a point where quality is controlled on behalf of contracted millers.
- 5 processors or millers (excluding 3 farmers' organizations engaged in milling) that are also wholesalers/retailers. One of them is an agricultural cooperative.

Table 3 shows current certified Khao Hom Mali Thung Kula Rong-Hai stakeholders. At the moment, there are no certified GI farmers who are not also members of certified farmer's organizations or certified agricultural cooperatives. These farmers may buy rice seeds from reliable sources, and some of them are also seed producers themselves. If farmers' organizations or agricultural cooperatives received the GI certification, member farmers generally sell their paddy to the certified farmers' organizations or agricultural cooperatives. In the past, only the enterprises which linked member farmers to processors or to marketing and retailing were successful suppliers of certified GI. The link from farmers to millers was sometimes supported by public sector intervention. For example, given that the products met certain quality and GI standards and farmers could supply a sufficient quantity, the RD negotiated a paddy price higher than the market price for farmer groups selling to certified millers. This provides farmers with more incentive, knowing that there is a market for it, to produce the paddy according to GI standards. When the millers have agreed the price, farmers deliver the paddy to millers directly or through collectors i.e. agricultural cooperatives who inspect the quality of the paddy and ensure that the paddy is from certified GI famers, then transfer it directly to millers. The collector is needed especially if there is a long distance between certified millers and farmers' fields.

This link between farmer, collectors (agricultural cooperatives), and millers was only created in the past few years. Certified GI farmers can also sell directly to the certified GI millers. These certified GI millers, including Kaset Wisai Agricultural Cooperative, sell rice for the domestic and international markets. Except for Kaset Wisai Agricultural Cooperative, other certified GI millers sell on international markets, but the products they currently sell are not advertised or promoted as PGI Khao Hom Mali Thung Kula Rong-Hai, but rather as Hom Mali rice in general. Nevertheless, they segregate Khao Hom Mali from TKR for premium markets. Two millers that export certified PGI Khao Hom Mali Thung Kula Rong-Hai to international markets are Poonphol Trading Company and J.P. Rice International Company. Their main premium rice export markets are Hong Kong and Singapore.

Figure 3 shows the vertical integration of stakeholders along the Khao Hom Mali Thung Kula Rong-Hai value chain. The number of boxes does not necessarily represent the number of stakeholders, for example seed producers and exporters, but possible vertical integration patterns.

Table 3 Certified GI Khao Hom Mali Thung Kula Rong-Hai, 2016

Stakeholder		District	Province	Est. no. of farmers
Farmers' group	Ban Gao Noi rice community enterprise (organic)	Phayakaphum Pisai	Mahasarakham	51
	Ban Chan Hom Hom Mali rice group	Chumphon Buri	Surin	37
	Ban Bo Kae Hom Mali quality rice producer group	Chumphon Buri	Surin	21
	Petch Thung Kula Ronghai Hom Mali rice group	Kaset Wisai	Roi Et	17
	Thung Thong group	Kaset Wisai	Roi Et	44
	Saew Noi watershed organic rice cultivation (organic)	Suwannabhumi	Roi Et	26
Farmers' group/ collector/processor/ retailer	Ban Umsaeng rice community enterprise (organic)	Rasi Salai	Sisaket	1252
	Ban Mayang rice community enterprise (seed producers)	Rasi Salai	Sisaket	30
	Nam-Om sustainable agriculture community enterprise (organic)	Kor Wang	Yasothon	n/a
Collector	Chumphon Buri Agricultural Cooperative, Ltd.	Chumphon Buri	Surin	–
	Agricultural and Land Reform Chumphon Buri Cooperative, Ltd.	Chumphon Buri	Surin	–
Processor/ wholesaler/ retailer	Ying Charoen Ka Khao Sarakham Company, Ltd.	Phayakaphum Pisai	Mahasarakham	–
	Kaset Wisai Agricultural Cooperative, Ltd.	Kaset Wisai	Roi Et	–
	Srisangdao rice mill	Suwannabhumi	Roi Et	–
	Poonphol Trading Company, Ltd.	Muang	Surin	–
	J.P. Rice International Company, Ltd.	Muang	Surin	–

The Thai certified GI products are sold on the domestic market through various channels such as local markets, agricultural trade fairs, and local supermarkets. These products are authorized to use Thai GI symbol (Fig. 4). In addition, if the stakeholders in all the stages of the value chain are all certified PGI, their products are authorized to use PGI symbol (Fig. 5). For Hom Mali rice products of cooperatives in Roi Et province, the provincial government created the brand "Thung Kula

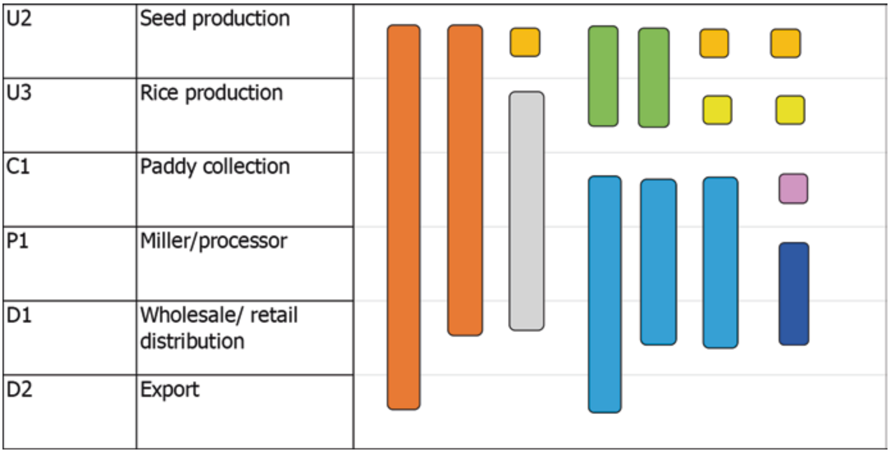

Fig. 3 Khao Hom Mali Thung Kula Rong-Hai supply chain structure

Fig. 4 Certification mark of Thai Geographical Indication (GI)

Fig. 5 Protected Geographical Indication (PGI) certification mark of the European Union

101" (Roi Et means 101) and promotes the products as province specialties, whether GI or not. As a result, Kaset Wisai Agricultural Cooperative is the only certified GI miller/wholesaler using a package in gold rather than blue to distinguish its products from those of other supply chains. Kaset Wisai Agricultural Cooperative also created a unique brand "Kerd Boon", and "TK Farm" is a brand created by Thung Kula Rong-Hai cluster for Hom Mali rice produced in Thung Kula Rong-Hai area, whether certified GI or not. Agricultural cooperative products are generally distributed through the nationwide cooperative network.

For domestic products, several GI certified millers advertise and market products as certified Thai GI Khao Hom Mali Thung Kula Rong-Hai. Farmer organizations which are also certified GI processors – namely the Ban Umsaeng rice community enterprise, Ban Mayang rice community enterprise, and Nam-Om sustainable agriculture community enterprise –advertise and market their products as certified Thai GI Khao Hom Mali Thung Kula Rong-Hai. Bang Mayang rice community enterprise, however, does not have sufficient capacity to operate a milling process so their products are sold to millers which are not certified GI processors. Their products are currently marketed under the name of Thung Kula Rong-Hai GI, but do not display the Thai GI symbol. Although the millers who are certified PGI processors do not market their products on the international market as Khao Hom Mali Thung Kula Rong-Hai PGI products, their products sold on the domestic market use PGI symbol.

The reason that the certified GI production is not exported is that it would have to be processed and packed in the geographical area. A large volume of rice produced by certified farmers and certified millers is sold in bulk to exporters located outside the territory who repackage the rice according the overseas customer requirements. This means the certified products may not display the GI label. Although the same rice and processing methods are used for products sold as certified GI on the domestic market, products for the export market are distributed mainly by exporters in much smaller volumes than normal Hom Mali rice, which can be sold as Hom Mali rice or organic Hom Mali rice without GI certification.

Local Production System and Governance

The control system of GI Khao Hom Mali Thung Kula Rong-Hai works at three different levels: self-control (auto-control), internal control and external control. At the auto-control level, farmers, processors, and packaging industries follow a Code of Practice which can be modified by group members. The auto-control system must be in place for internal control. At the internal control level, the GI committee appointed by the province authority or internal controllers of the farmers' organizations inspect the operations of farmers, processors, and packaging industries which are under a self-control system. As Thung Kula Rong-Hai covers five provinces, there is currently no GI committee at province level and internal control is carried out within the groups of member farmers. Use of the Thai GI label requires that producers follow the COP, and have a control system at province or producer level.

At the external control system level, the CB performs GI controls on behalf of the Department of Intellectual Property. The external control system is required for PGI products under European Union regulations on quality schemes for agricultural products and foodstuffs (Official Journal of the European Union 2012). The CB has to be accredited following the International Organisation for Standardisation (ISO). The CB currently accredited by the National Bureau of Agricultural Commodity and Food Standards has received ISO 17065. The Department of Intellectual Property (DIP) is responsible for the validation of specifications and inspection methods (production manual) and approving and supervising the CB. The accreditation bodies include Thai Industrial Standards Institute (TISI) and National Bureau of Agricultural Commodity and Food Standard (ACFS). The accreditation bodies have the rights to accredit CB according to ISO guide 65 and specific requirements laid down by DIP.

The certified GI products can be managed under different institutional arrangements which can be vertical or non-vertical. Vertically integrated systems are agricultural cooperatives or farmers' organizations engaged in activities spanning from rice production to marketing (orange and grey in Fig. 3). Non-vertically integrated systems consist of stakeholders who do not necessarily perform all the activities from seed production to marketing. It is recognized that the roles of agricultural cooperatives and farmers' organizations are important in supporting the production of and quality assurance for GI Khao Hom Mali Thunk Kula Rong-Hai (Napasintuwong 2017; Ngokkuen and Grote 2011). In the past, when links between farmers and millers were not supported, the transportation cost of the paddy from the farm gates to the millers was one of the factors prohibiting the adoption of GI standards (Ngokkuen and Grote 2011). In non-vertically integrated systems, millers and/or collectors have an important role in procuring certified GI paddy that matches with the market demand at a price that millers are willing to pay. Almost all GI certified millers process not only GI Khao Hom Mali Thung Kula Rong-Hai, but also Hom Mali rice and sometimes other types. These millers, who almost always also perform marketing activities, possess market information on the demand for GI Khao Hom Mali Thung Kula Rong-Hai. They may opt not to concentrate on developing and marketing GI products, as the market for GI Khao Hom Mali Thung Kula Rong-Hai is much smaller than non-GI Hom Mali rice, and the incentive for millers to control and supervise GI rice may not be as strong as if the whole supply chain was completely integrated.

The quality aspect of Hom Mali rice from Thung Kula Rong-Hai is perceived mainly through its aroma. This means that all production stages, from seed production, requiring for example pure varieties, to farming, requiring local knowledge of water draining, are essential in maximizing the rice aroma and quality. This is confirmed by the study by Changsri et al. (2015) which also finds that plants nutrients, grain moisture content and drying temperature, as well as milling and storage affect the grain quality, aroma and viscosity. Thus, one of the most critical steps in managing the quality of GI Khao Hom Mali Thung Kula Rong-Hai is farm management. Strict auto-control and internal control systems in farmers' organizations or agricultural cooperatives are necessary for delivering the maximum quality of certified GI products.

Sustainability Analysis

The impacts of geographical indication certification of Khao Hom Mali Thung Kula Rong-hai can be studied in its economic, environmental, and social dimensions using the Strength2Food method (Bellassen et al. 2016). This study compares certified Thai GI or EU PGI Khao Hom Mali Thung Kula Rong-Hai with a reference product, non-certified Khao Hom Mali Thung Kula Rong-Hai, the same rice produced in the same geographical area, but not certified either by an internal control system (for Thai GI) or by an external control system (for EU PGI). The share of certified product is less than 0.01% of all Hom Mali rice produced in Thung Kula Rong-Hai area. The results show that GI Khao Hom Mali Thung Kula Rong-hai has a less damaging impact on the environment. The GI Khao Hom Mali Thung Kula Rong-hai generally has a better economic impact than the reference product. Nevertheless, there is currently no export of certified GI Khao Hom Mali Thung Kula Rong-hai to any part of the world, so the economic impact from the export is much less than the one of Khao Hom Mali Thung Kula Rong-hai, one of Thailand's main export commodities. Overall, the social impacts of GI Khao Hom Mali Thung Kula Rong-hai are also positive compared to non-certified Khao Hom Mali Thung Kula Rong-hai, except for the generational change of workers (Fig. 6).

Economic Impact of Certified GI Khao Hom Mali Thung Kula Rong-Hai

The *price premium* is sizeable at all the levels of the GI value chain, increasing from farmers (19%) to millers (61%) and then at the retail level (90%). Concerning profitability, at farm level costs are similar in absolute terms, but as certified GI benefits from a higher price, its profitability is significantly higher in relative and absolute terms. The subsidies for organic production, which accounts for more than 90% of the GI production, increase this difference. At the processing level, costs are higher for certified GI than for reference products, but in relative terms, they represent a similar share of turnover, and GI is finally slightly more profitable at the P1 level.

Concerning exports, certified GI Khao Hom Mali Thung Kula Rong-hai rice is consumed exclusively on domestic markets, while 17% of non-certified rice is

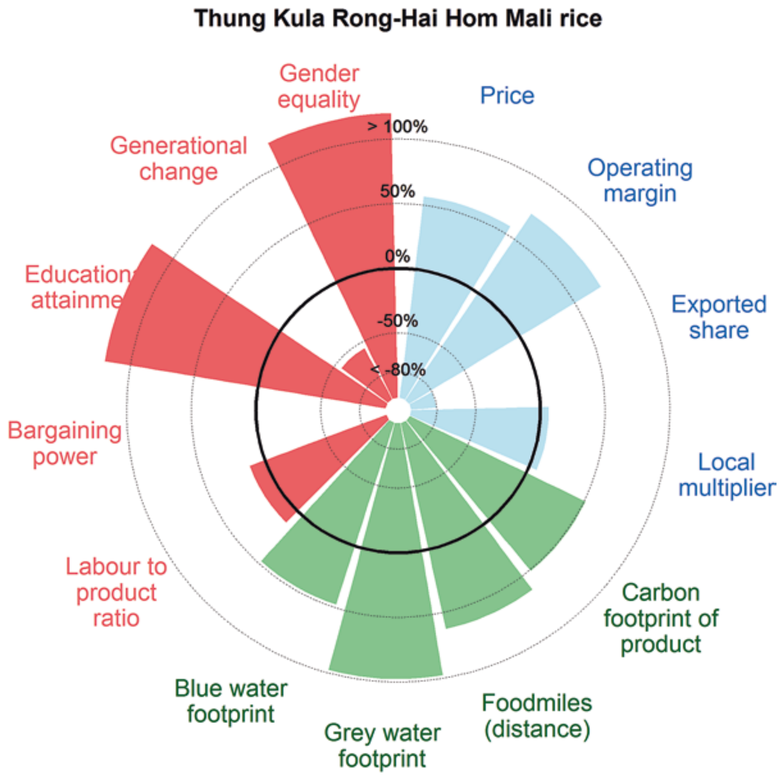

Fig. 6 Sustainability diagram of certified GI Khao Hom Mali Thung Kula Rong-hai

exported, to Europe and to the rest of the world. Export volumes are variable, as the rice market has recently undergone crisis and disequilibrium, and because rice availability is a key issue in the Thai food security strategy and an important element of Thailand's role in agricultural trade. Before 2007, Thailand was the only exporter of Hom Mali rice on the world market, but two competitors in the Jasmine-type rice market, Vietnam and Cambodia, have since emerged. Because rice production is subject to several factors, including production risks such as drought, flood, and export market competition, export has fluctuated.

The *local multiplier effect* of certified GI Khao Hom Mali Thung Kula Rong-hai is slightly higher than the one for its reference product: each *Thailand* Baht (THB) of turnover for TRK rice generates 1.47 THB of re-spending in the same region, versus 1.32 THB for the reference product. The main driver of these outcomes is the location of the rice farms: for both types of rice, all farms are located in the local area. A sensitivity analysis shows that the amount re-spent by suppliers in the local area (LM3) without local rice farms, would be lower by 48% for the TRK rice and by 41% for the non-certified GI Khao Hom Mali Thung Kula Rong-hai. The second main driver is the local re-spending of farms: without local suppliers, LM3 would fall by 21% for the certified GI Khao Hom Mali Thung Kula Rong-hai, and 15% for the conventional reference product.

Environmental Impact

Food Miles

Regarding *food miles*, the certified GI Khao Hom Mali Thung Kula Rong-hai supply chain, dominated by organic rice, is compared to the non-certified GI rice, from seed production to the retail market. Over the entire supply chain, from rice seeds to milled rice distribution units (U2-D1), certified GI rice travels 65% shorter distances (1100 t.km vs 3000 t.km) and releases 10% fewer emissions (135 vs 145 kg CO_2 eq) than conventional rice. This difference is mainly driven by exports. Certified GI rice is not exported, while 17% of the conventional production is sold abroad. This drives up distances and emissions for the reference product. The shorter distances travelled by the non-certified rice at the processing level and on the domestic market do not fully offset the longer distances travelled by exported non-certified GI rice. Similar trends explain the differential in emissions generated by transportation.

However, the benefits of shorter distances for the certified GI Khao Hom Mali Thung Kula Rong-hai are partly offset by the use of more carbon intensive transportation modes on the regional market and at the processing level, i.e., light vehicles, compared to less carbon intensive modes for exports of conventional rice, i.e., sea transport and heavy goods vehicles. The distribution level (P1-D1) concentrates most of the distance travelled in the product and more than 75% of emissions generated for transportation along the value chain. Certified GI Khao Hom Mali Thung Kula Rong-hai is more sustainable than its reference product in terms of distance travelled (−65%) and in terms of emissions released at the transportation stage (−10%).

Water Footprint

The values of green water footprint reflect rainwater consumed during the production process and refer to the total rainwater evapotranspiration from fields and plant plus the water incorporated into the harvested crop. They are computed by dividing rainwater consumed by the yield and multiplying by the final product ratio. The green water footprint accounts for the biggest share of the indicator. The green water footprint of the certified GI product is 4.26 m^3/kg while that of the reference product was 5.56 m^3/kg. Certified GI Khao Hom Mali Thung Kula Rong-hai production is characterised by a higher yield (2.81 ton/ha for certified GI and

2.31 ton/ha for non-certified GI) and a better final product ratio (0.45 for certified GI and 0.42 for the reference product). It is noted that the blue fraction of the water footprint, accounting for the consumptive use of fresh surface or groundwater, in the case of Khao Hom Mali Thung Kula Rong-hai (certified and non-certified) that pertains to the production of paddy is associated only with overheads, that is water consumed during the production of diesel and spreading of manure and chemicals. In both cases, rice production is rainfed and no irrigation is required. For most crops, irrigation accounts for a large part of the blue water footprint. The blue water footprint of the certified GI product is 0.004 m^3/kg while that of the non-certified product is 0.008 m^3/kg.

As for the grey water footprint which indicates the degree of freshwater pollution expressed by the volume of water required to dilute pollutants, although the yield and the final product ratio again make the indicator different across certified and non-certified products, the bulk of the difference reflects the amount of nitrogen applied to certified and non-certified GI rice. The majority of GI certified rice is organic and is assumed to use only organic nitrogen, although in higher amounts than the reference rice. However, non-certified GI rice also requires mineral nitrogen in an amount that is 30 times the amount of organic nitrogen. The grey water footprint of certified GI product is 0.006 m^3/kg compared to 0.261 m^3/kg of non-certified product.

For certified GI rice, both the blue and the grey water footprints are negligible in comparison with the green water footprint. In the case of non-certified GI rice, the grey water footprint becomes more important. Overall, non-certified GI rice production consumes more water than the reference product, as shown by the overall value of the water footprint.

Social Impact of Certified GI Khao Hom Mali Thung Kula Rong-Hai

Educational Attainment Indicator

The *educational attainment indicator,* which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The educational attainment indicator is higher for the certified GI Khao Hom Mali Thung Kula Rong-hai at farm level, 0.5 versus 0.11. The difference is 350% and can be explained by the fact that 40% of farmers have tertiary education. This group of certified farmers are generally more educated and skilled farmers. The difference is much smaller at the processing level since, given the same technology and labour requirements for the milling process, many of the certified millers also produce non-certified products.

Labour Use Ratio

The *labour use ratio*, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is higher for Thailand's certified GI Khao Hom Mali Thung Kula Rong-hai than for its non-certified reference. At farm level, it takes 304 hours of work to produce one ton of rice, where the reference product requires only 27 hours. Thus, at the farm level, the labour to product ratio of certified GI product is 0.169 while that of the non-certified product is 0.015. The difference (1026%) indicated that the certified GI products generate more jobs than the reference ones. As more than 90% of certified GI products are also certified organic and the rest must be certified GAP, labor input for quality rice is generally higher. For example, hand harvesting is still practised in certified GI farming, and because organic farming does not use chemicals, weeding also takes up more work hours.

The relative difference is slightly less sizeable at the processing level, since it takes 1 hour of work to prepare one ton of certified GI rice, but 4 hours for the non-certified GI rice from TKR. The activities carried out at the milling stage are more than just those required to operate the machines, so it requires a lot of labour. In fact, after the paddy is delivered, it has to be weighed, tested for quality, dried and stored. The milling is not done immediately, but only when an order for the final product comes in. The labour to product ratio of certified GI product at the processing level is 0.006 while that of non-certified product is 0.02 implying that the certified GI product is more labour efficient perhaps due to higher standard such as GMP.

Turnover-to-Labour Ratio Indicator

The *turnover-to-labour ratio indicator* gives an insight into labour productivity. The average turnover (profit) per employee is lower for certified GI farmers than for non-certified GI ones (−89%). But at the processing level, the productivity difference is positive and sizeable, with a relative difference of 533% in favour of the certified GI rice. These differences are mostly due to organic vs non-organic farming practices, milling technology and certified GMP vs non-certified GMP, which raise the price of the product at the processing level.

Generational Change Indicator

Thailand is experiencing labour shortages and an aging workforce in the agricultural sector. The generational change indicator reflect ratio between younger employees (age 15–35) to older employees (age 45–65); the higher value of the indicator suggests that the supply change employs more young workers than older ones. The generational change indicator of both supply chains at farm level is very small, suggesting that both the quality and reference product are seriously endangered in their social sustainability prospects due to the very limited employment of young compared to older workers. The non-certified GI rice is slightly more sustainable than the certified GI rice at the farm stage, 8% versus 5%, according to this indicator. This could be because certified rice GI requires more experienced and skilled farmers, so farming of certified products generally employs many more older farmers than non-certified farming. The non-certified GI rice is much more sustainable than the certified GI rice at the processing level, because the value of the generational change indicator for non-certified GI rice is more than three times higher (132% for certified GI product and 502% for non-certified product).

Gender Inequality Indicator

Gender inequalty index expresses the extent of the differece between male and female achievements in labour market of the supply chains. The higher the gender inequality index, the more the unequal opportunities are for male and female participation in the labour market. Both supply chains are characterised by some of the highest levels of social sustainability attainable according to the gender inequality indicator. In fact, at the farm stage of both supply chains there is almost complete equality in the opportunities for male and female employees and entrepreneurs. The gender inequality at the farm level of certified GI product is 0.07 while that of non-certified product is 0.00.

The rice processing stage of both supply chains is characterised by opposite levels of sustainability. The certified GI rice features lower level of gender inequality implying that the certified GI rice is more socially sustainable than the reference product, 0.45 versus 0.99, at the processing stage. This higher level of sustainability is given by similar percentages of secondary education certificates across genders and female entrepreneurship at the processing stage of the certified GI rice, compared to the reference product.

Conclusion

Certified GI Khao Hom Mali Thung Kula Rong-hai is one of the first registered agricultural products under Geographical Indications Protection Act of Thailand, and is the first rice product registered as PGI outside the European Union. Competition in the market for jasmine rice is becoming more intense, and the protected geographical indication is one of the ways the Thai government aims to differentiate Thai Hom Mali rice from foreign competitors. The name of the GI product, Khao Hom Mali Thung Kula Rong-hai, had been used long before the existence of the GI, and the use of the name without certification is not prohibited.

The only distinction between the certified GI Khao Hom Mali Thung Kula Rong-hai product and the reference product is the certification label. Given that the share of the certified GI is less than 0.01% of total Hom Mali rice produced in the same geographical area, the market for the certified GI product is very small, and none is currently exported.

The sustainability analysis found that overall the certified GI Khao Hom Mali Thung Kula Rong-hai product is more sustainable than non-certified one. Key factors including educational attainment, labour to product ratio, price premium, profit, and all the environmental indicators show that certified GI jasmine rice is more sustainable. Exceptions are the generational change, bargaining power, and export share of certified GI products indicators, which suggest that the performance of the GI rice is worse in terms of sustainability than that of the non-certified reference product. Certified products require more experienced and older farmers. No GI rice is currently exported. These results suggest that GI certification should make rice production more sustainable in this poor area of the country. And it should generate higher income and more employment in the area, thanks to a product being protected on the international market and thus able to face the competition of premium quality rice.

Annex I: Hom Mali Rice Production in Thailand, 2015/2016 Rainy Cropping Season

District/Province	Planted area ('000 ha)	Harvested area ('000 ha)	Output ('000 ton)	Yield (ton/ha)
Whole country				
All rice	9,290	8,815	24,312	2.758
Hom Mali rice	3,990	3,768	8,783	2.331
% Hom Mali rice	0.429	0.427	0.361	
Yasothon				
All rice	207.83	198.52	438.81	2.210
Hom Mali rice	106.97	101.83	230.49	2.263
Kor Wang	12.84	12.27	31.59	2.575
Maha Chanachai	25.78	24.75	62.33	2.519
Yasothon_TKR all rice	38.62	37.01	93.91	2.537
%TKR to Hom Mali rice Yasothon	0.361	0.363	0.407	
%TKR to all rice Yasothon	0.186	0.186	0.214	
Srisaket				
All rice	472.99	461.77	1,043.15	2.259
Hom Mali rice	432.43	422.07	948.99	2.248
Rasi Salai	33.94	33.09	84.79	2.563

(continued)

District/Province	Planted area ('000 ha)	Harvested area ('000 ha)	Output ('000 ton)	Yield (ton/ha)
Silalat	9.91	9.72	24.36	2.506
Sisaket_TKR all rice	43.85	42.81	109.14	2.550
%TKR to Hom Mali rice Sisaket	0.101	0.101	0.115	
%TKR to all rice Sisaket	0.093	0.093	0.105	
Surin				
All rice	493.24	474.61	1,145.71	2.414
Hom Mali rice	486.65	468.30	1,129.88	2.413
Chumpol Buri	46.38	44.35	111.98	2.525
Ta Tum	43.92	40.75	105.44	2.588
Surin_TKR all rice	90.30	85.10	217.42	2.555
%TKR to Hom Mali rice Surin	0.186	0.182	0.192	
%TKR to all rice Surin	0.183	0.179	0.190	
Maharasakham				
All rice	335.40	314.04	716.29	2.281
Hom Mali rice	167.90	157.76	360.00	2.282
Phayakaphum Pisai	44.46	29.96	58.04	1.938
Makasarakham_TKR all rice	44.46	29.96	0.00	1.938
%TKR to Hom Mali rice Mahasarakham	0.265	0.190	0.161	
%TKR to all rice Mahasarakham	0.133	0.095	0.081	
Roi Et				
All rice	485.73	454.62	1,080.71	2.377
Hom Mali rice	350.86	329.43	774.59	2.351
Kaset Wisai	65.96	61.46	145.97	2.375
Pratumra	26.79	17.53	41.08	2.344
Suwannabhumi	57.78	55.64	135.28	2.431
Phonsai	18.43	17.99	42.62	2.369
Nong Hee	9.54	9.53	23.46	2.463
Roi Et_TKR all rice	178.50	162.15	388.41	2.395
%TKR to Hom Mali rice Roi Et	0.509	0.492	0.501	
%TKR to all rice Roi Et	0.367	0.357	0.359	
TKR all rice	395.73	357.02	866.93	2.395
%TKR to national Hom Mali rice	0.099	0.095	0.099	
%TKR to national all rice	0.043	0.041	0.036	

Source: Office of Agricultural Economics 2017
Note: Hom Mali rice production at district level is not available

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Organic PGI Camargue Rice in France

Lisa Gauvrit and Burkhard Schaer

Introduction

Organic rice currently represents 20% of rice production in Camargue. This sizeable percentage is closely linked to the historical tradition of producing rice in the delta, and has been fostered for environmental protection purposes, because of market driven strategies and corporate positioning as well. This chapter first explores the conditions which led to starting organic rice cultivation in Camargue. It then presents the current organization and governance of the supply chain. Lastly, sustainability is analysed through the Strength2Food project methodology.

Development of Organic Rice in Camargue: Between Market Strategies and Sustainability Concerns

A Perspective on Starting Producing Organic Rice in Camargue

Camargue, One of the Largest Mediterranean Delta Plains

Covering 178,000 hectares, Camargue is a French natural region located on the Mediterranean coast, in the departments of Bouches-du-Rhône and Gard, and formed by the delta of the Rhône (Fig. 1).

Camargue is a wetland hosting a remarkable diversity of animal and plant species. It is classified as a biosphere reserve and a regional natural park. For several centuries, it has been the subject of water control operations and hydraulic

L. Gauvrit (✉) · B. Schaer (✉)
Ecozept, Montpellier, France
e-mail: gauvrit@ecozept.com; schaer@ecozept.com

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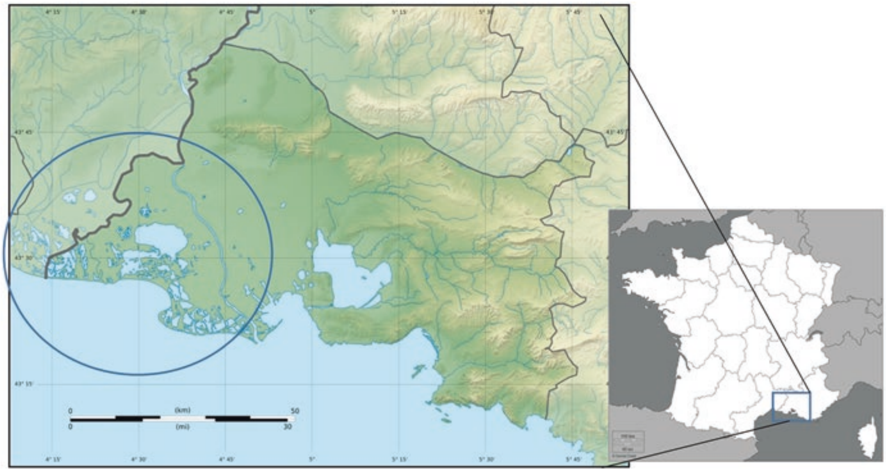

Fig. 1 Location of Camargue, department of Bouches du Rhône, Southern France. (Source: Wikipedia, author "Flappiefh")

installations, such that at the beginning of the twentieth century, the river Rhône was completely contained by its embankments (Mouret and Leclerc 2018).

The Mediterranean climate entails high temperatures and a drying wind over 200 days/year, which is favorable for rice growing in Camargue (Couderc 2013).

The Turbulent History of Rice Production in Camargue

Rice has been cultivated on a large scale in Camargue since the nineteenth century. The extent of rice-growing areas has fluctuated over time (Bassene et al. 2014), under the influence of the artificialization of the delta, market forces, ecological concerns and public policies.

During the first part of the twentieth century, rice cultivation in the delta increased rapidly from 1000 hectares in 1890 to more than 30,000 hectares in the early 1960s (Giraud 2008). The increase in rice cultivation in the area was a response to the salinization, and ensuing sterilisation, of the soils in the basin of the river Rhône. The latter were brought about by the extensive completion of dykes along the river in the mid-nineteenth century which was also instrumental to preventing the previously regular flooding of these farming-intensive areas by the river. Rice was introduced and required the flooding of rice fields, in crop rotation, by means of pumping and channelling, with controlled volumes of freshwater. Hence, rice cultivation prevented further salinization of the soil and desertification of the area (Mouret and Leclerc 2018). Moreover, after the Second World War, farm subsidies under the Marshall Plan substantially boosted rice cultivation.

Nevertheless, the creation of the precursor to the EU single market in the 1960s introduced sharp competition with other EU rice producing regions and particularly with Italy, which had very competitive production costs. In the 1980s, economic conditions were so unfavourable for French rice and the production area fell to less than 5000 hectares. In the absence of flooding periods, the serious problem of salinization of soils and ponds reappeared in Camargue. The dramatically lowered yields in all crop productions threatened the economy of the area and dramatically disrupted the ecological balance of the region (Delmotte 2012).

In response to this crisis, the French government launched a recovery plan. This included setting up a technical institute (the Centre Français du Riz – French Rice Center), incentives for better production practices (water management, fertilization and plant protection) and subsidies for the rehabilitation of infrastructures. This plan was effective in relaunching rice production, which reached 21,000 hectares in the early 2010s.

However, in 2013 the decoupling of subsidies from rice production again led to a downturn and drove rice areas down to 15,000 hectares in 2017. On the remaining 5000 hectares, rice was replaced by other crops, including vegetables such as tomato and fruits with intensive cropping systems, which are raising the concerns of the environmental protection organizations.

Finally, in reaction to producer activism and in response to ecological threats noted by local authorities, subsidies were again recoupled to rice in 2017. But the instability of the political context and long delays for subsidy payments to farmers lowered farmers' interest in rice cultivation in Camargue. It also revealed that a decline local rice production has wider implications on local employment: significant rice milling and trading facilities, which also deal with imported rice, could delocalize if local rice production is no longer sufficient to feed local processing plants, or fluctuates too much. According to the Rice Syndicate, the rice sector employs around 2000 people directly and indirectly in the region.

Differentiation Strategies and the Emergence of the *Riz de Camargue* PGI

The Sud Céréales cooperative has long been the only rice collector in the delta. In the 1980s, the creation of smaller operations for rice storage or milling marked the de-concentration of the sector, initiated by producers and local wholesalers. The aim was to diversify output and develop new market opportunities, in addition to the core big rice processors dominating the Camargue supply chain (Delmotte 2012; Quiédeville 2013).

Later in the 1990s, producers initiated collective action in order to differentiate Camargue rice on quality markets. The coordinated effort of producers in relation with upstream and downstream levels of the supply chain led to the application for and recognition of the PGI Camargue Rice in 2000.

In fact, annual domestic rice production in France amounts to between 80,000 and 100,000 tonnes, and consumption and industrial uses exceed 550,000 tonnes. The difference is imported mainly from Italy and Southeast Asian countries (Thailand, India, Pakistan, Myanmar, and Cambodia). The competitiveness of Camargue rice is low, as technical constraints are high (fewer pesticide molecules are authorized in France, than in other countries of the world, increasing weed resistance to herbicides, costly water management infrastructures). In a context of market competition and unstable political support to farmers, the PGI aims at emphasizing the link between rice production and the territory, and enhancing the strong natural and cultural image of Camargue and its attractiveness (Touzard 2018).

PGI production nowadays covers 90% of the hectares planted with rice and 95% of rice producers in Camargue. All stock keepers and processors in the sector are members of the PGI chain.

Sector operators report that the PGI has had significant impacts. It has made rice products better known and has sparked coordination along the supply chain in order for the product to meet strict specifications (e.g., varieties, technological attributes, purity of rice, conditioning, monitoring and controls). It also has provided complete traceability throughout the chain. It has encouraged upstream actors to move away from a model oriented to satisfying the standard needs of industrial processors, to embrace a more market and consumer oriented business model. This has included developing varieties which permit the segmentation of markets to make processors and rice brands distinguishable.

Nevertheless, only 20% of the final products are labelled as PGI. Although industrial processors, national rice brands and retailers' private labels may recognize that the PGI offers reliable quality control and traceability, they are not all interested in taking part in the system and prefer to retain their own branding and labelling strategies. Furthermore, the PGI rice does not enjoy a sizeable price premium on the market, as the price difference between PGI and non PGI rice is small (see section "Sustainability Assessment").

Determinants and Stakeholders of Organic Rice Development in the Delta

Organic production was first introduced by a group of pioneers who started organic rice cultivation under the recovery plan for rice in the delta in the 1980s (Mouret et al. 2004). Their main motivation was to adopt more environmentally friendly and healthier practices on farms.

In the early 1990s, as part of the differentiation strategies described above, a medium sized rice collector, SARL Thomas, together with producers, converted a significant part of its business to organic. SARL Thomas aimed to compete with larger companies by differentiating its position on a high added value market (Quiédeville 2013). It was followed by the main collector, Sud Céréales, which started to collect organic rice in response to the availability of the product from farmers. In 2003, Sud Céréales and SARL Thomas created a joint entity, Biosud, with the aim of creating and optimizing the supply chain for all their organic rice and baby food rice-based products. Other operators now also collect organic rice in response to market demand, but the revenues from organic rice are negligible as a share of their business turnover.

Sustainability concerns have grown in Camargue since the 2010s. Rice yields are no longer rising in conventional systems, in particular because of weed management issues (Marnotte and Thomas 2018). On the other hand, the impact of intensive rice systems is increasingly under scrutiny by nature conservationists, in particular on water quality in the delta. Rice production systems have improved their water management practices, but the use of pesticides directly impacts on wetlands, where water flows converge, and pollution becomes concentrated. That is the main reason for the interest in organic rice production and other low input rice systems on the part of territory and nature management institutions. The agronomy institute INRA has also made significant research efforts in organic rice through several projects since the 2000s, in order to create technical and scientific reference bases.

Evolution of Organic Rice Production in Camargue

Since 2013, organic production has doubled. Experts interviewed report that numerous factors have favoured this evolution (Table 1).

Firstly, market demand for organic rice is strong, at the national and European levels. In France, specialized organic brands report a growth of 10–15% per year for organic rice demand in volume terms, in line with the overall growth of the organic market.

Rice processors report that in comparison with imported organic rice, Camargue organic rice has a competitive advantage on the French and North-European markets. The high quality of the product and its reliable traceability are characteristics the consumer is willing to pay for. The fact that almost all organic producers are under the PGI scheme enhances the professional and reliable nature of the supply chain for downstream operators, according to organic stakeholders. But like conventional Camargue rice, only approximately 40% of organic rice bears the PGI label on the market.

Secondly, prices of organic crops, such as wheat, durum wheat, sunflower as well as rice in rotation in Camargue have reached levels which lead farmers to convert their land totally or partially to organic. Prices for organic crops in France have in

Table 1 Estimates of the evolution of organic rice production in Camargue from the early 1980s to 2017

Period	Estimated number of producers	Estimated area (ha)	Estimated share of total rice area (%)
1978–1993	5	100–200	<0.5
1993–2007	15	400–600	2.5
2013	30	1370	9
2016	48	2000	15
2017	48	3000	20

Source: Expert interviews; Mouret (2018); FranceAgriMer (2018) fact been high and stable since 2011, while conventional prices have sharply decreased since 2012–2013. The organic rice price is more than twice its conventional counterpart, and price differences were as high as +150% for organic wheat, +119% for organic corn, and +28% for organic sunflower in 2016 (FranceAgriMer 2017).

Another factor determining the success of organic rice production was the increasing involvement of the main stakeholders in organic rice processing. In 2015, SARL Thomas decided to become 100% organic. It also acquired a share of Biocamargue, another organic rice miller in the area, and invested in a plant processing rice into galettes (cakes).

Technical Specifications of Organic PGI Rice

Figure 2 presents the main operations in the PGI Riz de Camargue chain.

For organic PGI *Riz de Camargue*, organic certification introduces mandatory practices and standards at production and other levels of the chain. Table 2 shows key technical specifications for organic rice production and processing, and their implementation in Camargue.

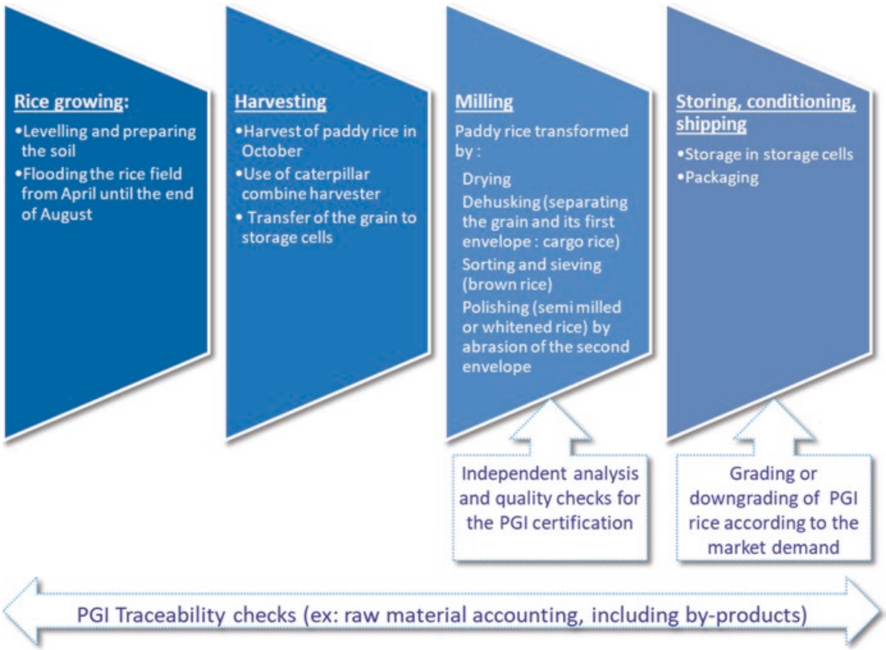

Fig. 2 Main operations in the production chain of PGI Camargue rice. (Source: Giraud (2008))

Table 2 Key technical specifications of organic PGI Camargue rice

Territory	
Geographical area	Camargue (PGI requirement).
Farming requirements and practices	
Seeds and varieties	GMO seeds are prohibited (organic requirement). Limited set of varieties are allowed. Common varieties for PGI: Selenio, Manobi, Cigalon for round grain, Ariete, Arelate or Thaibonnet for long grain. Common varieties for organic producers: Long A: Arelate (favourite of organic producers), Ariete, Albatros. Round rice: Selenio, Manobi, Cigalon. Red rice: Tam Tam.
Cropping practices	The PGI scheme publishes precise guidelines for cultivation practices. Organic production imposes further restrictions: The use of mineral fertilizers is forbidden. Organic rice producers use organic fertilizer: pellets composed mainly of dehydrated poultry manure, feather, bone, fish meal (Bayot 2018) that release nitrogen at different conditions and speed. Multi-annual crop rotation is an agronomic necessity in organic agriculture. Rice producers in Camargue mostly cultivate rice once in a 5 years rotation, including at least 2 years of alfalfa. Two consecutive years of rice is hard to manage because of the occurrence of weeds. The use of chemical pesticides is forbidden. Weed populations are mainly controlled through high density seeding, late preparation of soils, water management that minimizes dry periods, long rotations, more marginally hand weeding and duck breeding in rice fields.
Storage, processing and conditioning	
Type of preparation	Organic PGI Riz de Camargue can be brown, semi-milled, or white. Parboiled rice exists in conventional PGI but not in organic.
Storage	Organic rice must be stored separately from conventional rice. Systematic cleaning of contact materials is required handling organic and conventional rice.
Process	No chemical products can be used in storage and processing (organic requirement).
Quality requirements for the product	
Product specifications	PGI quality controls include criteria on: Rate of foreign material. Rate of broken grains, non-processed grains (% of paddy and cargo rice in the final product). Form and characteristics of grains: e.g., regularity, maturation, colour, humidity rate. Although the official organic supervision focuses on implementation and checks on accounting books, organic millers carry out further supplementary controls from field to intermediaries with producers, in order to guarantee the implementation of organic requirements. Soil and plant analysis are employed to search for pesticide residues, heavy metals, GMO, mycotoxins, and bacteria. Baby food supplementary requirements refer to the absence of arsenic in rice.
Traceability	Both PGI and organic chains require full traceability along the chain, tracing particularly raw materials, including weighing of by-products and dusts.
Governance	
Union or Committee	No specific organization was created by organic rice producers. Nevertheless, today they all are members of the PGI, managed and defended by the Syndicate of rice growers (Syndicat Français du Riz).

Description of the Organic Rice Value Chain in Camargue

Organic Rice Supply Chain in Camargue

Figure 3 shows the supply chain of organic rice in Camargue in 2017.

U1: Suppliers of Organic Inputs

There are two main upstream operators engaged in the supply of organic inputs for rice in Camargue, both privately owned and both mixed (i.e., conventional and organic). The first is closely involved in the development of the organic rice supply chain in Camargue, as it holds shares in Biosud (commercial structure described in parts 1.1.4 and 3.1.5), and is involved in the monitoring and control of organic production practices, on behalf of the main organic miller in Camargue. The second one also collects rice from different producers.

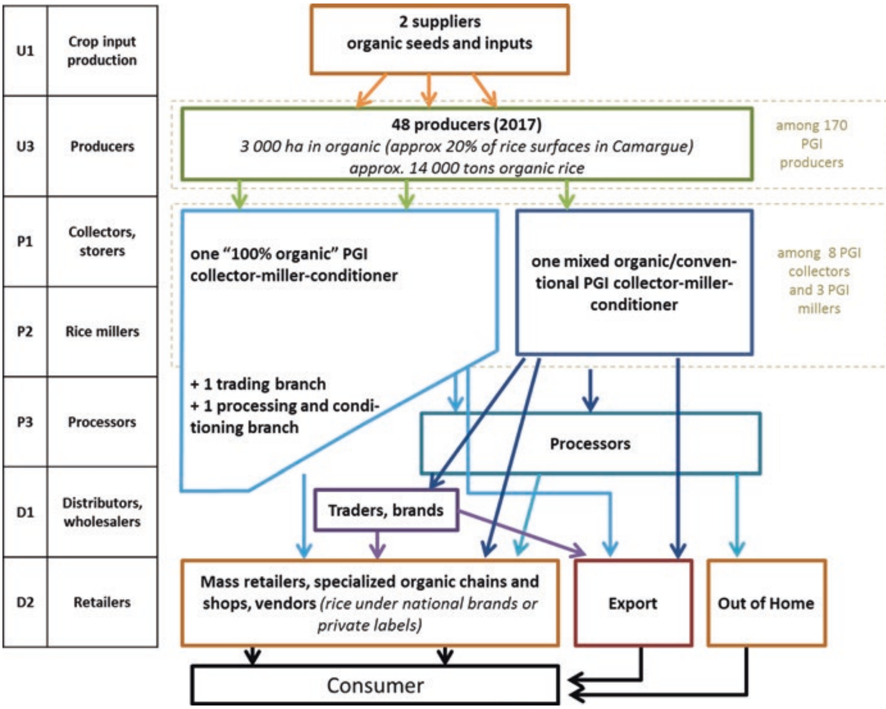

Fig. 3 Value chain of organic rice in Camargue, 2017. (Source: Ecozept-expert interviews, Mouret (2018); FranceAgriMer (2018))

U3: Organic Rice Farmers

There is a variety of rice farmers in Camargue: approximately one third are organic farmers with about 30% of their land in rice, and the rest are crop farmers who have partially or totally converted their land to organic. Across the farming sector in Camargue, the size of farms is very varied, ranging from less than 50 hectares to big farms of more than 300 hectares (Delmotte 2012). They devote between 20% and 100% of farmland to organic production.

Weed management is the main constraint faced by organic rice producers in Camargue. Unlike conventional producers, organic farmers cannot use chemicals for weed control. When they develop long rotations (ex: 1 year rice/1 year wheat/3 years alfalfa), organic rice yields are comparable to conventional ones (5–6 t/ha). But for a second consecutive year of rice in the rotation, yields fall sharply. It is thus very difficult to develop organic systems on lowlands, where it is necessary to grow rice frequently to prevent salinization.

Neither of these limitations have prevented organic rice from expanding rapidly in the past few years, and today output is approximately 14,000 tons and accounts for 20% of rice surfaces in Camargue.

P1 and P2: Rice Collectors, Storers and Millers

There are currently 8 PGI rice collectors in Camargue, including 1 cooperative. They collect other crops planted in the rotation: wheat, durum wheat, barley, sorghum, triticale, sunflower, as well as rice. Two of them are involved in organic rice collection and storage, and in 2018 a third one was due entering the organic sector.

These firms collect rice at the field gate, and sometimes harvest it. Very few farmers currently store rice on farm.

The main organic collector (more than 70% of organic rice volumes) is also storekeeper, miller and packer, and works exclusively with organic rice from Camargue. Currently, requirements of this enterprise go beyond the official organic certification requirements. It organizes supplementary technical visits, controls and plant analysis to appear trustworthy to the final consumer. Furthermore, 100% of its organic rice is also PGI. These strict requirements comprise a vector for technical exchange and progressive improvement in organic production methods, in a context where organic rice producers have largely been left to themselves improving cultural practices. Research programs led by INRA have also contributed to a better knowledge of organic rice systems in the past decade.

Organic rice storage and milling requires specific handling and know-how. For the storage of organic grains, for which the use of chemicals is prohibited, a process of cooling and a high level of grain cleaning are necessary, which requires accurate and reliable equipment. It also requires a specific organization of processes which foresee de-husking at the end of the milling process.

Moreover, organic millers deliver multiple finished rice categories in small volumes (e.g., semi-milled, white, scarified, red rice) and to high-requirements markets, such as baby food. This high segmentation requires systematic cleaning of the equipment after processing each category.

Yet, parboiling has not been applied to organic rice, pre-cooked organic rice from Camargue may be sold on the market in the near future because of the operation of a new organic miller.

P3: Conditioners and Processors

Organic rice (packed white/semi-complete/complete rice) consumed on the market is mainly milled in Camargue, under organic national brand labels or organic retailer private labels.

The main organic miller has developed a conditioning plant in Camargue capable of dealing with the big bags traded by one of its subsidiaries as well as the 250 g packs sold by its other subsidiary. Hence, the organic chain is more localized than the conventional one, for which the lion share of output is packed and labelled in other regions or countries by large industrial companies. The main milling factory in Arles closed 15 years ago (see local multiplier in section "Sustainability Assessment"). This is a crucial issue for conventional operators who would like to gain leadership in the last steps of the value chain.

A processing plant for organic rice belonging to the main organic miller in Camargue makes rice cakes.

Other processors source their rice in Camargue. These include major European or multinational companies in the baby food market, French and German organic national brands that incorporate organic rice in their recipes and big industrial processing groups such as Soufflet and Panzani/Ebro.

D1 and D2: Wholesale and Retail

Wholesale of organic rice is mainly carried out by specialized organic wholesalers, when the rice is not directly purchased by conventional retailers and organic retail chains. One major organic French wholesaler is involved in the value chain of organic Camargue rice: it co-owns the processing facility for rice packaging and cake processing with the Camargue organic miller.

Direct sale at farm level (final products) remains rare, although it is more frequent in the organic than in conventional sector (Giraud 2008; interview with French Rice Syndicate member).

Consumers

The main developments on the European consumer rice market in recent decades have been the use of technological specifications for cooking and the growth of aromatic rice (Basmati, Thai). Sector operators report that organic consumers are motivated by the natural nutritional quality of rice. This explains why organic rice is more diversified (semi-refined, wholegrain, scarified, black, pink…) than the conventional one, which is mainly white.

The PGI label is in proportion more present on organic rice products (40% of consumption rice volumes sold) than on conventional products (20%).

For specialized organic brands and retailers, this double labelling strategy makes it possible to highlight the transparency of the chain in terms of origin and the ethics of the enterprise working in an area of natural beauty. A differentiation strategy based on quality is not particularly important for processors while the first concern of organic firms is to remain credible in maintaining the organic certification.

Governance

Organic producers are not represented in a specific organization. The majority are only partially converted to organic, and many have converted in the last 5 years. Almost all however belong to the *Syndicat des Riziculteurs de France* (French rice producers syndicate), which is responsible for protecting the interests and promoting the PGI label. The Ruling Council of the PGI is composed of 40 members, including 30 rice growers. Traders, processors and millers are also members (Giraud 2008; interview with the president of the syndicate). As the organization managing the PGI, the Syndicate is in charge of enforcing the code of practice. It provides the link with local, national and European institutions, and advocates on the crucial issues affecting rice growers. It also sets and implements the communication strategy of the PGI. It is possible that the near future will see coordination with other quality schemes in the region, which would strengthen networks and promotional efforts. The contribution to the PGI organization amounts to 0.40 euros per ton of rice.

The PGI scheme gives rice growers the ability to act and decide as a group, in a sector that is dominated by the market power of a few downstream firms in the product value chain (Giraud 2008). However, rice growers continue to rely mainly on the traditional marketing channel.

In the organic chain, the number of firms is even smaller, and has fallen from 4 collectors in the 2000s to only 2 today. The group SARL Thomas – Sud Céréales – Biosud is the agent exerting the most market power in the chain. It is present both downstream and upstream, as input provider to organic farmers and as collector, miller, processor and trader. This group has played a decisive role in boosting organic rice production in Camargue, and developing commercial opportunities in recent years. It also however represents a high level of vertical integration which could limit the bargaining power of producers in the long run (See bargaining power in section "Sustainability Assessment").

Sustainability Assessment

Sustainability assessment of organic PGI rice was implemented according to the specific methodology of Strength2Food (Bellassen et al. 2016). PGI production nowadays covers 90% of the hectares planted with rice and 95% of rice producers in Camargue. But in terms of value chain, only 20% of rice volumes are sold as PGI. Almost 100% organic rice in Camargue is also PGI certified.

As a consequence, the indicators were elaborated using the whole conventional Camargue rice value chain, as a reference for the economic and the social dimensions.

For environmental indicators, the analysis was based on a comparison between the organic PGI and the non-organic PGI rice chain (Fig. 4).

Economic Indicators

Organic Camargue rice benefits from a price premium all along the value chain. The premium is stable from farmers to retailers, at around 130%. It in fact appears to be higher at processing level (158%), but it was not possible to collect information on costs at this stage allowing for the calculation of operating margins or profits. At the processing stage (cleaning and milling), yields are lower for organic rice, but no precise data could be collected as it is considered strategic data by processors. Despite these lower yields and the small size of processing units (and thus higher costs), it is likely that profitability remains similar to the conventional chain at the processing level. At the rice field level, costs are similar in absolute terms, for both intermediate consumption and wages. Considering higher prices and considering slightly higher subsidies for organic rice, profitability is thus higher at the crop system level: gross operating margin (only for rice production) represents 91% of turnover for organic farms versus 80% for conventional ones. Moreover, organic rice production is less dependant on subisidies than conventional systems.

These results at rice field level may nevertheless not be applicable to the whole farm: if all crops of the rotation are included, price premiums may be lower for organic vs conventional farms than for the same comparison for the sole rice production. This is because rice is only counted every 4–5 years in organic farms against every 1–3 years in conventional ones. Organic alfalfa covers 2–3 years in the rotation and provides a low margin. Quiédeville (2013) nevertheless confirms that the advantage of the organic system remains slightly positive at rotation level. Since 2013, the profitability of the other crops in organic rotations has increased sharply and output like organic wheat and sunflower have fetched high prices. This is likely

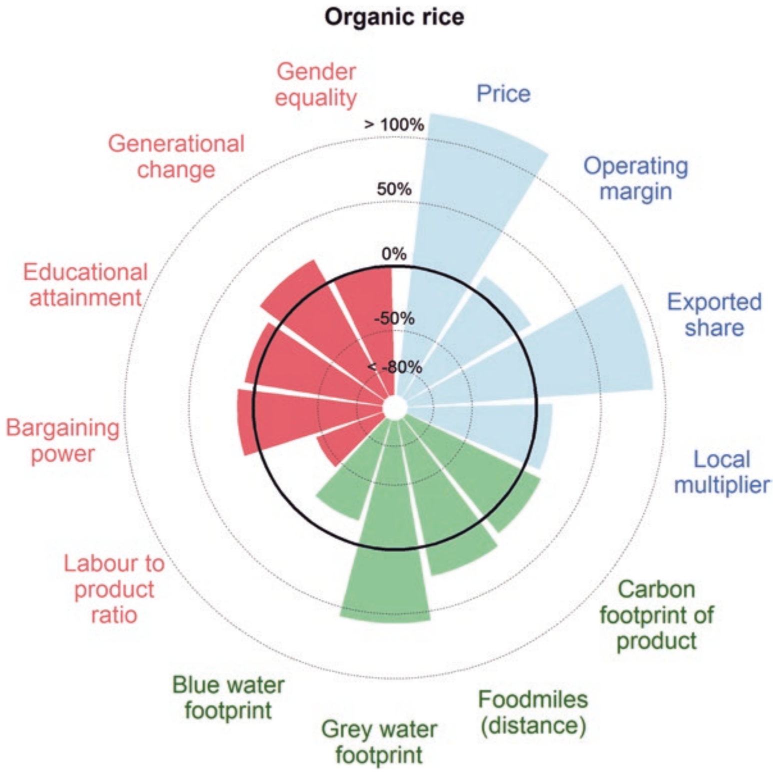

Fig. 4 Sustainability performance of organic rice (supply chain averages). (Each indicator is expressed as the difference between organic rice and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower)). Data sources for each variable are transparently documented in the data repository (https://www2.dijon.inra.fr/cesaer/informations/sustainability-indicators/)

to enhance organic comparative profitability at rotation level and to a certain extent explains the high number of organic conversions in the past years.

Concerning exports, organic rice accounts for a higher share of export to Europe, twice the conventional one.

The local multiplier effect of Organic PGI Camargue rice is 12% higher than its reference product: each euro of turnover for Organic PGI Camargue rice generates €1.29 of re-spending in the same area versus €1.04 for the reference product. (Area of reference in the LM3 calculation: Gard and Bouches du Rhône departments). The main driver of this outcome is the location of the rice farms: for the organic product all the farms are located within the local area; while conventional millers source only 65% of their rice in the same administrative region. Without local rice farms, the local multiplier would be 34% lower for organic rice and 25% lower for the conventional product. The second main driver is the location of suppliers of “other inputs and services": without local suppliers, the local multiplier would be lower by 14% for organic rice, and lower by 18% for conventional rice.

Environmental Indicators

Carbon Footprint

The carbon footprint of organic rice is 16% lower than its reference product (0.86 and 1.03 tCO2e/ton of processed rice respectively). The bulk of the difference is explained by the lower use of fertilizer in organic rice, and in particular the absence of mineral fertilizers, which are prohibited by the technical specifications. Both products are in the lower part of the literature range – 0.66 to 5.69 tCO2e/ton (Clune et al. 2017; Odegard et al. 2015) – which is explained by flooding which is only intermittent in Camargue and by the crop-specific estimate of N2O emissions used. The rice-specific N2O emission factor is in fact much lower than the default emission factor used in most LCAs. Hokazono and Hayashi (2012) find a 33% higher carbon footprint for organic rice in Japan, explained by much higher methane emissions from the flooding techniques, which weighs more on the lower yielding organic rice. Research programs are in fact underway to refine the understanding of methane emissions linked with the specific rice production system in the Camargue Delta. Because conventional and organic systems are based on completely different rotations and lead to different impacts at regional scale, further investigation on an extended comparison with the whole crop cycle would also be useful.

Food Miles

For food miles, the organic supply chain was compared to the conventional rice chain of Camargue, France, from U3 to D2. Over the entire supply chain, from rice production units to distribution units (U3–D2), organic rice from Camargue travels 20% shorter distances (1400 vs 1700 km) and releases 20% fewer emissions (140 vs 170 kg CO2 eq) than conventional rice. This difference is mainly driven by the difference in the supply chain organization on the domestic market. Organic rice from Camargue is milled locally, whereas conventional rice is milled farther away. However, the shorter distances traveled by organic rice on the domestic market are partly offset by the larger share of exports (20% against 12% for the conventional reference product), since export markets imply longer distances than the domestic market. Similar trends explain the differential in emissions generated by transportation. The distribution level (P2–D2) concentrates most of the kilometers embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 95%).

Water Footprint

Agriculture accounts for more than 99% of total water footprint of Camargue rice, and processing only a negligible part. Organic rice has a higher water footprint than conventional rice, which is mainly because of the difference in yield between the two systems.

Most of the blue water footprint – surface and groundwater use – in the indicator is clearly due to the great amount of water that rice requires (Fig. 5). The higher value shown by the organic chain is mainly due to the difference in yield. Irrigation is equivalent or slightly lower for organic rice on a per hectare basis and water consumed to produce fertilizers, pesticides, fuel etc. is also greater for the reference product. These differences do not however compensate for the difference in yield.

The grey water footprint – water pollution by nitrates – is much lower in the organic chain than in the conventional one. More nitrogen is in fact applied in the conventional reference product: organic farmers use 50 kg/ha of organic nitrogen whereas their conventional counterparts use of 150 kg/ha of mineral nitrogen.

The green water footprint – rainwater use – is higher for the organic chain per tonne of product. Provided meteorological data and crop parameters are similar, the only factor that contributes to increasing the green water footprint for the organic chain is the lower yield.

The water footprint indicator is extremely important in rice production, and the impact of conventional intensive rice systems on water quality in the Camargue Delta is increasingly subject to scrutiny by nature conservationists. Expert observers note that rice production systems have significantly improved their practices regarding water management in volume, but the use of pesticides – not accounted for in the water footprint estimated here – directly impacts natural wetlands where water flows converge and where a high concentration of pollution is measured.

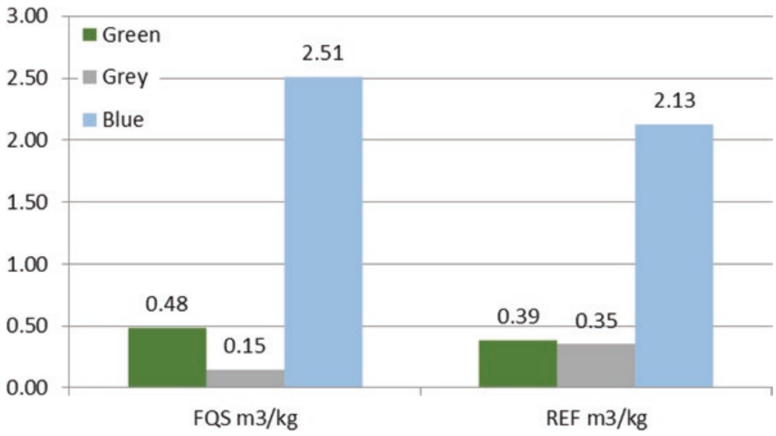

Fig. 5 Water footprint of organic rice in m3 per kg of paddy

In short, organic rice requires as much rain, surface water and groundwater as conventional rice per hectare, but as it yields less, it has a higher consumption of these water resources per kilogram of product. Nitrate impact is significantly lower in organic production per hectare as it is per kilogram. The impact of pesticides is not calculated, but pesticides are not used in organic farming.

Social Indicators

Employment and Educational Attainment

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is lower for organic rice than for its non-organic reference product (conventional rice in Camargue). At farm level, it takes 17 hours of work to produce 1 tonne of rice, and the reference product requires 25 hours. The difference indicates that organic rice production generates less employment than the reference system.

The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is slighty higher on organic PGI Camargue rice than on conventional one. Productivity levels are much higher at the processing level, with a relative difference of 37% in favour of organic rice. These differences are mostly due to the price of organic rice, which compensates for the lower yields at production level.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital, and greater educational achievement as an important outcome. The education attainment indicator, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The profiles of education levels are almost identical between operators in organic rice and in conventional rice production. The level of education is dominated by primary and secondary school certificates (60–69%).

Firms interviewed, both organic and conventional millers, underline the challenges related to education and training of employees in the sector. Very few courses focussing on rice exist in France, as it represents a small sector at national level, and most employees are trained inside the firms. Many firms tackle the challenge of intergenerational transmission of knowledge by establishing specific intern programs such as mentoring and internal training.

Bargaining Power

The sustainability assessment also explored bargaining power along the chain. The organic chain is dominated by the two levels of input suppliers (U1) and storers/millers (P1), which concentrate almost all the market power. This domination is reinforced by the fact that one of the actors at the U1 level also operates at P1 level.

Furthermore, without considering the oligopoly U1 and P1, the high bargaining power scores obtained at all levels suggest that bargaining power positions at all levels are strong. This implies that changes in the structure of competition at U1 and P1 levels would not necessarily translate into a significant evolution in the distribution of bargaining power along the supply chain.

Apart from the structure of competition, bargaining power scores show that the institutional context, i.e. presence of supply-chain specific unions or other professional associations, plays a key role in explaining the bargaining power of each level in both chains. Factors linked to transaction costs, in terms of both flexibility and asset specificity, make a significant contribution at the U1 and U3 levels of the organic chain, with values of 0.67 and 0.78 respectively. The contribution of transaction cost related variables is less important at the P1 level of the organic chain. By way of contrast, the contribution of this category of variables is relatively weak for the reference product, except at the U3 level (0.67). Similar conclusions apply for the reference product chain, although the domination of leading actors at the U1 and P1 levels is less marked than for the organic chain.

Generational Change and Gender Equality

As regards generational change and gender equality, it was not possible to calculate separate values for the farming stage (U3) of organic and conventional rice. But because many farms either produce both types of output or have converted from conventional to organic recently, the value of the indicator is assumed to be equal, or not significantly different, across the supply chains of organic and conventional rice. However, this should be understood as the outcome of the quantitative assessement, which was not supported by the qualitative evidence provided by the experts interviewed during the data collection process.

At the farming stage, the values of the indicators suggest that this stage of the supply chains suffers from a limited involvement of young workers compared to older ones. This is a widey recognised issue that is being addressed through the training of interns and the promotion of sponsorship programs, which are aimed at overcoming the lack of formal training provided by the education system. Because this transmission of knowledge is de-facto a form of "on-the-job-training", it still requires the involvement of experienced workers in large numbers. The value of the gender equality indicator suggests that rice farming is characterized by limited entrepreneurial and employment opportunities for females, which keeps the gender equality indicator low.

At the processing stage, the organic rice supply chain appears to be more sustainable than the conventional chain on the basis of both indicators. There is higher employment of the 15–35 year age range in the organic chain than the 45–65 range. Gender discrimination also appears to be much lower in the organic chain, with equal employment of males and females as well as higher percentages of women completing secondary education. At the processing level, women are overrepresented in office jobs, although their involvement in operational activities has increased over the years. In turn, the gender equality indicator for the processing stage highlights a much higher social sustainability of organic rice than the conventional one.

At the suppry chain level, organic PGI Camargue rice is more sustainable than the conventional one according to the generational change indicator while no sizeable difference is calculated acros the chains, employing the gender equality indicator.

Discussion

The organic rice chain in Camargue is currently characterized by buoyant market demand and several dynamics on the supply side. The sustainability assessment made according to the Strength2Food project methodology suggests that the quality production is more sustainable than the reference product. It reveals a positive environmental balance at rice field level, better local integration of the chain and the involvement of organic companies for social improvement on the territory.

To complete discussion of these results, however, other aspects need to be taken into consideration.

Regarding economic performance, it was not possible to closely investigate value distribution along the rice chain in this research. Touzard (2018) notes the variability of value distribution in the organic chain in the commercial channel, in relation to the high margins earned by retailers on organic products. Competition with low cost imported organic rice and price pressure are likely to exacerbate this issue in the future.

Furthermore, organic producers at present have no coordination body able to represent their interests in the organic value chain, or more generally in local affairs, which is a potential weakness. A sound relationship with the rice syndicate and the PGI union will also need to be built, as organic rice appears to be considered as a pure competitor with other rice quality schemes on the conventional retail market.

Regarding the future development of organic rice systems in Camargue and their environmental impacts, one major issue is related to the longer rotations that are needed, which would lead to a reduction of total rice surfaces if the organic rice system developed significantly in the delta. Salinization problems would in this case require a high level of territorial and professional management (Delmotte et al. 2013) and would necessitate technical improvements for weed control in particular.

The Camargue organic rice sector therefore faces challenges at different levels, and there is a need for innovations in governance at both value chain and territorial levels as well as technical solutions.

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Part III
Fruits and Vegetables

Organic Olive Oil in Croatia

Marina Tomić Maksan and Ružica Brečić

Characteristics of the 4 PDO for Olive Oil in Croatia

PDOs and Geographical Areas

PDO olive oil in Croatia is an extra virgin olive oil obtained mechanically from the Croatian olive fruit. There are 4 PDO olive oils in Croatia: Krk, Cres, Šolta and Korčula. In this monograph we are going to present all 4 Croatian PDO olive oils.

The island of Krk is located in the center of the Kvarner, which is part of the northern Adriatic. All stages of oil production take place exclusively in the area of the island of Krk and the smaller islands located within the administrative boundaries of the local self-government units: the town of Krk and the municipalities of Baška, Vrbnik, Punat, Dobrinj, Malinska-Dubašnica and Omišalj (Figs. 1 and 2).

The area of production of Šolta olive oil includes the area of the island of Šolta and the seven small islands: Polebrnjak, Saskin, Balkun, Kamik, Šarac, Grmej and Stipanska, which coincides with the area of Šolta. Figure 3 shows the area where Šolta olive oil is produced.

The area of Korčula olive oil production covers the entire island of Korčula with cadastral communes of Vela Luka, Blato, Smokvica, Čara, Račišće, Pupnat, Žrnovo, Korčula and Lumbarda. Figure 4 shows the map of the geographical area of production of Korčula olive oil.

M. T. Maksan (✉)
University of Zagreb, Faculty of Agriculture, Zagreb, Croatia
e-mail: matomic@agr.hr

R. Brečić
University of Zagreb, Faculty of Economics & Business, Zagreb, Croatia

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Fig. 1 Geographical area of Krk olive oil production

Fig. 2 Geographical area of Cres Island olive oil production

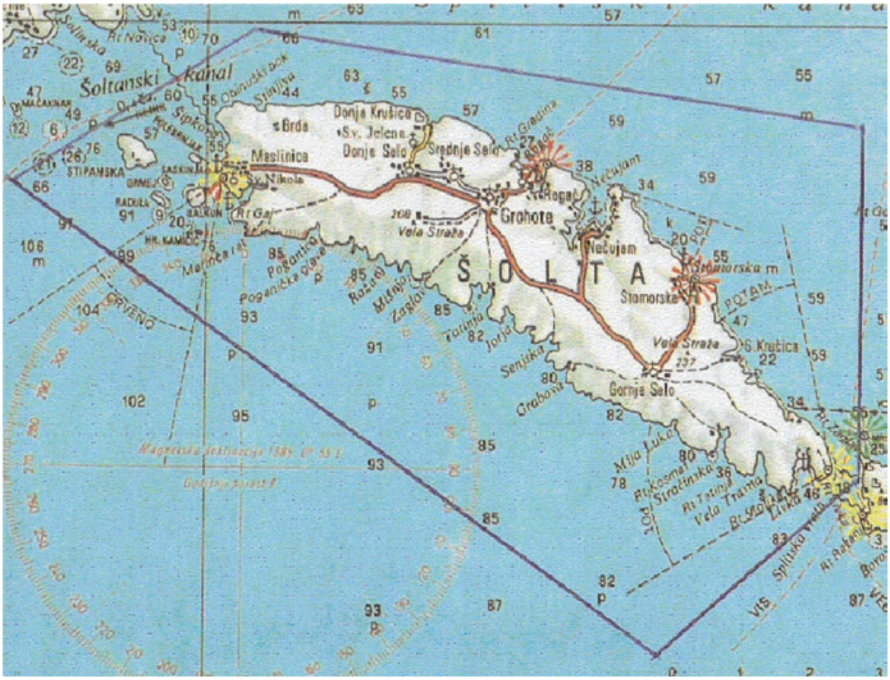


Fig. 3 Geographical area of Šolta Island olive oil production. (Source: Ministry of Agriculture)

Fig. 4 Geographical area of Korčula Island olive oil production. (Source: http://www.korcula-experts.com/)

Varieties of Olives in the Different PDOs

Krk PDO olive oil is produced from the following autochthonous varieties of olives: Debela, Naška, Rošulja and Slatka, which individually or together must make up at least 80% of the product (Table 1). For the production of Krk olive oil, other varieties from the defined geographical area may be used, but not more than 20%. This 20% does not reduce product quality that much.

Table 1 Varieties of olives in 4 Croatian PDO olive oils

	Krk olive oil	% of olive varieties	Cres olive oil	% of olive varieties	Šolta olive oil	% of olive varieties	Korčula olive oil	% of olive varieties
Olive varieties	Debela, Naška, Rošulja and Slatka	≥80	Slivnjača and Plominka	≥90	Levantinka and Oblica	≥95	Lastovka and Drobnica	≥80

Cres PDO olive oil is extra virgin and it is produced from autochthonous varieties Slivnjača and Plominka, which are grown individually or together and make up a minimum of 90% of the product (Table 1).

Šolta PDO olive oil is produced from the fruits of an autochthonous olive variety Levantinka, which must make up at least 50% of the proportion of olives. The other variety that may produce Šolta olive oil is Oblica. The proportion of Levantinka and Oblica together must be at least 95%. The remaining 5% may come from other varieties grown in the Šolta which do not affect the final properties of the product (Table 1).

Korčula PDO olive oil is produced from the autochthonous varieties Lastovka and Drobnica, which individually or in combination, must make up at least 80% of the total (Table 1).

Description of the Autochthonous Olive Varieties

Debela (Synonyms: Lošinjka, Krčka krupna)

The fruit is large and very fleshy. The average weight of the fruit is 4.6 g. The amount of oil in the fruit can be up to 20%. This variety is resistant to wind, drought and low temperatures and it is used for production of olive oil although it can also be used for producing table olives.

Naška (Synonim Drobnica)

The fruit is round and elongated, with an average weight of 2 g. It is used for production of olive oil, quantity of oil in fruits reaches up to 19%. This variety is susceptible to cold and wind.

Rošulja

The fruit is medium in size, round, with an average weight of 3.2 g. Average percentage of oil in fruit is 19.4%. It is sensitive to wind.

Slatka (Synonim Plominka)

The fruit is fleshy and tapered, with an average weight of 2.8 g. The amount of oil in the fruit can be up to 16%. It grows abundantly, and the fruits are used for olive oil and for food. It is resistant to frost and cold.

Slivnjača

Slivnjača tree is lower than the Plominka tree, and its branches are short, thick, upright and strong. The leaf is short and wide, dark-green on the top and a shiny, light-green on the underside. The petiole of the leaf is medium long. The fruit is oval shaped, large with a small spike on top, the mature fruits are purple and reddish. The flesh is dense and purple. The blade is elongated and twisted on both sides, reddish-yellow with darker horns. Petiole is long and thin. The hollow of the petiole is poorly expressed, and the navel is slightly raised.

Levantinka

An olive variety which develops a thickly branched tree with spherical crown. The leaf is large, long and wide, the top surface of the leaf is intensely green, and the underside is silvery. Levantinka is self-fertilizing, with a regular and abundant yield, as each grove usually holds three to five fruit trees. The fruit is medium in size, long with a small tip, and has an average weight of 4 g. The amount of oil in the fruit usually ranges from 16% to 22%.

Oblica

Oblica is part of a botanical group of olives with mixed characteristics, the fruit is used for olive oil production and for preserved olives. The fruit is a round and medium-sized with a thick skin; at full maturity the skin is easily separated from the solid, dark colored flesh. The blade average is 0.8 g, ellipsoidal, elongated and asymmetric. The amount of oil in the fruit usually ranges from 17% to 22%.

Lastovka

Lastovka develops a moderately vigorous tree. The fruit is long, branched and symmetrical and is used exclusively for oil production. The flesh of the fruit is red and medium solid. The blade is sickle shaped, slightly bent, and rounded with a short spike. Lastovka is the most populous variety of the Island of Korčula with an oil content of 16.40–24% in fresh fruit. It is extremely resistant to long-lasting water shortages.

Technical Specifications

Table 2 describes the key technical specifications for the four PDO olive oils in Croatia.

Physical-chemical properties of the four Croatian PDO olive oils are presented in Table 3 (Figs. 5, 6, and 7).

Šolta olive oil has no symbol as it is not mandatory.

PDO Olive Oil Value Chain

This section describes the PDO olive oil value chain. Note that most Croatian olive oil producers are small-scale producers (up to 150 olive trees) so there is no significant difference in the value chain of PDO olive oil and conventional olive oil. It is a short value chain, where most of the olive producers are also retailers, while they use oil refineries only for olive processing. Given the fact that Croatia had about 78,049,852 overnight stays in 2016, tourism is the most important sales channel for olive oil producers. Therefore, PDO olive oil producers sell their olive oil directly to the final consumer through tourism.

Value Chain and its Components

Figure 8 shows how the PDO olive oil value chain in Croatia is organized. We will shortly describe each type of stakeholder in the PDO olive oil value chain.

U1: Olive Seedlings

Producers of PDO olive oil need olive seedlings. According to the results of the survey (interviews with PDO olive oil producers and experts from the Zagreb Olive Institute), the biggest suppliers of olive seedlings is nursery Garden Prud in Metković (but there are also many other nursery gardens), where most olive producers purchase olive seedlings. Demand for olive seedlings is mainly for the following varieties: Lastovka, Istrian Bjelica, Levantinka, Drobnica, Leccino and Pendolino.

U2: Producers of Other Inputs (Fertilizers and Pesticides)

There are more than 20 different olive tree pathogens, most of which are fungal. It is important to emphasize that most producers buy fertilizers from the domestic state-owned company Petrokemija d.d. and pesticides from the private company Chromos Agro d.o.o.

Table 2 Technical specifications for the four PDO olive oils in Croatia

Territory				
	Krk olive oil	**Cres olive oil**	**Šolta olive oil**	**Korčula olive oil**
Olive grove/ olives production	Maximum planting density in the olive groves is up to 250 olives per hectare.	Maximum planting density in the olive groves is up to 280 olives per hectare.	Maximum planting density in the olive groves is up to 250 olives per hectare.	
	Soil preparation and olive planting is carried out manually or with easy-to-carry equipment.			
Harvest	Olives grown for PDO olive oil must be harvested directly from the tree. Most commonly, this is done manually, or with use of light transmitting machines, and the net or canvas into which the pickled olives fall. Olives may not be collected from the ground. Olive harvesting must end by December 15th.	Olives grown for PDO olive oil must be harvested directly from the tree. Producers can use light transmitting machines, and the net or canvas into which the pickled olives fall. Olive harvesting must end by January 31st.	Olive harvesting takes place in the period October 15th to December 1st.	Olives grown for PDO olive oil must be harvested directly from the tree. Most commonly, this is done manually, and the use of light transmitting machines is permitted, and the net or canvas into which the pickled olives fall. Olives may not be collected from the ground. Olive harvesting takes place in the period December 1st to February 1st.

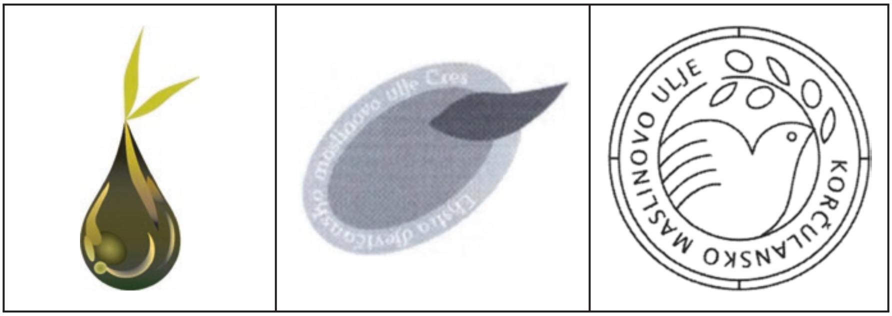
(continued)

Table 2 (continued)

Territory				
Olive processing	Mechanical and physical processes for washing, centrifuging, decanting and/or filtration may be used for the extraction of PDO olive oil. During the oil extraction process, no additives other than water are permitted, and the temperature of the olive dough and oil during processing must be lower than 27 °C. Olive oil processing must be done within 48 hours of harvesting.	The olives must be washed with cold water before processing. Olive oil processing must be done within 48 hours of harvesting.	Olive oil processing must be done within 48 hours after harvesting. Olives are kept in baskets or thin layers (10–15 cm) on the ground. It is forbidden to use mesh bags or to keep olives in water or in the sea.	The olives must be washed with cold water before processing. During the oil extraction process, the temperature of the olive dough and the oil during processing must be lower than 27 °C.
Olive oil storage	After processing, the oil must be stored in sealed containers made of materials which are inert to the oil. The containers in which the PDO olive oil is stored must be specially marked. If there is more than one container at a single location, every container must be marked with the appropriate ordinal number. The storing warehouse must be dry and aerated, and the temperature in the warehouse must be from 12 to 20 °C. During storage, the oil must not be exposed to light. Within 1 month from olive processing, the oil is separated from the precipitate. Oil clarification can also be carried out by filtration. Overcrowding and transportation may adversely affect the physical-chemical and sensory properties of PDO olive oil. Before packaging the PDO olive oil, tests must be carried out to check if the oil has all the characteristics required in the code of specifications. PDO olive oil may be put on the market if the material which is in contact with the oil is inert with respect to the oil.			
Packaging	Krk olive oil may be stored in dark packs of 100, 250, 500, 750 and 1000 mL.	Cres, Šolta and Korčula olive oil may be stored in dark packs of a max volume of 1 L.		
	The packaging of olive oil must be done within the relevant geographic area of the suited specification. This greatly facilitates traceability, which would otherwise be more difficult to guarantee. Quality is compromised by transportation. Olive oil is sensitive to external influences (light, temperature, air) and any unnecessary transportation and packaging outside the production area negatively affects its physical-chemical and organoleptic properties. It is not permitted to use terms other than those mentioned in the specifications with the name PDO olive oil. Other names, companies, trademarks may be used only if they do not mislead consumers. Using the names of farms, special locations, place names, and other specific names is only allowed if the product is obtained solely from olive trees picked in olive groves that are part of the farm, or olive groves that are on the area defined in the specification.			

Table 3 Physical-chemical properties of 4 Croatian PDO olive oils

	Krk olive oil	Cres olive oil	Šolta olive oil	Korčula olive oil
	%			
Free fatty acid content	≤0.50	≤0.50	≤0.70	≤0.60
Peroxide number	≤8.0 mmol O_2/kg	≤8.0 mmol O_2/kg	≤7.0 mmol O_2/kg	≤6.0 mmol O_2/kg
Specific extinction in UV	K270 ≤ 0.20 K232 ≤ 2.25	K270 ≤ 0.20 K232 ≤ 2.20	K270 ≤ 0.220 K232 ≤ 2.50	K270 ≤ 0.22 K232 ≤ 2.50
Organoleptic properties	Smell of fresh olive	Smell of fresh olive	Smell of fresh olive	Smell of fresh olive
Median fruitiness	n/a	n/a	n/a	≥2.50
Taste	Taste of healthy and fresh olive	Taste of healthy and fresh olive	Taste of healthy and fresh olive	Taste of healthy and fresh olive
Median fruitiness	≥1	≥2	n/a	≥2.5
Bitterness (median)	≥2	≥2	≥1	≥3
Piquancy (median)	≥2	≥2	≥1	≥3



Figs. 5, 6, and 7 (From left to right) present the symbol of Krk olive oil, Cres olive oil and Korčula olive oil, respectively

Fungal diseases include tinder fungus (*Fomes igniarius*), Fumagina (*Capnodium eleaphilum*), olive scab (*Gloeosporium olivarum*), mosses and lichens, Bird's eye spot or olive leaf spot, *Cercospora cladosporioides* and *Pseudomonas savastanoi*. Most common phytophagus are olive twige midge (*Clinodiplosis oleisuga*), black scale (*Saissetia oleae*), olive bark beetle (*Phloeotribus scarabeoides*), *Phloeotrips oleae Liothrips oleae*, olive borer (*Hylesinus oleiperda*), olive fruit fly (*Bactrocera oleae*), olive weevil (*Otiorrynchus cribricollis*), *Coenorrhychus cribripennis* and olive moth (*Prays oleae*) (Del Gabro 2015).

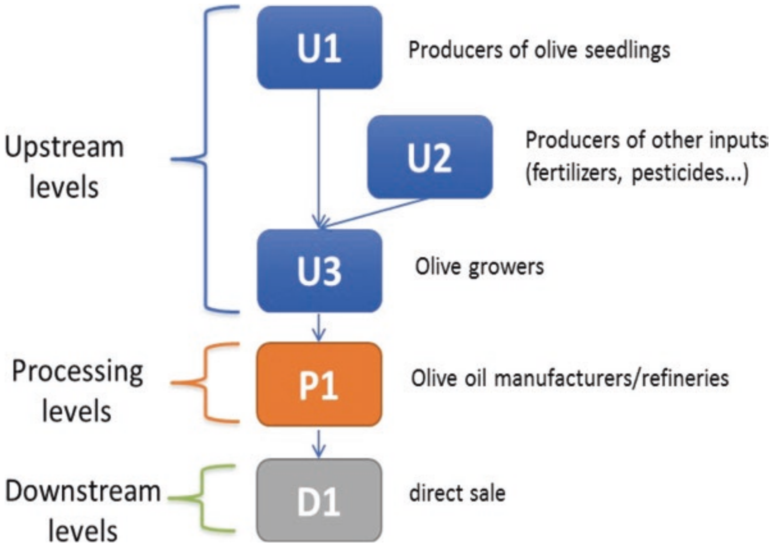


Fig. 8 The PDO olive oil value chain

However, according to the results of a survey conducted with olive growers and experts from the Faculty of Agriculture in Zagreb, the most common diseases of olive trees are: Bird's eye spot, olive fruit fly and olive moth. Bird's eye spot (*Spilocaea oleaginea Cast.*) is the most widespread disease that occurs in Croatian olive groves and against which protection measures must be enforced.

The *Prays oleae* is one of the most important pests not only Croatia but globally. Damage can sometimes be great, but on average, 20–30% of annual damage to the olive yield is made by *Prays oleae*. The olive fruit fly is also an important olive pest in Croatia.

U3: Olive Growers

According to the data of the Croatian Chamber of Agriculture, 40,000 households are involved in olive growing in Croatia, 17 of these produce olive oil with a designation of origin. It is important to notice that most conventional and PDO olive producers have small production areas. The average family farm in Croatia has 100–150 olive trees, which produce 100–150 L of oil (Mesić et al. 2015). Strict production regulations for PDO olive oil compared to conventional olive oil may be the reason for the low number of PDO olive producers. Furthermore, for most PDO olive producers it is a labor of love, not a living.

Olive trees were cultivated on a total area of 18,184 ha in 2016, while in 2010 it was 17,096 ha, which represents a 6% growth (Croatian Bureau of Statistics 2016). The total production of olives in 2016 was 31,183 tonnes in Croatia (Croatian Bureau of Statistics 2016). According to the results of the survey, the total production of olives used for the production of PDO olive oil was 101 tonnes in 2016, which is about 0.3% of total olive production.

The situation of PDO and conventional olive producers is very similar in terms of production area (small, patchy areas), production volume (low production quantity) and technical profile (for example, inappropriate infrastructure, especially access roads to orchards).

According to Mesić et al. (2015), in the 20 years up to 2016 in Croatia, there was a continuous increase in production due to increased investment in this agricultural sector, as well as incentives at local, regional and national level, introduction of new technologies in production, increase in demand for olive oil as well as increase in knowledge about the nutritional value of olive oil (Šimunović 2005). On the other hand, the main limiting factors for the development of the Croatian olive and olive oil market are the patchy, small plots and insufficient storage capacities.

P1: Olive Oil Manufacturers

The processing of olives into olive oil in Croatia takes place in 184 oil refineries. The leading counties are Split-Dalmatia County (51 oil refineries), Zadar County (38 oil refineries), Dubrovnik – Neretva County (30 oil refineries) and Istra County (30 oil refineries) (List of oil refineries). Šibenik-Knin County has 20 oil refineries, Primorje-Gorski Kotar County 14 oil refineries, while the Lika-Senj County has only one oil refinery. The biggest problem with oil refineries in Croatia is that they use their maximum capacity for only 10 days a year, which raises the question of profitability. The average cost of olive processing is 0.20 euros/kg of olives, but in most oil refineries the cost varies from year to year.

In Croatia four oil refineries process olive oil with designations of origin, where the cost of processing is 0.19 euros. There is no oil refinery that has the highest share on the domestic olive oil market. Olive oil refineries in Croatia are under private ownership. It is important to mention that oil refineries do not have any type of contract (short-term, long-term) with olive producers.

D1: Direct Sale

As mentioned earlier, only 17 producers are involved in the production of olive oil with a designation of origin, while about 40,000 households (HPK) are involved in the production of olive oil in Croatia. Total production of olive oil in 2015 was 35,352 hL (Croatian Bureau of Statistics 2016), while olive oil production in 2016 was 34,538 hL (Croatian Bureau of Statistics 2017). According to the results of a survey of producers of olive oil under a designation of origin, total PDO olive oil production in 2016 was 12,500 kg or approximately 125 hL.

Although geographical indications are a key element for improving the competitiveness of agricultural products, ensuring socioeconomic development of rural areas, territorial and environmental protection (Marescotti 2003, cited in

Mesić et al. 2011), in Croatia the importance of labeling products with geographical indications is not yet sufficiently recognized amongst producers and consumers.

Due to the limited production of PDO olive oil, olive producers are also distributors. In the supply chain of PDO olive oil there are no other actors (distributors). PDO olive oil is sold directly through tourism (direct sale). The average price of PDO olive oil in 2016 was EUR 20.39 L^{-1}, with the price of Cres and Krk PDO olive oil significantly higher than the prices of Korčula and Šolta PDO olive oil. In 2016, the price of olive oil without a PDO label was about 50% lower, at 10.48 euros/L.

Governance of the PDOs

All four PDO olive oils in Croatia are protected on the basis of a recognition procedure which was initiated by producers who are members of producer associations. On Krk island there is an association of olive producers called Drobnica. The Association for the development of agriculture and agrotourism "Ulika" is the one managing the PDO on Cres island, while on Šolta island there is an association of olive producers called "Zlatna Šoltanka". Finally, on Korčula island there is an association of olive producers called Vela Luka.

In each association, a group of enthusiasts/olive producers started the procedure for the protection of olive oil with a designation of origin. They are also responsible for communication and marketing activities.

In Croatia, the Ministry of Agriculture is responsible for the protection of the product with the designation of origin. Figure 9 presents national process of protecting the name of a geographical indication.

Biotechnicon Entrepreneurial Center d.o.o. is responsible for control over the production and processing of the three PDO olive oils in Croatia; Cres, Šolta and Krk, while Bureau Veritas Croatia d.o.o. is responsible for the control of Korčula PDO olive oil.

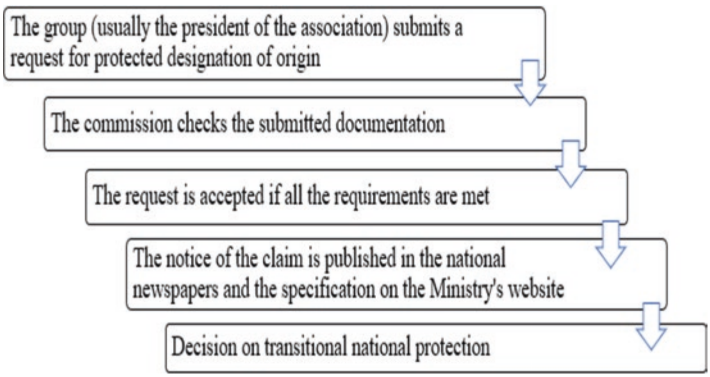


Fig. 9 The national application process for the protection of a Geographical Indication. (Source: http://www.mps.hr/datastore/filestore/81/NAC–POSTUPAK–SHEMA.pdf)

Sustainability Diagram Based on Strength2Food Indicators

Sustainability assessment of PDO olive oil in Croatia was implemented according to the specific methodology of Strength2Food (Bellassen et al. 2016).

Regarding **economic indicators** (price premium) PDO Olive oil has the same price as conventional olive oil at the processing level. At the downstream level, the PDO product has a high price premium (of the order of 90%). This high price premium is explained by how the product is sold; it is sold directly to tourists. Moreover, the product under PDO represents only 0.3% of the total production of olive oil. Other common economic indicators such as value-added, gross operating margin or net result could not be estimated due to the lack of accountancy data on PDO "farms". Indeed, for PDO producers, olive and olive oil production is a very marginal activity, almost a hobby, and therefore expenditure for specific inputs and the labour allocated to these activities is not recorded.

If we look at the export share indicator, there is no export of PDO olive oil, whereas the export share of conventional olive oil is 3.9% of total turnover (5% of total production), mainly exported to Europe. The price of conventional olive oil on the European market is close to that of the domestic price, whereas the price on the extra-European market is smaller than that of the domestic market. It is more profitable to sell on the domestic market.

The **carbon footprint** (kg CO2e t^{-1}) of PDO olive oil is 45% lower than its reference. The PDO has a much lower carbon footprint than the reference product, mostly thanks to the higher olive yield and lower use of energy for soil and plant preparation for production. The order of magnitude is comparable to the 3.52 kg CO2e t^{-1} reported by Rinaldi et al. (2014) for the cultivation stage in Italy. The overall footprint of Croatian olive oil is much lower due to the absence of freezing in the Croatian process.

Concerning **food miles**, the PDO supply chain was compared to the conventional olive chain from U3 to P1, and to the conventional Croatian olive oil sector from P1 to D1. Over the entire supply chain, from olive farms to distribution units (U3–D1), there is a significant difference between the FQS and its reference product. The former travels on average much shorter distances (80 km compared with 350 km) and releases lower emissions (45 kg CO2 eq compared with 70 kg CO2 eq) than the latter. The shorter distances covered by PDO olive oil, as well as the lower emissions generated, can be explained by the fact that this product is not exported, contrary to its reference. Most of the kilometers traveled and emissions generated along the value chain are concentrated at the processing level (U3–P1) for the FQS (i.e. around 90%). An interesting point is that although most of the kilometers covered by the reference product (i.e. 75%) are at the distribution level (P1–D1) most of the emissions released (i.e. 75%) are concentrated at the processing level (U3–P1). This is due to the fact that although exported conventional olive oil travels long distances (43% of exports are outside Europe), part of it uses carbon-extensive modes (sea transport) while olives rely on carbon-intensive modes (road transport) and implies a low product ratio of olives to olive oil. We can conclude from the sustainability

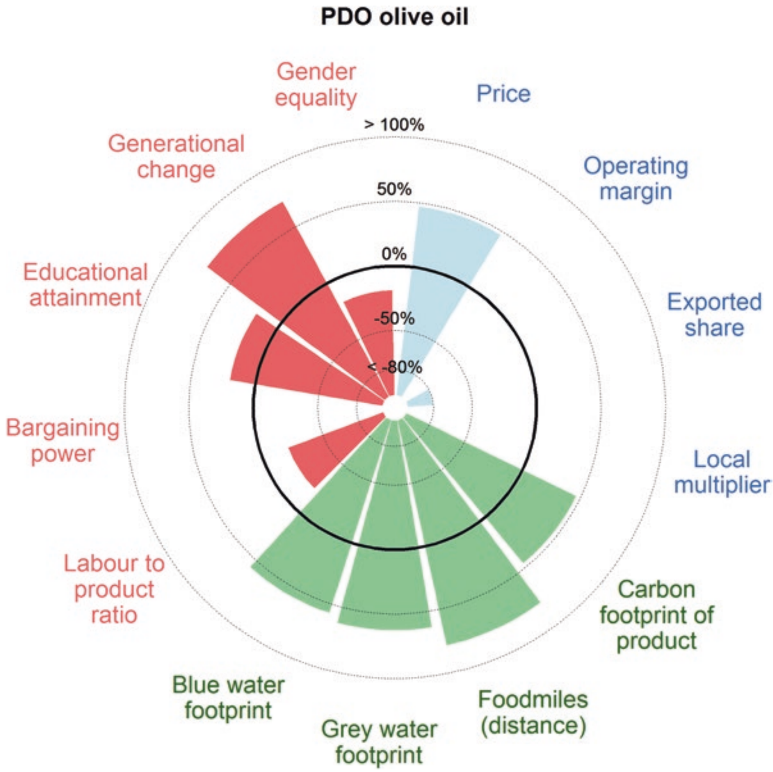


Fig. 10 Sustainability performance of PDO olive oil (supply chain averages). (Each indicator is expressed as the difference between PDO olive oil and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

diagram (Fig. 10) that PDO olive oil is more sustainable than its reference in terms of distance traveled (−80%) and in terms of the carbon emissions of the transport stage (−40%).

The water footprint at farm level (m^3/t olives) for the conventional olive oil is 54% higher than for FQS (PDO olive oil). At processing level (refineries) the water footprint is just 4% higher for conventional olive oil in comparison to PDO olive oil. The water footprint at the final, downstream level is 56% higher for conventional olive oil than for the PDO. What causes this difference?

For both products computation of the water footprint involved the agricultural phase and the refinery process. The small difference in the water footprint in the refinery process is mainly due to the different input of water used in the refining phase. All the other issues (i.e. electricity consumption) that characterize the refining process are the same and thus do not contribute anything to the indicator values.

Most of the difference between FQS and the REF lies in the agricultural phase. In particular, the highest difference concerns the **green water footprint**, which is

8.92 (m^3/kg of oil produced) for FQS and 19.63 for the REF product. This difference is due entirely to the different yield in terms of olives produced per ha of surface, which is higher for FQS (3.22) than REF (1.55).

Next there is a different water requirement for the **grey water footprint** in favor of the FQS because the use of fertilizers and pesticides is higher in the REF product. In particular, the production process for the REF product employs more nitrogen than FQS, in the form of mineral (78 vs. 75 kg/ha) and organic nitrogen (27 vs. 12 kg/ha). In both cultivars copper is used for pest control but in REF production "dimethoate" is also used, which contributes to an increase in the grey water footprint of the REF product.

The **blue water footprint** further contributes to the difference between FQS and REF. The blue water footprint is higher for the REF product due to the overheads in particular because it requires a higher quantity of fertilizers and pesticides; on the other hand diesel consumption is higher for the FQS but not enough to compensate for the differences caused by the other issues.

The ratio of tons of olive oil to tons of olives is pretty similar for PDO and conventional olive oil (0.1 ton of oil from 1 ton of olives).

If we look at the **educational attainment** indicator, we can see that PDO olive oil producers have 31% higher education levels at farm level and 9% higher education levels at processing compared to conventional olive oil producers.

It was not possible to calculate the bargaining power indicator for the PDO olive oil supply chain in Croatia because it is fully integrated since olive producers are also in charge of distribution.

Regarding the **generational change and gender equality indicator**, there is no difference in the generational change indicator between PDO olives and reference olives at the farming stage. Moreover, the olive growing stage in the supply chains of both types of oils produced in Croatia are somewhat at risk in their sustainability prospects due to a rather low employment level of 15–35-year-olds, compared to 45–65-year-olds. Non-PDO olive farming in Croatia appears to be more socially sustainable than PDO olive oil due to a higher level of gender equality (double the value). This result derives from a very low level of female entrepreneurship (farm ownership) at the farm stage of the PDO production, compared to that of reference olive oil. However, these results may also reflect that it was not possible to collect separate data for olive growers and processors in the non-PDO olive oil supply chain because of the lack of reliable sources. In turn, the values of the indicators for the non-PDO olive oil supply chain are the same at different stages of the supply chain and may represent an "average" for the whole supply chain.

The processing stage for both PDO and reference supply chains produced ambiguous results due to the specificity of the data sources. In particular, for PDO olive oil, we surveyed four processors producing PDO olive oil (this is total number of processors included in production of PDO olive oil in Croatia, as the industry is in its infancy). All the processors were managers of very small operations with a very limited workforce. The managers reported a perfect age balance in their workforce. The generational change indicator, calculated at 100%, is encouraging, especially if future recruits are younger rather than older, increasing the likelihood of production being maintained/increased in the future. However, this value is rather uninformative in terms of the current state of sustainability of the PDO olive oil processing stage of the supply chain. Because of the limited number of informants and the small-scale of operations they run, the data provided for the PDO olive oil processing stage of the supply chain is unsuitable to properly calculate the gender equality indicator. In fact, the data provided suggests that there are neither female plant managers nor female employees at this stage of the supply chain. Gender equality at the processing stage of the PDO olive oil supply chain may be at the "minimum" level, mainly because women are not represented in the workforce/ownership at this stage of this supply chain. This implies a minimum level of equality. At the supply chain level, PDO olive oil from Croatia appears more socially sustainable than its reference product with respect to the generational change indicator, while the opposite is true for the gender equality indicator.

Conclusion

Although Croatia has the potential to develop its market for olive oil labeled PDO, only 17 producers are involved in its production. There are four PDOs in Croatia: Krk, Cres, Šolta and Korčula. The Ministry of Agriculture is responsible for the protection of the product with the designation of origin. The PDO olive oil value chain in Croatia, where most olive producers are also retailers, is rather short,

The PDO product accounts for only 0.3% of the total production of olive oil and there is no export of the PDO product. The export share of conventional olive oil is 3.9% of total turnover and is mainly exported to Europe. For PDO olive oil producers in Croatia it is more profitable to sell on the domestic market because the price of conventional olive oil on the European market and the domestic market is similar, whereas the price on the extra European market is lower than on the domestic market.

The carbon footprint of PDO olive oil is lower compared to the carbon footprint of reference olive oil at all levels. PDO olive oil travels on average much shorter distances and releases lower emissions than the reference product. Most of the kilometers traveled and emissions generated along the value chain for PDO olive oil are concentrated at the processing level, while for the reference product they are at the farm and retail level.

The water footprint at all levels (farm, processing, downstream) for the reference product is higher than for PDO olive oil. Regarding educational attainment, PDO olive oil producers have a higher education level than reference product producers.

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PDO Kalocsai Paprika Powder in Hungary

Péter Csillag and Áron Török

Introduction

Ground (or milled) paprika is one of the most popular spices in Hungary and is the most important in Hungarian cuisine among domestically produced spice vegetables. Domestic consumption is 300–320 g/capita/year, totalling 3000–3200 tons. Today, since domestic production has declined significantly during the last 15 years and falls short of demand, about 60% of paprika is imported. Kalocsai ground paprika PDO ('Kalocsai fűszerpaprika őrlemény – oltalom alatt álló eredetmegjelölés') accounts for 50% of the Hungarian production.

Paprika (Capsicum annuum) was brought in by the Ottomans during the sixteenth century, but became widespread only in the nineteenth century when the now classic paprika-based dishes became popular elements of Hungarian cuisine.

There are two traditional centres of paprika production in Hungary (Fig. 1): Kalocsa (16,000 inhabitants) and Szeged (162,000 inhabitants). The climate in the area of these two cities in the Great Hungarian Plain is suitable for paprika production.

The first paprika research and cross breeding institute in Europe was established in Kalocsa in 1917. Until the 1930s only diverse hot species were bred and

P. Csillag (✉)
ECO-SENSUS Research and Communication Non-profit Ltd., Szekszárd, Hungary
e-mail: csillag.peter@ecosensus.hu

Á. Török
ECO-SENSUS Research and Communication Non-profit Ltd., Szekszárd, Hungary

Department of Agricultural Economics and Rural Development, Corvinus University of Budapest, Budapest, Hungary

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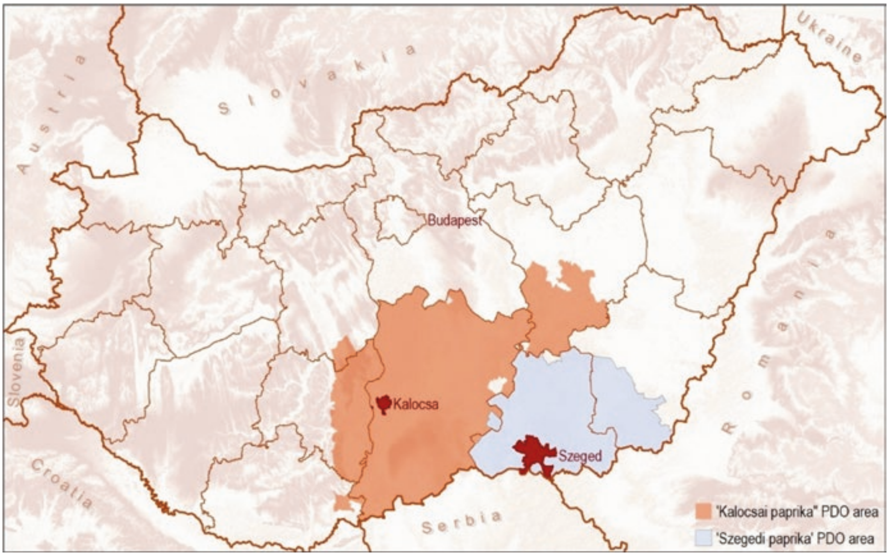

Fig. 1 Spice paprika production PDO areas in Hungary

manufactured. The first mild (non-hot) paprika species were developed in 1927, which boosted consumption, and thereby production, significantly.

In order to regulate such increases in production and to ensure the quality of emerging export sales, the Hungarian government issued a regulation on paprika production (No. 1890/1934. M.E.). This directive established the terms of the Hungarian paprika regime and clearly defined the Kalocsa and the Szeged PDO areas.

Through the accession of Hungary to the EU in 2004, both paprika production areas – Kalocsa and Szeged – obtained authentic PDO protection.[1] The quality requirements of the paprika produced are specified by the PDO description and also, although without regional distinction, by the Codex Alimentarius Hungaricus (Directive MÉ 2-108 – "Ground paprika with distinctive quality label").[2]

[1] The PDO protection of "Kalocsai fűszerpaprika-őrlemény" was submitted under the dossier number HU/PDO/0005/0393 in 21 October 2004, published in 11 October 2011 and registered in 5 July 2012.

The "Szegedi fűszerpaprika-őrlemény/Szegedi paprika" PDO was submitted also in 21 October 2004, published in 20 February 2010 and registered in 4 November 2010.

[2] The common roots and the close relation of the Kalocsa and Szeged paprika regimes are also indicated by the agreed mutual use of paprika varieties of the two areas, i.e. paprika varieties with the name 'Szeged' are used in the Kalocsa region and varieties with the name 'Kalocsa' are cultivated in the Szeged paprika region as well.

Characteristics of "Kalocsai Paprika"

Raw Material

Raw paprika used in the production of the PDO product ('Kalocsai fűszerpaprika-őrlemény' PDO)[3] should be manufactured by the grinding of paprika (Capsicum annuum L. var. Longum DC.) grown in the Kalocsa region from sealed seeds of certified species. The typical colour and flavour of the paprika results from the local species and the well-established and quality assured manufacturing process.

The standard paprika is sweet, matured and sound. The pungency of the hot paprika is categorised by its capsaicin content. Between 30–200 mg/kg the ground paprika is mildly hot, between 200 is 500 mg/kg hot, and above 500 mg/kg extra hot.

Certified (state-owned) paprika varieties include:

- Sweet varieties: Delikát, Favorit, Folklór, Kaldóm, Kalocsai 50, Kalocsai 801, Kalorez, Rubin, Szegedi 20, Szegedi 80, Jubileum, Kalmár, Kalocsai merevszárú 622, Remény.
- Hot varieties: Kalocsai V-2, Kalóz, Szegedi 178.

The above varieties represent 60–70% of the paprika production area. Besides these, four varieties – Meteorit, Mihálytelek, Fesztivál, Napfény – of the private Szeged Paprika Corporation are also commonly sown in the Kalocsa PDO area, and represent 30–40% of the cultivated paprika area.

Production Area

The original regulation in 1934 pertained to a smaller area (Kalocsa and further 21 settlements around) than the current one of the Kalocsai PDO. Originally it was the area of the city of Kalocsa along both sides of the Danube. The west bank area was originally located on the east side, but the course of the river was modified in the nineteenth century, and a small part of the paprika area, the village of Bogyiszló, moved to the other side. The Trans-Danubian part of the Kalocsa paprika region came to include further settlements like Fadd, Dunaszentgyörgy and Kajdacs too.

During the twentieth century, the paprika area expanded to the north (Solt) to the east (Kiskunság plain) and to the south (Bácska plain). The climate for paprika cultivation was also suitable and from the 1960s to 1990 cooperatives entered into paprika production offering incentives to their members to produce paprika in their free time. Some cooperatives and state farms also invested in paprika dryers. So the

[3] Prior to the submission of the PDO protection, the Hungarian Intellectual Property Office registered "Kalocsai paprika" appellation of origin on 30 November 1998, and even earlier the World Intellectual Property Organization (WIPO) registered the appellation of origin 'Kalocsa, Kalocsai, Kalocsaer' under No. 501 on the 6 May, 1969.

final and current area of the Kalocsa PDO consists of 174 settlements in 6 counties which are entitled to use the 'Kalocsai PDO' label.

Quality Attributes

The PDO legislation also enumerates the exact physical and chemical attributes of paprika, such as minimum pigment content, maximum moisture content, particle size, level of pungency described by ranges for capsaicin content and the prohibition of any additives. The entire production process is prescribed in detail (plantation, growing, harvesting, drying, processing and packaging). The climate and geology of the mid-Danube-Tisza region are substantial contributors to the Kalocsai paprika's qualities. The alkalinity and salinity of the alluvial soil and the moderate amount of sunshine the area receives (1600–1800 h/year) help the Kalocsai paprika retain a higher sugar content. This means that, even though the peppers may never become as fully pigmented as those in sunnier climates (with 3000 h/year sunshine), after skilful post-ripening, drying and grinding a very harmonic, spicy paprika is produced (Table 1).

Hungarian Paprika Market Data

The total yield of raw paprika in Hungary produced for grinding purposes is around 15,000–18,000 tons/year, harvested from about 900 hectares. A further 15,000 tons of raw spice paprika is produced for condiment manufacturing. In the last 20–30 years a new form of paprika gained popularity: non-PDO paprika paste (minced paprika and paprika condiment) filled into glasses or tubes. This manufacturing method does not require the drying of the spice paprika and a huge yield per hectare can be reached via excessive application of fertilizers and hybrid species. Paprika paste production is dominated by two major manufacturers: the Hungarian owned Univer Product Zrt[4] in Kecskemét and the Dutch owned B.W.A. Kft[5] in Hajós. Univer contracts yearly 500 hectares of spice paprika, BWA also contracts a significant area of 250–300 hectares. This area almost equals the one of the Kalocsa PDO.

Therefore only 50% of the spice paprika sown in Hungary will be processed into ground spice paprika. The proportion of Kalocsa PDO in the Hungarian cultivation area is around 60% (500–600 hectares), the other paprika PDO, Szeged accounts for the other 40% (350–400 hectares).

[4] http://www.univer.hu/en/

[5] http://www.bwa-kft.hu/index-en.php

Table 1 Summary of the technical specifications/code of practice of the 'Kalocsai paprika' QS or of the elements that generate its quality

Territory	
Geographical area	The production of the raw material (grinding paprika) and all the processing and packaging process has to be carried out in the PDO territory (see Fig. 1).
Varieties/ breeds	17 grinding paprika varieties are allowed
Arable farming practices	
Fertilization	The product description advises to use manure but mineral fertilization is not forbidden.
Plant health	There is no constraints in terms of phytosanitary products use.
Field operations	Only sealed seed is allowed; it can be sown directly in the soil (between the beginning of March and the end of May) or seedlings can be planted from the middle of May. Before planting or sowing, the soil should be thoroughly prepared. The mature pods can be harvested by machines or manually.
Processing	
First stage	After harvesting a 10–40 days long post-ripening period comes, when the produce is to be stored in wooden boxes, containers, sacks or strung up in garlands (separated by lot) in order to increase the pigment content as much as possible and prevent any deterioration and contamination during storage.
Second stage	The product is then dried in a gentle manner (<80 °C) imitating the conditions of natural drying by indirect dryers or in the open air to a moisture content below 10%, and it is then identified by labels. The paprika thus preserves the natural taste and aroma. After drying the labelled product is stored in cool, dark quarters, free from pests. The dried paprika is then ground at a temperature which must remain below 80 °C. During grinding the oil content of the paprika seed covers the surface of the granules, thereby protecting them from adverse decay processes. Millstones, rolling mills, hammer mills and impact mills are suitable for grinding. Paprika must be ground with a natural proportion of seeds. At the end of grinding, paprika must be conditioned to a minimum moisture content of 8% and a maximum of 11% by adding tested natural water.
Conditioning	The ground product may be introduced to the market after homogenisation, germ reduction, packaging and appropriate marking and labelling.

The Kalocsa PDO region produces 9000–9500 tons of raw paprika out of which 1200–1300 tons of ground paprika will be marketed.

As shown in Fig. 2, the two PDO areas entirely cover the spice paprika production of Hungary. Trends of Kalocsai PDO production are essentially the same as those of total production (Fig. 3).

Hungary's production of spice paprika has declined after the country's EU-accession. One of the reasons for this decline was the transformation and breaking-up of agricultural cooperatives and state farms involved in paprika production (in the settlements of Bátya, Dusnok, Dunapataj and Fajsz). Before that the bulk of the paprika was produced by small family farms which received services from the cooperatives at reduced rates in order to promote paprika production. The cooperatives also organized the production and set up processing (drying) facilities.

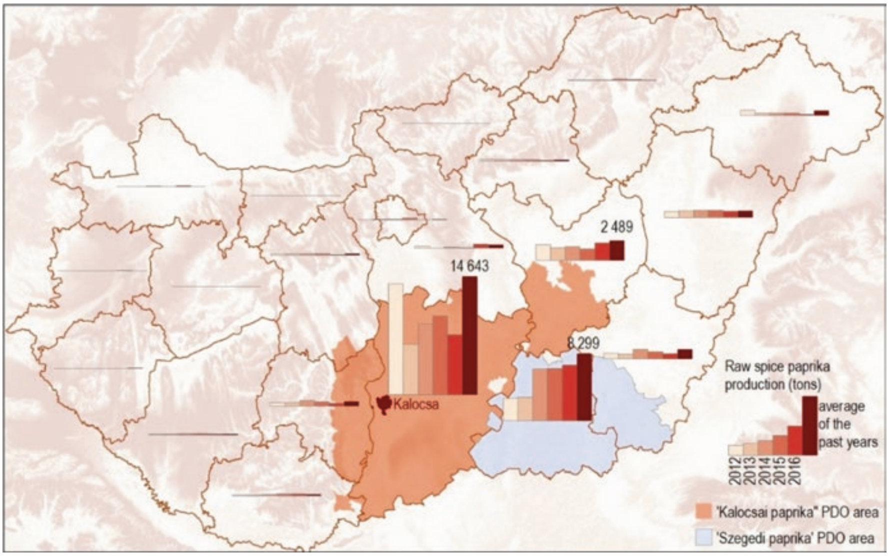

Fig. 2 Spice paprika farming in the Kalocsai PDO and Szegedi PDO areas.
The data also contains the sowing area of spice paprika for condiment purposes, so in this sense it is somewhat distorted, but this is still an appropriate way to present the distribution of the production. (Source: Hungarian Central Statistical Office)

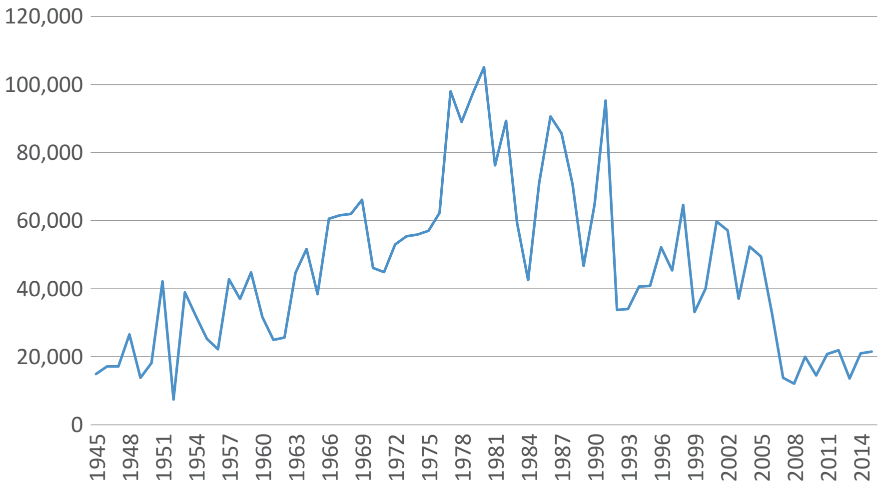

Fig. 3 Raw spice paprika production, tons. (Source: Hungarian Central Statistical Office)

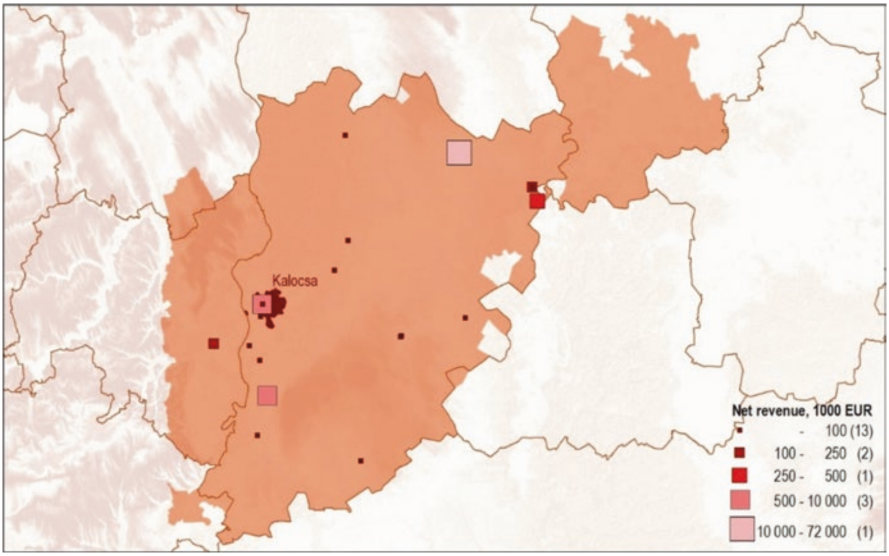

Fig. 4 Paprika processing companies in the 'Kalocsai' PDO area (above 3 million EUR annual turnover). Own graphic. Source of data: Ceginfo.hu

The other reason for the fall in production was the paprika scandal in 2004. On May 1, 2004 at the time of Hungary' formal EU accession, the high import duty levied on paprika was reduced overnight from 44.2% to 5%, radically increasing the appeal of cheap imports. A well established Hungarian processor had imported 88 tons from Brazil out of which 8 tons were tested positive for Aflatoxin B1.[6]

As a result of the scandal, the export of the leading paprika processor has fallen significantly, losing most of its traditional markets in Austria, Bulgaria and Slovakia.

The processing of the Kalocsai PDO paprika is concentrated in Kalocsa. The market leader is Kalocsai Fűszerpaprika Zrt, however estimates suggest that small farms' production (sold from farm or on local producers' markets) exceeds 'industrial' paprika production.

The paradox of the Kalocsai PDO is that the highest quality paprika produced by small farmers (which accounts for the half of the total Kalocsai production) is not labelled, because small farmers and processors do not use the 'Kalocsai-fűszerpaprika' PDO, they use their name and/or the name of their residence instead (Fig. 4).

The retail consumption of domestic ground paprika in Hungary totals 3000–3200 tons (300–320 g/capita/year). Out of this volume small farmers (small producers) account for approximately 1000 tons, but this quantity does not appear in the retail trade because small producers typically sell their high quality ground

[6] The rationale for imports was not clear. There are several possibilities: bad harvest in the previous year (2003) that cut production by 60%, or the aim of improving insufficient colour attributed to the bad weather, or the intention of lowering the cost with mixing Hungarian paprika with cheap Latin-American peppers.

paprika directly from home or at local producers' markets. The retail volume of the ground paprika is about 2000 tons. The foreign trade balance is negative: at national level, export is usually about 1000 tons and a massive 1500–2000 tons is imported. Adding up to the retail consumption the food industry (meat processing, preserving) demands a yearly amount of 300–400 tons which is supplied from import sources (this segment is dominantly supplied by the Rubin Szegedi Paprikafeldolgozó Kft. selling mainly Chinese paprika).

"Kalocsai Paprika" Value Chain

Inputs of Paprika Growing

The two most important inputs of paprika growing are the quality seed and manual labour (hoeing, harvesting). Within the Kalocsai PDO, only certified and sealed pepper seed can be sown and, in order to maintain higher yields and good quality, the non-PDO growers also prefer to use certified seed. Some producers realize very high yields (30 tons/hectare) sowing new hybrid pepper varieties combined with extra amounts of fertilizers and irrigation but this way of production ignores quality traditions of the Kalocsai paprika. Certified seed is distributed by the state owned vegetable breeding institution (ZKI Zöldségtermesztési Kutató Intézet Zrt[7]) at 200 EUR/kg. The required amount of seed is 7–8 kg/hectare. Small growers (under 2 ha) are often supplied by the private Szegedi Paprika Zrt[8] which distributes its own varieties at a moderate price (one third of the state owned varieties). However, the PDO technical specifications do not allow these varieties. Approximately 60–70% of the PDO area is sown with ZKI certified seed, the other 30–40% of the paprika area is sown with seeds from Szeged. There are three players in Hungary involved in breeding spice pepper: ZKI (state owned), Szegedi Paprika Zrt (private), and Univer[9] (private, leading producer of paprika condiments and pastes).

Regarding competitiveness of production, the renewal of the applied paprika varieties seems to be crucial to the large-scale farmers, since paprika breeding activities of the past 10–15 years were focusing on higher yields and resistance to Xanthomonas bacteria. These two properties were found mainly in species with longer breeding season. In regard to the limited number of sunny hours in Hungary, late-ripening varieties cannot be harvested because, even in long and mild autumns, the ripening process is not sufficient: the proportion of green pods on the plants can go up to 30%, which increases waste and reduces the competitiveness of production. Contrary to the large producers, small farmers do not face this problem since they harvest manually and never pick the green pods. The highest quality growers

[7] http://zki.hu/about-us/our-activities/?lang=en

[8] http://szegedipaprika.hu/?lang=en

[9] http://www.univer.hu/en/company/univer_product_plc.html

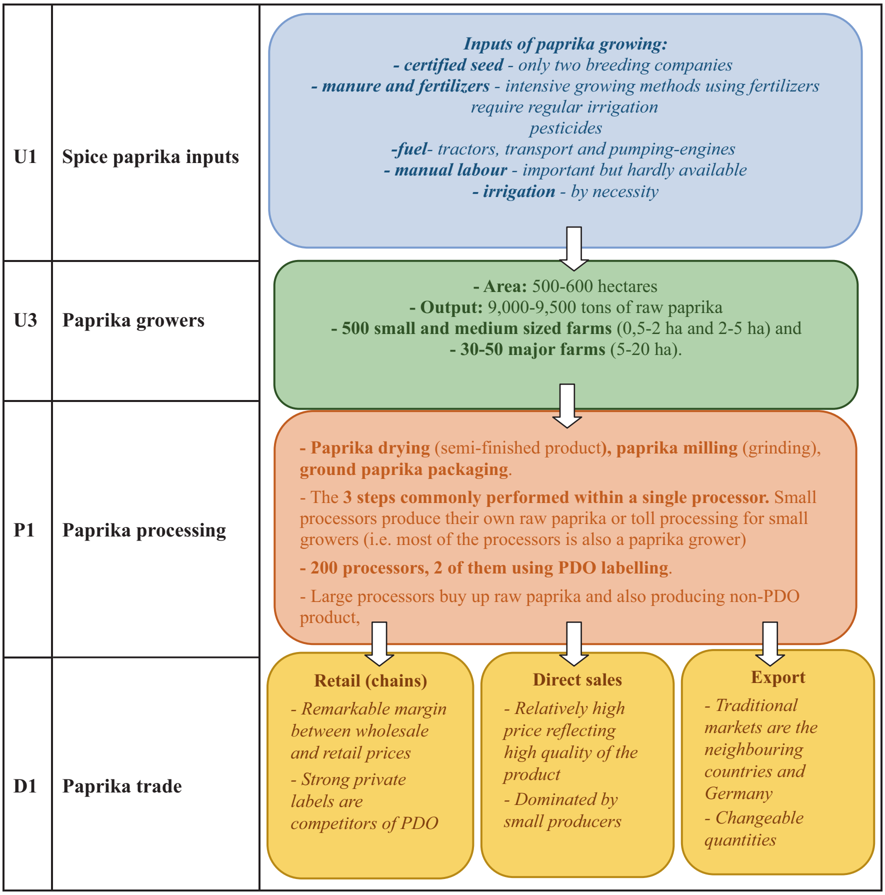

Fig. 5 The value chain of "Kalocsai paprika"

harvest only once (one way) and leave all the unripe pods on the plant and plough under in late autumn.

A further critical input of paprika growing and processing is manual work or more precisely the scarcity of it. The paprika needs to be hoed 8–10 times (in every 10 days) and a quality product can only be hand-harvested. The rural labour force is ageing and also the less qualified young people leave the rural regions or commute to cities for higher wages they earn in non-agricultural activities.

Paprika Growers

In the Kalocsai PDO area, around 500 small (0.5–2 ha) and medium sized (2–5 ha) farms and further 30–50 major farms (5–20 ha) are involved in pepper growing. Major growers operate in the centre of the Kalocsai area (Kalocsa, Bátya, Fajsz,

a
b


Fig. 6 Portraits of two paprika growers. (**a**) A 0.4 hectare paprika grower from Bogyiszló (JÓZSA, Bálint). (**b**) A 10 hectares paprika producer from Fadd (MOCSÁN, Zoltán). (Source: Eco-Sensus Photo)

Dusnok) or in the northern part of it (Szabadszállás, Mezőhék). The very qualitative growers typically also process their product, the only service they sometimes demand being grinding (rarely drying) (Fig. 6).

In Hungary, three different growing systems prevail in paprika growing:

[1a] in the area of Kalocsai (PDO) the extensive, mechanized method is dominant. The average farm size is 10–15 hectares. A higher amount of nitrogenous fertilizer, intense irrigation, new hybrid varieties, and herbicides are used and the harvest is mechanized, resulting in an average yield of 18–25 tons/hectare. Roughly 40–50% of the Kalocsai PDO is produced this way.

[1b] Small farmers (under 5 ha) use manure and small doses of fertilizer, traditional varieties, minimal or no herbicide, reasonable irrigation, 8–10 times per season manual hoeing, manual harvesting one or two times, with the unripe remainder ploughed under. Average yields vary between 12 and 15 tons. This method results the best quality raw material. 50–60% of the paprika output is grown by this method (Fig. 7).

Fig. 7 Manual harvest of paprika in the settlement Bátya (above) and Fadd (below) on the two opposite sides of the Danube. (Source: SZABO, Peter (above) Eco-Sensus Photo (below))

[2] In the Szeged PDO region, an intensive growing method is frequently used: plastic houses, intense nutrient supply combined with intense irrigation. The cultivation area of these horticultural farms is typically 1–2 hectares. One significant weakness of this method is the unstable quality of hybrid seed developed for the plastic house purposes, and a further problem is the middle-class quality of the crop. In the Kalocsa PDO area, this method is not used.

Paprika Processing

The harvested raw pepper is first post-ripened in knitted bags (Raschel bag) or in wooden boxes. The post-ripened pods then will be dried with hot air (using mainly gas, although oil, wood or straw may also be used as a fuel). Drying and milling almost always take place in the same facility, although the two operations are separated in time (or "non-simultaneously").

The ripened paprika will be dried all at once and the semi-finished product (dry paprika pods) will be stored in bags. The legislation prescribes a 90-day warranty period, albeit a high-quality ground paprika can be stored easily even for 240 days. Characteristically, those products which were harvested by machine and dried with more hot air tend to lose their colour.

Within the Kalocsai PDO area there are about 200 processors, out of which only 2 use the Kalocsai PDO labelling. Small-sized driers and mills often provide their services to small growers with less than 1–2 hectares cultivating area. The main drying capacities operate in the settlements of Kalocsa, Bátya, Sükösd, Mélykút, Bogyiszló.

All large paprika processors (over 500,000 EUR turnover) also sell imported paprika and/or paprika without Kalocsai labelling, on the rationale of utilizing packaging capacities and with the aim to supply all kinds of demand and ultimately achieve higher revenue. However, this accompaniment does not support the competitiveness of Kalocsai paprika. Paprika processors generally also have packaging equipment, but the three steps of processing (drying, milling and packaging) will sometimes be carried out in different facilities by different companies. Processors usually use only the Kalocsai name on the packaging, but do not include the EU PDO logo. (Fig. 9)

Small processors, who dry and grind primarily their own raw material, very often provide drying and milling services for other small growers who produce only several 10–100 kg of ground paprika yearly. These producers do not use the Kalocsai label, they sell their product in plastic bags with 0.5–1.0 kg capacity (Fig. 8).

Paprika Sales

There are two ways of marketing paprika:

1. About 50% of the total volume of the Kalocsai PDO paprika originates from small-scale farming. Small producers sell their product directly to the consumers (households, restaurants, butchers) from home or in local farmers' market (within the allowed 40 km range) or in Budapest. This quantity of paprika enjoys VAT-exempt status. Typical package size is 0.5 and 1 kg. The price range of these products varies between 2700 and 4500 HUF/kg net (= 9–15 EUR/kg). Despite the fact that the strength of the Hungarian paprika is its flavour instead of its colour, the average Hungarian consumer decides based on the colour of the ground paprika. This is why small producers at the local farmers' markets prefer transparent plastic bags instead of non-transparent plastic or paper.
2. Large paprika processors (including the market leader Kalocsai Fűszerpaprika Zrt) act as wholesalers on the market, selling their product exclusively to retail chains (Aldi, Auchan, CBA, Coop, Lidl, Penny Market, SPAR, Tesco), sometimes to industrial partners (meat and preserving industry), or to export markets. The bulk of the retailed quantities is sold under private labels, with only a few famous brands (e.g. Kotányi, Univer) managing to sell at higher prices. The two major PDO paprika manufacturers (Kalocsai Fűszerpaprika Zrt and Szegedi

Fig. 8 Small scale paprika dryer, grinder and end product. (Source: SZABO, Peter, producer (5 ha area, 6 tons of ground paprika from Bátya, near Kalocsa))

Fig. 9 Different ways of labelling paprika in the Kalocsa region.
(**a**) Kalocsai PDO paprika using 'Kalocsai' designation but not marking the EU PDO logo. (Source: http://www.kalocsaipaprika.com/termekek-1/) (**b**) Kalocsai PDO paprika using all requisites of Kalocsai PDO labelling. https://bevasarlas.tesco.hu/groceries/hu-HU/products/2004002660420. (**c**) A typical paprika grower producing 15 tons ground paprika per year (integrating raw paprika growing, drying, grounding and packaging) not using the PDO labelling but his family name (Mocsán) and his resident village (Fadd) instead

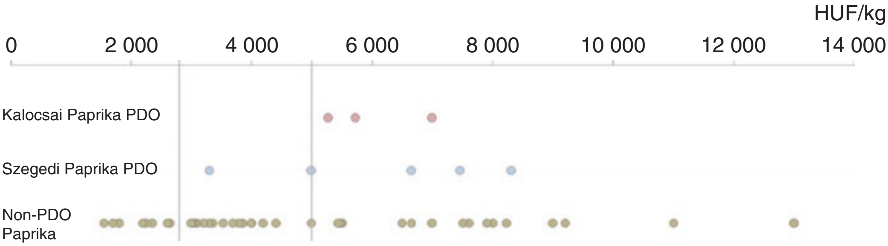

Fig. 10 Ground paprika retail prices in Hungary, HUF/kg. (Source: Eco-Sensus survey, conducted during November–December 2017)

Table 2 Ground paprika wholesale, retail and direct sale prices, HUF/kg

	Kalocsa PDO, average	Szegedi PDO, average	Non-PDO average
Retail price	5.992	5.671	4.089
Wholesale price	1.992	1.831	1.659
Direct sale small farmer price (VAT-exempted)	3.625	3.388	–

Source: Eco-Sensus Survey, Nov–Dec, 2017. Package weights were converted to kilograms, then retail items vary among 10–500 g, small farmers sell directly in 0.5–1.0 kg bags. Extreme values were excluded. Wholesale prices originate from the paprika producers or, in some cases, were derived from retail prices

Paprika Zrt) also have a brand strategy but they do not manage to sell at high prices, seemingly because consumers do not prefer these brands to other (imported) ones. PDO paprika's main competitors are imported products, since domestic paprika is easily replaceable with imported ones, and the retail and industrial demand are price sensitive. Replaceability of domestic paprika with imported pepper is supported by the consumers' behaviour of choosing a paprika by its colour instead of its flavour, as imported paprika has better colour. A general behaviour of paprika manufacturers which supply retail chains is to import cheap (often milled) paprika, pack it and deliver it to the retailer. Some major suppliers sell only imported products.

Consumers willing to pay the price premium of the PDO quality are the main customers of small producers, buying the (generally not labelled) paprika directly. These transactions are very personal and loyal, consumers have confidence in their traditional producers, although the decision to buy there is also often made based on the colour of the product.

For the purposes of this chapter, a retail and direct sale survey was conducted ($n = 96$, 78 retail items and 18 direct sale items) in order to gain information about retail prices, the quality of the paprika retailed and the correlation of the two (Fig. 10).

As we could observe, the great majority of ground paprika marketed in retail units (supermarket, shops etc.) is not PDO paprika. The price premium of PDO paprika is small at the wholesale level, and is substantial at the retail level, i.e. the margin is skimmed by the retail chains (Table 2). It is also remarkable, that some famous non-PDO brands (e.g. Kotányi, Univer) can be sold at higher prices than PDOs.

Paprika Trade

Export

Three channels of exports are recorded in national statistics[10]:

1. *Intra-EU trade in bulk.* In this case, paprika is delivered in 20 or 50 kg bags. The main destination is Germany, which traditionally sets a high value on Hungarian paprika. German customers esteem the flavour of the paprika instead of its colour. Interestingly the paprika is exported without PDO labelling. The main supplier of this segment is Kalocsai Fűszerpaprika Zrt exporting 400–450 tons annually to the German market.[11]
2. *Intra EU-trade through retail chains*. Retail chains purchase paprika in retail packaging (resealable bags) and distribute it over the region's countries (Austria, Romania, Slovakia) through the chain units. The major PDO producer, Kalocsai Paprika Zrt sells 200 tons in this way, but also non-PDO paprika in this case, because the chains do not require PDO quality and premium.
3. *Extra-EU trade.* Export shipments to extra-EU territories are occasional or only minor amounts are concerned. Traditional export destinations are Japan, Canada, USA.

Import

Hungary imports 2000 tons of paprika annually (paprika pods or ground paprika). Imports of spice paprika jumped during the last 5 years, and can be linked with China's rapidly growing production since about 2007. Import is 60–70% cheaper than domestic product. Foreign competitors sun-dry and produce with cheaper labour. The total ground paprika production of the world is about 125,000 tons, out of which 100,000 tons are produced in China. 80% of the import to Hungary originates from China. Minor quantities are imported from Serbia, Spain (actually from China, Peru and South-Africa). Chinese import is fostered by low freightage (importing a paprika shipment from China by sea to Italian or Croatian ports and from there carry it by truck is cheaper than to deliver a shipment from Spain to Hungary by truck).

[10] Source of foreign trade data: Statistical Office and interview with Mr. Németh.

[11] The Hungarian export totalling 1000–1200 tons/year is dominated by three companies (Kalocsai Fűszerpaprika Zrt, Szegedi Paprika Zrt., and HFI Kft.) two of them are owned by the same investors.

Governance of the PDO, and Bargaining Power of Producers

The PDO is governed by two official bodies: the regional (county level) Government Office[12] is responsible for the registration and authorisation and the National Food Chain Safety Office (NFCSO) is performing compliance control.[13] The county's Government Office issues certificates on the PDO-status of the registered producers.

According to producer and consumer interviews however, the key factor of the quality reliance is the strong producer-consumer relation which manifests in the dominance of the direct sales among quality-conscious consumers.

The fact that only a few market players out of 200 ground paprika producers use the PDO labelling indicates an insufficient promotion of the PDO label. Without an effective and long-term promotion activity there will be no significant improvement in the label-use or the market recognition of the label.

Sustainability Assessment of Kalocsai Paprika Value Chain

In order to estimate the sustainability of the Hungarian PDO paprika powder, the specific methodology of the Strength2Food project was applied (Bellassen et al. 2016). For benchmarking purposes, as reference or counterpart product, the special characteristics of the product was considered. First, the significant paprika producing areas are almost all covered by the two PDO territories (Kalocsai and Szegedi paprika powder), therefore we can say that the only paprika production in Hungary that is not allowed to be used in the PDO value chains are the modernist varieties that are not mentioned in the code of practice. These varieties are mainly used for paprika paste production. Therefore, in this chapter we consider the paprika powder produced from imported (mainly Chinese) raw materials (and therefore not allowed for the Hungarian PDO name) as a reference product.

Due to the very limited amount of official data of the paprika value chain, the majority of the inputs for computing the indicators are collected via personal interviews (producers, processors and industry experts). On the other hand, all the available data are included, mainly gained from the databases of the Hungarian Central Statistical Office and the Hungarian FADN (Fig. 11).

The PDO paprika value chain reaches substantial price premium, at all levels. However, the price premium depends on the length of the distribution channel: at direct sales the price premium is +130% on farm level, while at indirect sale 69% price premium reveals at the processing level, and on the market it is sold on with only 47% of price premium. At processing level – the only level where we have estimates for the reference paprika – the profitability is quite moderate, but never-

[12] Bács-Kiskun megyei Kormányhivatal- Kecskeméti Járási Hivatal, Élelmiszer-biztonsági, Növény- és talajvédelmi Főosztály- Élelmiszer-biztonági és Állategészségügyi Osztály 2.

[13] Government decree on the PDOs' control.

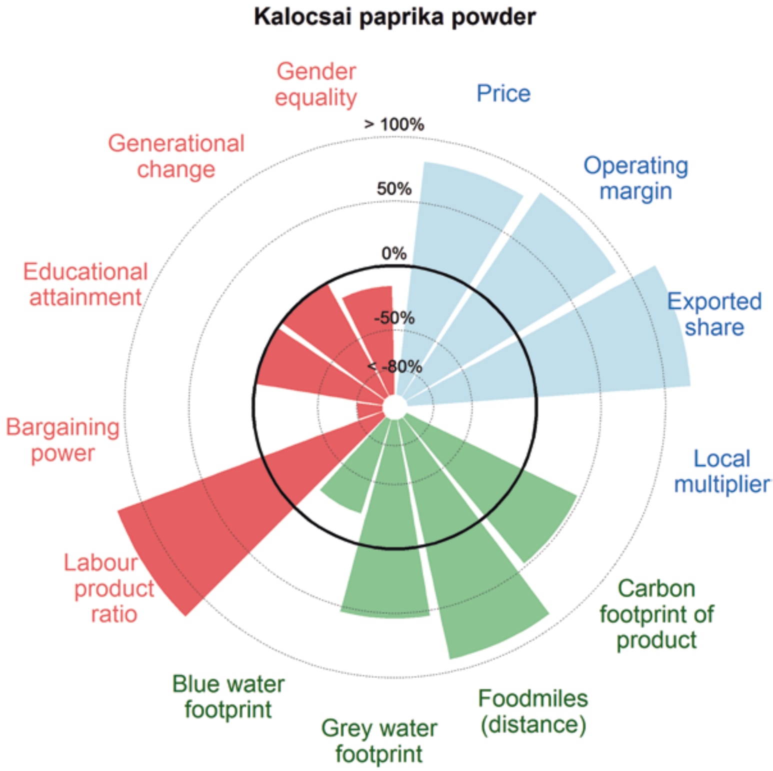

Fig. 11 Sustainability performance of PDO Kalocsai paprika (supply chain averages). (Each indicator is expressed as the difference between PDO Kalocsai paprika and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

theless higher for the PDO: 9% and 4%, respectively. It should be noted that profitability at farm level is difficult to compare, as reference is based on directly imported dried paprika from different countries, for which no economic data was available. The difference in gross value added is even more advantageous for the PDO, as PDO processing is more labour intensive than reference processing. Regarding the foreign markets, only PDO paprika powder (though in many cases without PDO label but suitable for the certification) is exported and the paprika export focuses on European destination. The exported products are above the average price, as the share of export in value is (much) higher, than the share in volume.

The carbon footprint of the raw PDO pepper and its reference – 94 and 223 kgCO2e ton^{-1} respectively – are comparable, although somewhat lower than the only literature reference of 368 kgCO2e ton^{-1} (Wang et al. 2018). The 43% difference – 1 and 1.7 tCO2e ton^{-1} respectively – found for the paprika itself (excluding transport) is explained by two main drivers: a twice larger use of mineral fertilizers in China – where the reference pepper is assumed to be produced – than in Hungary, and a twice higher yield in Hungary. Fuel use for cropping, 100 times more important in Hungary, does not offset the first two drivers of carbon footprint.

Concerning foodmiles, over the entire supply chain from raw paprika to paprika powder (U1–D1), there is a significant difference between the FQS and its reference. PDO paprika powder travels much shorter distances (1200 km instead of 80,000 km) and releases much less emissions (160 kg CO_2 eq instead of 3000 kg CO_2 eq) than the reference. The ratio is respectively 1–60 and 1–20 in support of the FQS. The shorter distance embedded in the PDO paprika powder can be explained by the shorter distance travelled by raw paprika from farms to processing units, as PDO specifications impose on farmers and processors to be located in a geographically restricted area, the Kalocsa region whereas the reference raw product is imported from China. The distribution level (P1–D1) concentrates most of the kilometers embedded in the product and most of the emissions generated along the value chain (i.e. almost two thirds) for the FQS, while the production and processing levels (U1–P1) concentrate most of the kilometres and most of the emissions (i.e. more than 80%) for the reference product.

The overall blue water footprint – surface and groundwater use – is slightly higher for the PDO paprika (0.494 m^3/kg vs 0.402 m^3/kg) as a result of two opposite factors: the much larger use of irrigation water, which is largely offset by the higher yield. The green water footprint – rainwater use – is much lower for the PDO paprika than that of its reference, again because of its higher yield.

Regarding grey water footprint – water pollution by nitrates, the PDO paprika performs better. This result is the combination of two factors: a lower input of nitrogen in both forms, mineral (138 kg/ha vs 265 kg/ha) and organic (5.6 kg/ha vs 35.6 kg/ha), and the higher yield (22.5 t/ha vs 11.7 t/ha). In addition, the final product ratio, that is the amount of paprika powder produced by one ton of raw paprika, is lower for the PDO (0.12 vs 0.14) reduced this difference.

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). At the farm level, it takes 688 hours to product one ton of Kalocsai paprika powder. There is no information on conventional production at farm level because the raw material is mostly imported. At the process level, the allocation of labour to production is higher for Kalocsai paprika powder than for its non-PDO reference. It takes 1152 hours of work to produce a ton of PDO paprika when the reference product requires only 279 hours. The difference (313%) indicates that the PDO product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is of the same order in PDO firm than in non-PDO ones. These results are mostly due to the farms/firms structure, as the FQS requires more labour as this processing method (e.g.: hand drying, small-scalemilling) is quite labour intensive, while the conventional production is more mechanized.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The education attainment indicator, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator for PDO-paprika powder is very low at the farm level: most workers have a primary (75%) or secondary (20%) educational attainment. At the processing level, the educational attainment level indicator is much higher and identical for PDO and non-PDO product: 25% employees have at least a licence (bachelor).

Bargaining power is quite evenly distributed among producers and processors for the FQS, even though processors take advantage over producers, as evidenced by the higher by their higher bargaining power score (0.71 vs. 0.31). This can be explained by a lower number of processors than of producers. Besides, contrary to producers, processors are organized in professional unions, whether pertaining to the FQS or not. Finally, they enjoy small advantage in terms of resource specificity (drying and milling equipment). Bargaining power seems to be even more evenly distributed for the reference.

At the farming stage, Kalocsai paprika growing could be somewhat endangered in its sustainability prospects due to a rather limited employment of 15–35-year-old, compared to 45–65-year-old. It should be noted that because the counterpart product is imported dried paprika which is turned into powder, no data are available for the paprika growing stage of the supply chain to calculate the generational change indicator. Hence, no comparison on the levels of social sustainability can be drawn at the farming stage across the two products.

An even lower level of social sustainability, in terms of the value of the generational change indicator, characterizes the stage of the paprika driers and mills. However, it is as low for the PDO than for its reference.

Regarding the gender inequality indicator, the PDO product is less sustainable than the counterpart, at least at the paprika driers and mills stage, which is the only one for which a direct comparison can be made. This result is due to the very small share of female employment in the Kalocsai paprika supply chain. Everything else being equal across the two supply chains, the higher level of female employment in the processing stage of the reference (imported) dry paprika contributes to a higher level of sustainability of the latter, compared to the PDO product.

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Organic Tomatoes in Italy

Michele Donati, Marianna Guareschi, and Mario Veneziani

Description of the Product and Its History

Northern Italy has been renowned since the end of the nineteenth century as a national centre for the production and processing of tomato. In 2016, with a production of 5.2 million tonnes of processed tomato and a 13.6% share of the global market, Italy was the second largest world tomato producer after California (30%), just ahead of China (13.5%), and the first in Europe (50% of the market), far ahead of Spain and Portugal (around 40% altogether). Half of Italian tomatoes are grown and processed in Northern Italy. The northern Italy tomato cluster area includes the Regions of Emilia-Romagna, Lombardy, Veneto, Piedmont and an area of the Autonomous Province of Bolzano. Three quarters of the area devoted to tomato production is in Emilia Romagna, where tomato for industrial processing is the major horticultural crop, especially in the Parma, Piacenza, and Ferrara provinces (Mantino and Forcina 2018).

Organic tomato represents a niche product and market, although output and sales are increasing every year. In 2017, roughly 6.6% of the utilised agricultural area was cultivated following the requirements of organic production, while the remaining followed the rules of the regulation for integrated production (OI Northern Italy Tomato for Industry 2015). In this chapter, integrated production will be considered "conventional" production, compared to the (higher) "quality" organic production. The whole value chain of tomato production and processing – organic and conventional – is organised in an inter-branch organisation recognized by the Region and the European Union. It accounts for 39,000 hectares of tomato plants, comprises

M. Donati
Department of Chemistry, Life Sciences and Environmental Sustainability, Università di Parma, Parma, Italy

M. Guareschi · M. Veneziani (✉)
Department of Economics and Management, Università di Parma, Parma, Italy
e-mail: mario.veneziani@unipr.it

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2,000 producers grouped into 17 producer organisations and 21 processing companies operating 28 plants, processing around three million tonnes of tomatoes into concentrate, pulp and paste (Mantino and Forcina 2018).

Intrinsic Attributes (Colour, Flavour, Taste) Including the Description of Factors Affecting the Intrinsic Quality Attribute

Tomato is made up of 94% water, 3% sugar, 2% fibers, and 1% protein, vitamins, minerals, antioxidants (lycopene). In the northern Italy cluster, the main variety cultivated is the "round tomato" which is juicy, with a refreshingly sweet flavor. A small percentage of "long tomato" (0.7%) and "cherry tomato" (0.5%) are also cultivated (OI Northern Italy Tomato for Industry 2015). Although tomato is often eaten fresh, the industry in northern Italy processes it for preservation. Tomato can thus be consumed as pulp, concentrate, canned, and in sauces for dishes such as pasta, pizza, vegetables and soups.

Extrinsic Quality Attributes

Links with the Territory

The tomato-producing provinces in Emilia Romagna feature a soil which ranges from predominantly clay, to sandy-clay, to silt. The climate, often characterised by a big difference between day and night temperatures, is ideal for tomato growing (Gray 2009). The value chain is characterised by geographical proximity, long-standing and consolidated relationships between agricultural producers and the local industrial sector, historical traditions and local identity, and a distinctive governance influencing the economic performance and the development pattern at the local level (Mantino and Forcina 2018).

The Characteristics of the Quality Scheme of the Northern Italy Organic Industrial Tomato

The northern Italy organic tomato for industry production system follows the European Council Regulation (EC) No 834/2007 and the Commission Regulation (EC) No 889/2008 which establish organic production standards (i.e., Art.12, Title III, EC 834/2007, see summary in Table 1).

Organic tomato production in northern Italy also fosters environmental protection. Although water consumption is concentrated at the stages of tomato cultivation (irrigation) and manufacturing (cooling and cleaning as well as processing), water consumption along the whole tomato supply chain is nowadays limited by practices

Table 1 Summary of the technical specifications and elements that generate quality

Territory	
Geographical area	No restriction, although this chapter focuses on northern Italy
Varieties	No GMO permitted. Varieties include: Dexter, Fokker, Genius, Guadalete, Heinz 3402, Heinz 4107, ISI29783, Leader, Littano, Mascalzone, Nemacrimson, Nerman, Perfectpeel, Quorum, Ruphus, Terranova UG 13306
Arable farming practices	
Fertilization	The fertility and biological activity of the soil is maintained and increased by multiannual crop rotation including legumes and other green manure crops, and by the application of livestock manure or organic matter, both preferably composted, from organic production. In addition, fertilizers and soil conditioners may be used only if authorized for use in organic production (Annex I CE n. 889/2008). Mineral nitrogen fertilizers not allowed
Plant health	The prevention of damage caused by pests, diseases and weeds is accomplished primarily by natural enemies, selection of species and varieties, crop rotation, cultivation techniques and thermal processes. In the case of recognised threat to a crop, only plant protection products authorised for use in organic production (Annex II CE n. 889/2008) can be used
Field operations	No restriction. Typical operations are: deep pruning (35–40 cm); subsoiling, fertilization (if necessary), sowing (February–April), transplanting, crop protection (if necessary), irrigation, weeding, collection (June–September)
Transportation *From farms to processing plant*	Tractors and trucks
Processing	
First stage	Washing and sorting
Second stage	Sauce or concentrates: shredding at high temperature, refining, concentration, pasteurization, and packaging/Pulps and peeled tomato: peeling of tomato, cutting or shredding, pasteurization, and packaging
Transportation *From processing plants to retailers*	Trucks
Conditioning	In natural conditions without additives and preservatives
Other	

Source: Authors' compilation

aimed at reducing water demand, such as water-saving irrigation systems. In order to save water and maximize both yield and quality, micro-irrigation, including fertirrigation, is the preferred practice for effective and sustainable water management. Micro-irrigation consists in delivering the right amount of water directly onto the roots of the plants or into the soil in very close proximity, using lower pressure and flow than in a sprinkler system. Developing optimal water management strategies is, in fact, one of the main concerns of the tomato supply chain.

The organic tomato quality scheme is also guaranteed by an agreement between producer organisations and the Italian Association of Food Products Industries (AIIPA). The agreement is a framework contract, signed every year, and overall aims to: (i) develop synergies in the scheduling of production quantities and in the classification of the quality of processed tomatoes, as a function of market objectives; (ii) meet the traceability criteria laid down in Regulation (EC) 178/2002 and (iii) guarantee the use of GMO-free tomato, grown following environmentally friendly policies (integrated or organic methods), to increase the share of quality products in national production.

The 2018 framework agreement introduced a specific rule book for organic production, reflecting the increase in production levels over recent years. It establishes specific bargaining methods for organic tomato, and also guarantees additional checks for quality control required by producer organisations and processing firms. Thus, both producer organizations and processing firms are committed to guaranteeing additional checks in the organic tomato value chain.

On one hand, producer organizations work alongside the partner farmers offering advisory services and checking compliance with the production process and the suitability of the product. In this sense they: (a) verify in advance compliance with organic requirements; (b) provide technical advice to farmers on choosing the most suitable tomato variety, purchasing seeds, implementing crop development strategies, agronomic practices, control of weeds according to the procedures laid down in the organic tomato regulation; (c) carry out scheduled self-tests on the organic tomato ready for delivery, including checks for the absence of pesticide residues on the fruit, leaves, roots and soil; (d) verify the traceability of individual tomato loads transported from the field to the processing firms; (e) provide the processing firm with the certainty that each producer organization is certified to sell organic produce, organic certification for each member farm, documentation certifying the organic characteristics of the individual loads of tomatoes transported and the documents in which all the agronomic operations are recorded.

The processing firms also have their own procedures and inspection for the conformity of tomatoes entering factories. They (a) select organic tomato samples in the field to check their compliance with the mandatory requirements; (b) verify the validity of the organic certification of the producer organization; (c) verify farmers' documents about the agronomic practices in the field; (d) verify farms' organic certification; (e) receive from the tomato transporter a health and hygiene statement for the transport used for the organic tomatoes; (f) select organic tomato samples before entering the processing plant to verify compliance with the rules of organic production and the absence of pesticides through specific analyses; (g) process organic tomato through dedicated production lines, or alternatively guarantee that the production lines are completely clean; (h) analyze the processed product to verify the absence of pesticides.

Several labels are used in addition to the organic label. Some of these focus directly on the product and refer to its intrinsic qualities (i.e., 100% Italian, GMO free). Others refer to the entire supply chain and validate its overall management, environmental, ethical and food safety performance. For example, ISO 22005 traces as well as the product itself, the cultivation and processing it has undergone. This makes it possible to determine the history or origin of the product and to identify all the responsible organizations along the food chain. Eco-Management and Audit

Scheme (EMAS) and Environmental Management System (EMS) are EU certifications of the environmental objectives of the farms/firms (i.e., of the organisations) relating to energy, materials, water, waste, biodiversity and emissions. International certifications like ISO are required for exports to certain countries. British Retail Consortium and International Food Standards certifications are nowadays almost equivalent and are required for registration as an exporter with the Food and Drug Administration to access the USA market. Such certifications mainly refer to hygiene and food safety requirements (e.g., HACCP, Good Manufacturing Practice, Good Laboratory Practice, Good Hygiene Practice). Safety, quality, reputation, trust are the essential attributes of this detailed framework. Official recognition of product/process/system quality guarantees the trustworthiness of the tomato stakeholders, reduces transaction costs, adds value to the whole supply chain and signals its differentiation on the market (Mantino and Forcina 2018).

Historical Background

Francesco Cirio established the first pea canning industry in Italy in 1858, and at the end of the century the firm started producing the first processed tomato preserves. In 1888, Brandino Vignali opened a factory in Basilicanova near Parma to produce "tomato extract" following the technique of "black preserve" typical of peasant households. This was obtained by sun-drying the tomato paste, previously concentrated in large copper pots (Canali 2012). The first tomato processing company was founded in Piacenza in 1906. In 1912, ten companies were operating in the Piacenza province and in the following year, due to the first crisis, at least three closed, leading to a 50% reduction in the cultivated area (Periti 1998). From the late nineteenth century, in the area of Parma and Piacenza, as well as in other neighboring areas in the Po Valley, a scientific approach to agricultural production, and training and dissemination for farmers, was developed. There were for example *comizi agrar*i – agrarian meetings– and *cattedre ambulanti* – itinerant chairs. In the same areas and times, the first cooperatives were established, aimed at purchasing new inputs, including chemical fertilizers and machinery, on more favorable terms. Innovative scientific applications of the techniques for the industrial processing of tomatoes were introduced, and produced a concentrate paste that could be easily preserved, distributed and marketed. In 1922, the Experimental Station of Preserves (SSICA) was established in Parma to assist the emerging processed tomato district in its efforts towards technological innovation and development. So the northern Italy tomato supply chain was created thanks to agronomic and technological innovation, and training and dissemination, against a background of favorable social and political conditions of these areas (Canali 2012).

Since the 1980s, a pivotal role has been played by producer organizations. The Common Agricultural Policy (CAP) of the European Economic Community (EEC, later European Union (EU)) required the aggregation of tomato supply in order to access aid from the Common Market Organization (CMO), but producer organizations already existed in the value chain of the northern Italy tomato cluster. They led negotiations on the farm gate price of tomatoes with processing industries, organized collective purchases of production inputs, and offered tailored-made consultancy services and technical support. Later, in order to prepare for forthcoming EU CAP reforms and the challenges related to the decoupling and reduction in levels of support, stakeholders set up the “Processed Tomato Cluster” in 2007 (Mantino and Forcina 2018). During the period 2007–2010, the association expanded its geographical influence to include other areas specialized in tomato production in the nearby Regions (Lombardy, Piedmont, Veneto and the Province of Bolzano). In May 2011, the association evolved into the present Inter-Branch Organization of the Processed Tomato of Northern Italy which was formally recognized by the EU and Emilia-Romagna Region on December 22nd of the same year.

Organic production has been facilitated by the Emilia Romagna Region integrated production scheme through the introduction of the dedicated QC mark (*Qualità Controllata*). Integrated production defines strict rules in terms of chemical input use and water consumption, and can be interpreted as an intermediate step in converting from conventional to organic agriculture. Conversion to organic agriculture for farms using integrated production is less costly and less risky than for conventional farms.

Description of the Territory and the Local Production System

As noted above, Piacenza, Parma and Ferrara are the leading producing provinces in northern Italy with more than 50% of total northern Italy tomato cultivation (Table 2) and feature most of the processing firms of the value chain, representing more than 60% of processed tomato (1.7 million tonnes) (Mantino and Forcina 2018). Emilia Romagna has 17 processing tomato industries, representing 70% of total industries (Fig. 1).

These areas are characterized by relative prosperity with average income per capita exceeding 30,000 EUR per year and high population density. The economy is particularly thriving in the industrial sector, and is supported by a strong tertiary sector and advanced services. The prosperous economy is driven by sectors linked to agriculture, especially machinery for agriculture and food production. However, environmental problems, mainly related to the very intensive modes of agricultural production, impact on the quality of water.

Several factors characterize the area from a production and institutional point of view. These include the coexistence in the same territory of an intensive and highly productive agriculture; world-famous PDOs and PGIs (e.g., Parmigiano Reggiano PDO cheese, Parma ham PDO, and Salame Felino PGI); large agri-food companies specialized in sugar production, grain milling and pasta making (e.g., Barilla), and dairy and pork processing companies. There are also companies specialized in providing services and innovation to food producers. The production area is also famous for the presence of manufacturing enterprises producing for the

Table 2 Area cultivated with tomatoes, both integrated and organic (hectares)

Province	Average total (2011–2016)	Total 2016	Total 2017	Organic 2017	% Organic ha 2017/ Total ha 2017
Piacenza	9,027	9,840	10,003	76.5	0.8
Parma	4,445	4,667	4,666	184	3.9
Reggio Emilia	831	1,050	993	46	4.6
Mantova	3,534	4,129	3,963	37.5	0.9
Cremona	1,988	2,216	2,102	16.5	0.8
Ravenna	2,009	2,136	1,929	350	18.1
Ferrara	6,431	7,429	6,177	1,500	24.3
Alessandria	1,483	1,700	1,821		
Other	5,053	5,328	5,051	99.5	2.0
Total	**34,801**	**38,495**	**36,705**	**2,110**	**5.75**

Source: Report IO (2017)

Fig. 1 Location of the northern Italy tomato for industry processing industries. (Source: Inter-Branch Organization of the Processed Tomato of Northern Italy (http://www.oipomodoronorditalia.it/))

food industry, which deliver cutting-edge technologies for the processing, preservation, storage and packaging phases of the production process. The province of Reggio Emilia especially is home to several companies making agri-food equipment.

It is important to note that there are institutions connected to these industries which support the value chain(s) and local development. As noted above, Parma is the headquarters of SSICA, one of the most important applied research institutions in the preserved food sector globally, which takes part in national and international research projects. Other active institutions include farmer unions, the European Food Safety Authority (EFSA), certification bodies; the Chamber of Commerce, the LEADER agency, the Ente Fiera and public institutions (including the "Mountain Communities" and regional parks). All these public and private entities pursue common goals and deliver significant benefits in the provinces which are the area of influence of the northern Italy tomato cluster. The relations between these institutions are facilitated by the fact that often the members of each institution work simultaneously in multiple institutions ensuring close links between them. This close cooperation reduces transaction costs and is beneficial to the decision-making process.

The Local System

Organic processed tomato production is embedded in the processed tomato Localized Agri-Food System (LAFS). The LAFS is characterized by a very complex structure which is the result of different factors interacting over time. Mantino and Forcina (2018) explain that the value chain encompasses a very detailed system of functional, technological, and organizational relationships between the various actors representing the production and processing stages of the value chain, institutions, research centers, and providers of technical means. Figure 2 summarizes this system: the local system where relevant trade relationships occur (in green) is much wider than the supply chain (in blue) and the inter-branch organization (in pink). Links between actors can be formal and informal, both horizontal (among farmers and among processors) and vertical (e.g., cooperation between producers for the management of processing plants, contractual relations between producer organizations and industry associations).

In the Parma and Piacenza areas, tomato producers are members of local and/or interregional producer organizations (the Interprovincial Associations of Fruit and Vegetables Producers A.In.P.O. and As.I.P.O., and the Interregional Fruit and Vegetables Consortium of Producer Organisations C.I.O.) or of "integrated" cooperatives that grow and process tomatoes (Consorzio Padano Ortofrutticolo-CO.PAD.OR., Consorzio Casalasco del Pomodoro, Agricoltori Riuniti Piacentini-ARP), through which they collectively purchase the means of production, receive agronomic and technical assistance, and sell to processing companies. The biggest private processing companies such as Mutti, Rodolfi, Greci Alimentari and Emiliana Conserve, which have a turnover of more than EUR 50 million and more than 100 permanent employees, are located in Parma and Piacenza, and most of them still belong to the founding families, even when publicly traded. They process nearly half of the tomatoes going through the value chain.

Description of the Value Chain

The value chain of the northern Italy industrial organic tomato cluster consists of three main types of actors which interact with the aim of ensuring the high quality of the final product (Fig. 3).

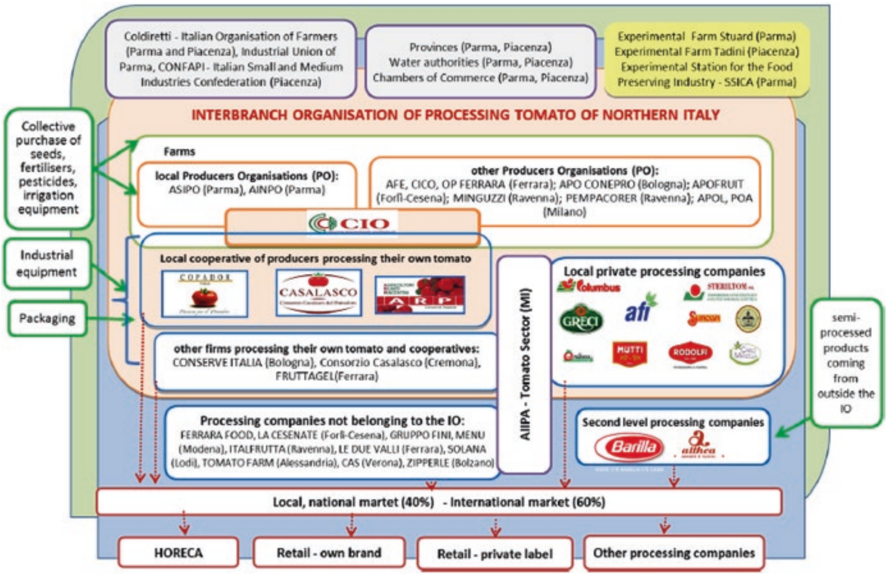

Fig. 2 The industrial tomato system in northern Italy. (Source: Mantino and Forcina (2018))

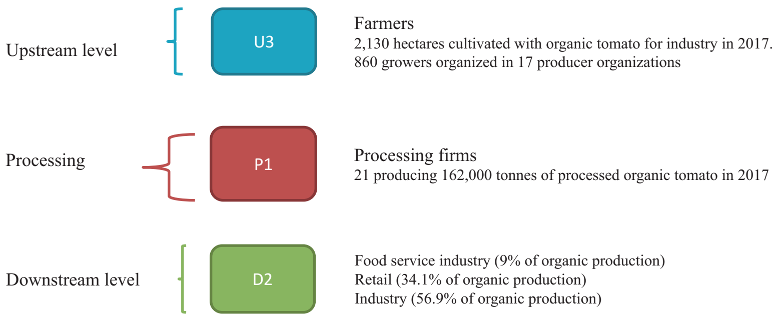

Fig. 3 Value chain technical diagram

Farmers

The area of production of organic tomatoes reached 2,310 hectares in 2017, increasing 75% from 2015 and representing 60.7% of total Italian organic tomato production (IO 2017). In 2018, 2,700 hectares produced organic tomatoes (IO 2018). The number of farms that cultivate both organic and integrated tomato for industry in the northern Italy industrial tomato industry cluster reached 1,860 in 2017. In aggregate, they planted 34,932 ha and are organized in 17 producer organizations. Each farm grows on average 18.78 ha of tomatoes. The volume of tomatoes delivered by farmers in 2017 reached 2,715,084 tonnes, 96% of which was delivered by producer organizations members of the inter-branch organization and just 4% by farms not

Table 3 Quantity delivered by farmers in the North of Italy in 2017

Quantity delivered	Processing firms		Total
	Members of the inter-branch organization	North of Italy-non-members	
Producer organization members of the inter-branch organization	2,566,389	38,230	2,604,619
Farmers not members of a producer organization	110,465		110,465
Total	2,676,854	38,230	2,715,084

Source: OI Report (2017)

represented in the inter-branch organization (Table 3). Tomato prices fell in the last 5 years, reaching 81 €/tonne in 2016 for "round" varieties (mainly used for the production of paste and concentrate), 103.4 €/tonne for "long" varieties (used for canned and pulp) and 137.2 €/tonne for organic tomatoes. For the year 2017, the Framework Contract for Northern Italy agreed on the price of €80.75 per tonne (including 1 euro for services) (ISMEA 2017). Organic tomatoes commanded a higher price at 130 €/tonne in 2017 (Fanfani and Pieri 2017).

A.In.PO and As.I.PO are the main local producer organizations. Both started as producers' cooperatives in the middle of the 1970s and were recognized as producer organizations by the Region in 1997. A.In.PO includes more than 400 tomato farmers (individual producers and two cooperatives); its members cultivate 6,200 hectares and have a productive capacity of 400,000 tonnes per year of industrial tomato. As.I.PO gathers tomato producers growing tomatoes on 5,600 hectares, delivering almost 400,000 tonnes of fresh produce. Another important organization is the CIO, a second-level producer organization established in 2000 on the initiative of four tomato producers and processing organizations (A.In.PO, ARP; Consorzio Casalasco del Pomodoro, Cremona; CO.PAD.OR., Parma) and recently recognized as an Association of Producers Organization. It groups 650 producers cultivating 12,000 hectares (accounting for 30–35% of northern Italy cultivated land), producing 830,000 tonnes of tomatoes and processing 480,000 tonnes of final product (Mantino and Forcina 2018).

Processing Firms

Twenty-one processing firms in the northern Italy tomato cluster operated 28 factories and handled 162,000 tonnes of organic produce in 2017. Organic tomatoes are mainly turned into puree (24,854 tonnes), pulp (19,410 tonnes), double concentrate (12,283 tonnes), other concentrates (2,378 tonnes), frozen products (2,016 tonnes), sauces (145 tonnes) and flakes (24 tonnes) (IO 2017).

There are two different types of processing firms in the northern Italy tomato value-chain: cooperatives and private firms. In 2012, cooperatives processed 43% of total production and private firms processed 56%, while in 2017 the total

Table 4 Quantity of processed tomato (integrated and organic) per firm category (tonnes)

	Cooperatives	Private	Total
2012	986,280	1,303,087	2,289,367
%	43.08	56.92	100
2013	827,520	1,055,915	1,883,435
%	43.94	56.06	100
2014	981,965	1,374,849	2,356,814
%	41.66	58.34	100
2015	1,110,735	1,540,310	2,651,045
%	41.90	58.10	100
2016	1,151,815	1,661,823	2,813,638
%	40.94	59.06	100
2017	920,638	1,764,972	2,685,610
%	34.28	65.72	100
%Var 2017–2012	−6.66	35.45	

Source: OI Report (2017)

tomato processed by cooperatives decreased to 34.3% of total output versus 65.7% processed by private firms (Table 4).

Among the biggest cooperatives that process their own tomatoes there is the Consorzio Casalasco del Pomodoro and CO.PAD.OR. Consorzio Casalasco del Pomodoro is now the first industrial tomato producer and processor in Italy and the third in Europe. In 2015, it took over ARP, a cooperative operating in Piacenza since 1958 in cultivation, processing and distribution of tomato and in 2017 purchased two brands of the Parmalat Group, Cirio and Pomì. It now includes 370 farms cultivating tomato on 7,000 hectares and producing 560,000 tonnes of tomato. It has more than 50 processing lines, formerly belonging to ARP, employs nearly 1,300 permanent and seasonal workers, and generates a turnover of EUR 270 million. CO.PAD.OR. was established in 1987; its members cultivate 4,000 hectares and process around 300 thousand tonnes of fresh tomatoes every year (Mantino and Forcina 2018).

The biggest private processing firms are located in the provinces of Parma and Piacenza and most of them still belong to the founding families. They include Mutti, Rodolfi, Greci Alimentari and Emiliana Conserve. Mutti is the Italian retail market leader: it was set up in 1899, processes almost 200 thousand tonnes of tomatoes grown by 400 tomato farms and employs around 700 people, of whom 150 on a permanent basis. It has a 30% share of the Italian market. 2015 turnover amounted to EUR 234 million (+178% in comparison to 2003), 1/3 of which was earned on the export market. Mutti is very pro-active in product and process innovation, and willing to pay higher prices for tomatoes produced under stringent rules in order to achieve high quality levels. Rodolfi was founded in 1896 and in 2013 merged with the processing firm E&O Von Felten. It processes almost 150 thousand tonnes of tomatoes and employs around 200 people. It sells to the retail market, i.e. the final consumer, to further processors and abroad. In fact, 1/4 of its turnover is on the export market (Mantino and Forcina 2018).

Small and medium sized processing firms with less than 100 employees are the key to ensure the product is processed locally and maintaining organizational and operational diversity in the northern Italy tomato cluster. Notable examples include well-structured old family business (Columbus, Steriltom, Carlo Manzella), small scale tomato processors (Terre di San Giorgio) and operations specialized in processing fruit and vegetables, of which tomatoes are only a small percentage (Suncan). Columbus was established in 1983 and belongs to the group Romano Freddi of Mantova, owned by the same family, processes tomato in a plant active since 1912. It employs more than 70 people; processes up to 150 thousand tonnes of tomato, mostly for third parties, and exports 65% of its output. Steriltom was established in 1934 and still belongs to the Squeri family, which is also a tomato grower. It employs 25 people, processes around 150 thousand tonnes of tomato and is a leader in pulp production for the food service industry and further industrial processing, with a turnover of around EUR 45 million, 55% on the export market (Mantino and Forcina 2018).

Marketing Channels

Processed northern Italy organic tomatoes are mainly sold for further processing to other companies to make ready products (56.9%), to retailers (34.1%) and to the food service industry (9%) (IO 2017).

Chain Governance

The northern Italy organic processed tomato value chain is characterized by an innovative governance system, the inter-branch organization, which ensures both vertical and horizontal cooperation. The inter-branch organization facilitates establishing and maintaining shared rules and specific tasks of coordination and control. It encourages collaboration between producer and processor organizations to ensure the economic, environmental and social sustainability of the final product.

The inter-branch organization is composed of farmers, all members of producer organizations, and associations of producer organizations and private and cooperative processing firms. It involves 62 members representing all the key actors of the tomato value chain. Decisions are taken by a majority of three-quarters of the ordinary members; the vote of each member weighs in proportion to share in the total output. However, neither tomato growers collectively, nor tomato processors as a group can tilt decision making in their favor. Advisory members are Province authorities, Chambers of Commerce, farmers' unions such as Coldiretti, and representatives of processing firms (i.e., UPI, CONFAPI, and AIIPA). They do not have the right to vote but have the right to issue opinions. Ordinary members are all the private processing industries, the cooperatives of producers processing their own tomato (e.g., CO.PAD.OR., Conserve Italia, the recently merged ARP and Consorzio Casalasco del Pomodoro), the producer organizations (ASIPO and AINPO), the association of producer organizations (e.g., the Interregional Fruit and Vegetables Consortium – CIO) and all the other processing firms and producer organizations (e.g., AFE, CICO, APO CONERPO, APOFRTUIT, Ferrara Food, Conserve Italia, Tomato Farm) (Mantino and Forcina 2018).

The inter-branch organization is a "neutral" institutional space where the tradeoff between intensification, cost-reduction and improved quality requirements of the processed tomato is negotiated. Farmers may push towards intensification, while the industrial sector may try to raise the quality features of the processed product. The fundamental tool to reconcile these conflicting positions is the quantitative and qualitative programming and control of production, which takes into account the volume of market demand. The inter-branch organization provides assistance, a common identity and a united voice, by defining and managing fair rules of conduct concerning the exchange of information and cooperation. It does not intervene in any transaction within the value chain; nevertheless, it exerts a key influence in stabilizing the market. It manages vertical relationships between producers and processing firms, acts as a guarantor of the compliance with the rules agreed upon, monitors the requirement to use only tomato produced in the area, and supports producers and processors in managing the general contractual framework and the reference price, in a transparent manner. Moreover, it facilitates implementation and consent with the single supply/delivery contract with respect to the price and terms of payment, and handles the exchange of data concerning the tomato growing campaign, such as origin, quantity and quality of tomatoes. These functions impact effectively on the stability and sustainability of the LAFS over time, strengthening the sense of belonging, ownership, and equality of treatment among members (Mantino and Forcina 2018).

Sustainability Assessment

The sustainability performance of the northern Italy organic processed tomato has been assessed using the Strength2Food method (Bellassen et al. 2016). The values of the indicators for the organic product are compared to those for the reference product, which is tomato produced under the integrated production scheme in the northern Italy processed tomato district (Fig. 4). All calculations are based on primary data collected from supply chain members (e.g., the northern Italy processed tomato inter-branch organization, tomato processing companies, tomato farms) and secondary data extracted from the scientific and technical literature, agricultural handbooks and databases (e.g., the Italian FADN). Each indicator is expressed as the difference between the FQS and its reference product. For the environmental indicators for which lower is better, the opposite of the difference (e.g., +20% when the carbon footprint is 20% lower) and the supply chain total – rather than supply chain average – are displayed.

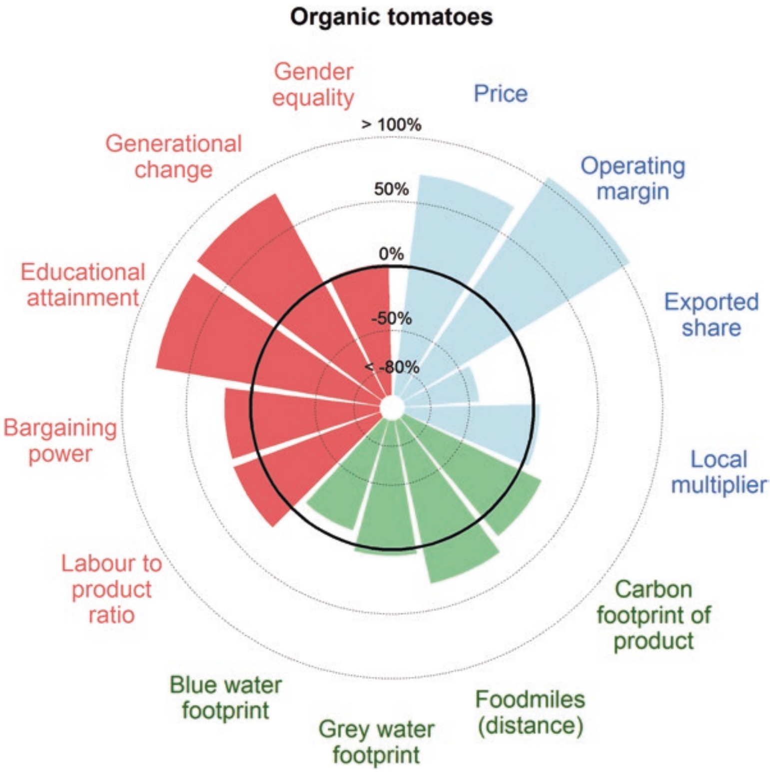

Fig. 4 Sustainability performance of organic tomatoes (supply chain averages). (Each indicator is expressed as the difference between organic tomatoes and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

Economic Indicators

Price Premium, Profitability and Value Distribution

The price of the northern Italy organic processed tomatoes is 63% higher than the reference product, at both farm and processing level. At the downstream (retail) stage, the price of the organic product is almost double. The price premium recorded for the organic product reflects consumer willingness to pay for higher quality (i.e., fewer health risks) of the FQS. The gross value added is higher at the farm (77%) and processing levels (44%) for the FQS, compared to the reference product (49% and 41%, respectively). The gross operating margin is higher by 24% for organic tomato compared to the reference tomato at farm level (35% vs. 11%), and is slightly lower at the processing level (28% vs. 30%). Organic processed tomato products are exported less than the reference (23% vs. 39%). This has implications for the food miles indicator (see below). The processing technology used for organic tomato is the same as that used for the reference tomato; in other words, processing costs are the same and the price commanded at every stage is higher, so the margin at the processing stage for organic production is higher in absolute value, although slightly lower in relative terms.

Local Multiplier

The local multiplier for the northern Italy organic processed tomato is slightly higher than the multiplier of the reference product (2.05 and 1.96, respectively). For organic tomatoes, because the indicator exceeds two, one euro spent purchasing processed organic tomatoes generates more than one euro of extra financial flows within the local area. For the reference product, the extra financial flows fall just short of one euro. All the tomatoes, organic and reference, originate from the same area. The location of tomato farms is a key variable that contributes to the high local multiplier for both products. If tomatoes originated from outside the local area, the local multiplier would decline by more than 50% in both cases. The higher share of payroll spending on local employees at the processing stage in the organic tomatoes value chain is the main determinant of the improved local performance of the FQS compared to the reference product. The second main determinant is the payroll that accounts for more than 13% of the value of the indicator. In this respect, seasonal labor at the processing stage appears to be the main factor affecting the payroll weight in the value of the local multiplier.

Environmental Indicators

Carbon Footprint

The carbon footprint of fresh organic tomatoes and their reference, 18 and 34 kgCO_2e ton^{-1} respectively, are lower than the literature range of 6,000 kgCO_2e ton^{-1} (Clune et al. 2017). This wide range found in the literature is the result of different production methods, with very high values for growing tomatoes in heated greenhouses, where most of the carbon footprint comes from greenhouse construction and heating (Almeida et al. 2014; Röös and Karlsson 2013). Tomatoes grown in open fields in Italy are thus below the range. The bulk of the 48% difference between organic tomatoes and the reference product is because no synthetic nitrogen fertilizers are used for organic tomatoes. This gain is only marginally offset by the 13% lower yield of organic tomatoes. The integration of processing reduces the difference between the organic and reference product. In fact, the carbon footprint of processed organic tomatoes, shown in Fig. 4, is only 18% lower than the carbon footprint for the reference product, with 147 and 180 kgCO_2e ton^{-1} respectively.

Extended Food Miles

Over the entire supply chain, from tomato farms to distribution units (U3-D1), organic tomatoes travel 30% shorter distances (2,000 km vs. 2,800 km) and release 20% less emissions (130 vs. 165 kg CO_2 eq.) than their reference product. This difference is mostly driven by the differences in the destination of the final product (i.e., export or domestic market): 35% of the organic processed tomatoes are exported against 60% of the reference processed tomatoes. Because a lower percentage of output is exported, organic processed tomatoes travel shorter distances and emissions are lower. Otherwise, organic processed tomato shows patterns similar to the reference product: it is exported in the same proportion, to similar export countries, and sold in similar proportions throughout Italy. A somewhat larger share of organic product is distributed in northern Italy, which implies shorter distances and lower emissions, but this is not enough to offset the longer distances and higher emissions of the reference product on the export market. The distribution level (P1-D1) concentrates most of the kilometres embedded in the product and most of the emissions, more than 90%, generated for transportation along the value chain. Regarding the food miles indicators, organic processed tomatoes are thus more sustainable than their reference product in terms of distance travelled and emissions released at the transportation stage.

Water Footprint

Overall, organic processed tomatoes show a higher water footprint than the reference product. The difference in yields is the main reason for the difference in the green water footprint (rainwater use). In fact, crop parameters and weather conditions are exactly the same. The grey water footprint (water pollution by nitrates) is slightly higher for the reference crop. This reflects the higher amount of nitrogen that is used: both mineral and organic fertilizers are applied to the reference product whereas only organic fertilizer is applied to organic tomatoes. However, in terms of tonnes of substance applied, considering both mineral and organic nitrogen fertilizers, the amount is equal on a per hectare basis; there is no difference, with 25 kgN/ha applied.

The blue water footprint (surface and groundwater use) of organic tomatoes for industrial processing (32.6 m^3/t) and of the reference product (28.5 m^3/t) are comparable with regional and country average values (32.9 m^3/t; 30.7 m^3/t). The green water footprint of both types of tomato is lower than the regional and national values.

The life cycle analysis component of the blue water footprint is higher for the reference product (2.74 m^3/t versus 2.33 m^3/t) and is essentially due to the higher nutrient and pesticide use. The processing phases are exactly the same, which means that the same amount of blue water is consumed by the two products.

Social Indicators

Employment

The labor use ratio indicator, calculated on the basis of output, reflects labor requirements for a unit of physical output. The allocation of labor to production is higher for organic tomatoes than for the reference product. At farm level, it takes 4 hours of work to produce a tonne of organic tomatoes while the reference product requires 3 hours. The difference (33%) indicates that organic production requires more labor than the reference one. The turnover-to-labor ratio indicator provides an insight into the average product of labor. The average turnover per employee is slightly higher on organic farms than on conventional ones. The average product of labor level is much higher at the processing stage, with a relative difference of 63% in favor of organic tomatoes. This is due to better market conditions and higher consumer willingness to pay for organic products than conventional ones.

Bargaining Power

The organic supply chain is characterized by the dominance of one leading player at the processing stage, whose influence is counteracted by a producer organization made up of tomato producer members. Bargaining power can be qualified as fairly evenly distributed along the supply chain, although the downstream level has a persistent advantage over the upstream one. The upstream level in fact has a more favourable competitive position; processors enjoy a commercial advantage over producers, because they have a higher degree of contractual flexibility with downstream levels than do producers with processors. This bargaining power advantage is, in turn, partially offset by institutional factors.

Overall, the bargaining power distribution scores of the FQS and the reference product are fairly similar, and it appears that organic certification does not provide an advantage over the reference product.

Finally, comparing the weakest stages of both supply chains, average bargaining power scores obtained at farm level for both supply chains are 0.45 for organic and 0.44 for the reference product. This reveals vulnerability to significant changes in the competitive structure or market position for both supply chains.

Educational Attainment

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The educational attainment indicator, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The educational attainment indicator is higher for the employees of organic farms. The difference is 153% and is attributable to the fact that 38% of producers have employees holding at least a first cycle degree or equivalent. There is no difference at the processing level.

Generational Change and Gender Equality

At the farm stage, the generational change indicator is 160% higher for organic tomatoes than the reference product. However, because it is lower than 100% for both products, both could be deemed endangered as they employ more 45–65 year-olds than 15–35 year-olds. Likewise, there is higher gender equality at farm level for the FQS, reflecting the higher level of female employment and female education.

At the processing stage, both products perform equally because the organic and conventional products are processed in the same plants, with the same personnel. The generational change indicator is much higher than 100%, indicating that a higher number of young people are employed at the tomato processing stage than older people. This may reflect the high reliance on seasonal labor provided by students. Both products perform poorly regarding gender equality mainly due to the extreme levels of inequality in the ownership of processing firms, which is the exclusive domain of males. This is not offset by the high, and equal across gender, share of employees with higher than secondary education levels at the processing stage of the chain. The evidence of a high level of education at the processing stage is consistent with its reliance on young seasonal workers; these are often university students who have completed upper secondary education, and thus raise the value of the indicator.

At supply chain level, the generational change indicator for the organic product is 80% higher than for the reference product, while the gender equality indicator for both products is almost identical.

Conclusions

The volume of northern Italy organic processed tomato is increasing every year. This means that farmers, processing firms and all the actors involved in the value chain are looking for higher quality and food safety, paying special attention to the environmental and social benefits of production methods, and the move towards organic production fulfills these expectations. This trend is possible because organic production is embedded in the northern Italy processed tomato cluster, which is the expression of the interaction of agronomic and technological innovation and training as well as the social and institutional conditions of the area. The contractual arrangements between producers and processing firms, and the governance model of the inter-branch organization, are key elements in the increase in quality and provision of environmental and social benefits in the LAFS. Public policies support the value chain, promoting and fostering collective producer actions and the coordination of producers and processing firms. The drive towards higher quality has encouraged the creation of national and regional quality schemes, such as QC, which promote an integrated production system aiming at reducing environmental impacts, while maintaining high yields and prices. This is facilitating the final move towards organic production methods, reducing the costs of conversion, providing improved management capabilities, and benefitting from the support of the inter-branch organization for both farmers and processing firms.

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PDO Opperdoezer Potatoes in the Netherlands

Jack Peerlings and Liesbeth Dries

General Information

The Opperdoezer Ronde is a potato variety that was first grown in 1860 by farmer J. Sluis in the village of Opperdoes in the province of North-Holland in the Netherlands (Fig. 1). In 1996 the Opperdoezer Ronde became a PDO protected product but the product is, in fact, much older (Veerman 2015).

The Opperdoezer Ronde is a so-called 'nine-week' potato', because 9 weeks elapses between planting the seedling and harvesting. Because of the trend to grow the potato earlier in the season, however, 9 weeks is no longer an accurate name as the growing period is now between 10 and 12 weeks. The Opperdoezer Ronde is an early potato that grows from May till September, and is therefore only available to the consumer in summer and autumn. The potato has a very thin fragile skin and is therefore sometimes harvested by hand, in which case it is a more labour intensive product than other potatoes. The Opperdoezer Ronde is officially described as a yellow/white fiberish, irregular shaped, oval, deep eyed tuber with a low starch percentage. The potato grows best on high, light, sulphur rich soils. These soils contribute to the taste of the potato (Veerman 2015).

The potato is grown in the village of Opperdoes, which covers an area of 1600 ha of which 1100 ha of farmland. 450 ha of the farmland is assigned to growing Opperdoezer Ronde. The potatoes are grown every 3 years in the crop rotation, so on average 140–160 ha of land is used yearly for the production of Opperdoezer Ronde (see Fig. 1). The Opperdoezer Ronde fits in a production system in which farmers also grow other crops, mainly cabbage (sometimes also on the same land later in the season). Crop rotation is applied to prevent potato fatigued soils. The total potato production was 3,159,707 tonnes in the Netherlands

J. Peerlings (✉) · L. Dries (✉)
Agricultural Economics and Rural Policy Group of Wageningen University, Wageningen, Netherlands
e-mail: jack.peerlings@wur.nl; liesbeth.dries@wur.nl

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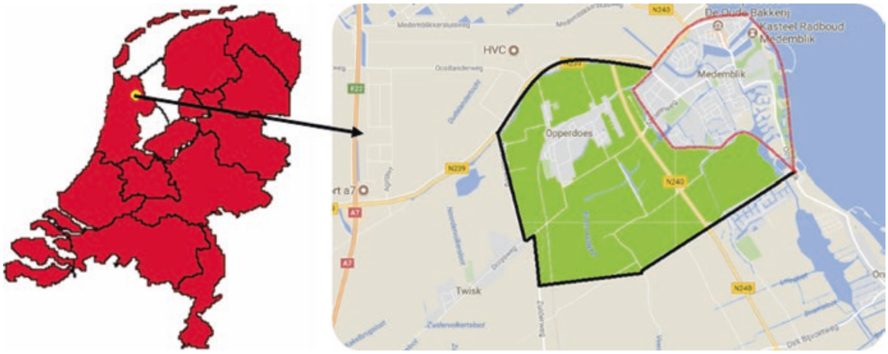

Fig. 1 The location of the village of Opperdoes in the Netherlands. In green, areas where cultivation of Opperdoezer Ronde is permitted in and around the village of Opperdoes. The area of the village of Medemblikis shown in red. There is an on-going debate over whether Medemblikis should also be allowed to grow Opperdoezer Ronde. (Source: Manshanden 2018)

in 2016 (CBS 2017). The yearly production of Opperdoezer Ronde varies between 3000 and 4000 tonnes. So the Opperdoezer Ronde has only a very small market share (Veerman 2015 and Manshanden 2018).

The Opperdoezer Ronde is one of the few products in the Netherlands with a PDO status (e.g. Mout 2004). There are no other potatoes that have this status. The co-operative the 'Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA' holds the rights to produce the potato. The main reason for the co-operative to apply for the status of PDO was to protect their market position at relatively low costs. Given that the Opperdoezer Ronde is a special potato variety, with a long-standing tradition (i.e. grown from 1860) and that is grown in a specific area (i.e. Opperdoes) the co-operative was able to gain PDO status.

The data used in this research are based on an interview with an expert in the area of potato growing, an interview with the chair of the co-operative the 'Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA' and an interview with a farmer who both breeds and grows Opperdoezer Ronde. The quality of data cannot be guaranteed and our figures should be interpreted and used with caution. This is especially true because the stakeholders were hesitant to share information.

Technical Specifications

As noted in the first section, the Opperdoezer Ronde is officially described as a yellow/white fiberish, irregular shaped, oval, deep eyed tuber with a low starch percentage (EU streekproducten.nl 2018). The potato grows best on high, light, sulphur rich ground. The area around the village Opperdoes has these soils, and therefore, the growing area is limited to the village Opperdoes (see Fig. 1). This is the only official 'technical' description given in the application for the PDO status and on the basis of which the status is granted (Product dossier 2017).

The Opperdoezer Ronde is a firm-boiling potato with a unique taste. The taste is partly determined by the soils on which it is grown and the location of the growing area relatively close to the sea. It is an ideal potato to serve with melted butter but it can also be used for frying and baking or as an ingredient in salads. Because of its thin skin it has to be handled with care, and peeling is not necessary. Given that the Opperdoezer Ronde has been grown since 1860 it has become part of Dutch heritage (Veerman 2015).

Because the growing season is shorter than for regular potato varieties, the use of inputs such as fertilizer and plant protection (i.e. pesticides etc.) per hectare is somewhat lower (but not per kg harvested). Water availability is not an issue. There is no irrigation because rainfall is sufficient in every period of the year. Some fields have a drainage system, this is however also the case for regular potato fields (Manshanden 2018).

Value Chain

Marketing

There are 20–25 producers of the Opperdoezer Ronde who work together in the co-operative the 'Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA'. This co-operative holds the rights to produce the potato. The farmers are allowed to sell one third of their harvest through direct farm sales and the rest is marketed through a company called The Greenery (via a subsidiary called J.H. Wagenaar), a large company marketing many other vegetables and fruits. J.H. Wagenaar concluded a contract with 'Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA' to get the sole right to market the Opperdoezer Ronde. Interviews indicate direct farm sales are much smaller than the permitted one third of the harvest but exact data on direct farm sales are not available. J.H. Wagenaar is the wholesaler in Fig. 2. Within J.H. Wagenaar, there is one person responsible for marketing. The potatoes are

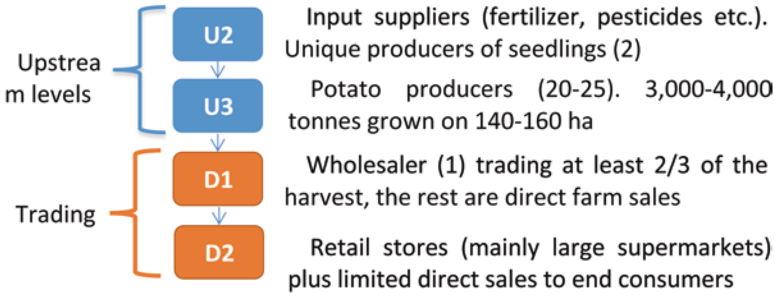

Fig. 2 Opperdoezer Ronde value chain

mainly sold to large supermarkets. There are no exports. J.H. Wagenaar receives a commission of roughly 5% which is common for this type of relatively small product (Manshanden 2018).

Seedlings

The seedlings for the Opperdoezer Ronde are grown by two growers in isolation from regular potato growers to prevent infections. The two growers are under contract with the "Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA". To protect the potato from generic products, the seedlings are only sold by the co-operative to the farmers (Manshanden 2018).

The two growers use strain selection methods in order to sustain and multiply the existing strain. They do this using two methods, the classical method and the laboratory method. The classical method comes down to selecting plants on the fields on the basis of appearance, strength, earliness, the amount of potatoes per plant, size of potatoes and if all the potatoes have more or less an equal size. The ones that score high on these criteria will be kept aside and will be used by the seedling growers to multiply. The plants that score low, have diseases or have become mixed with other breeds, will be destroyed. The laboratory method uses seedlings created in the laboratory, which are then selected on the same criteria after determining that they are free of diseases. There is no visible difference between the seedlings from the two methods. In both methods the seedling growers will multiply seedlings over a few years to reach a volume large enough to supply all the 20–25 producers with clean seedlings (Manshanden 2018).

In the case of Opperdoezer Ronde the certification cost comes in the form of an annual contribution to the "Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA". The contribution is about €40 per farmer and per year. In addition, the cost of the seedlings are about €0.69 per kilo, while conventional seedlings cost about €0.28 per kilo. In an interview with a breeder / grower it became clear that the higher cost does not relate to the small volume, but solely to the costs borne by the organisation. These costs include publicity and lawyers when needed (Manshanden 2018).

Sustainability Performance Assessment

To assess the sustainability performance of the Opperdoezer Ronde, we compared the Opperdoezer Ronde with consumption potatoes grown in IJsselmeerpolders, an adjacent region. Information on output and input use of consumption potatoes in the IJsselmeerpolders was published in the KWIN report (WUR 2015). Consumption potatoes are used for direct consumption or the production of potato products such as fries and potato chips. Besides consumption potatoes there are seedlings and

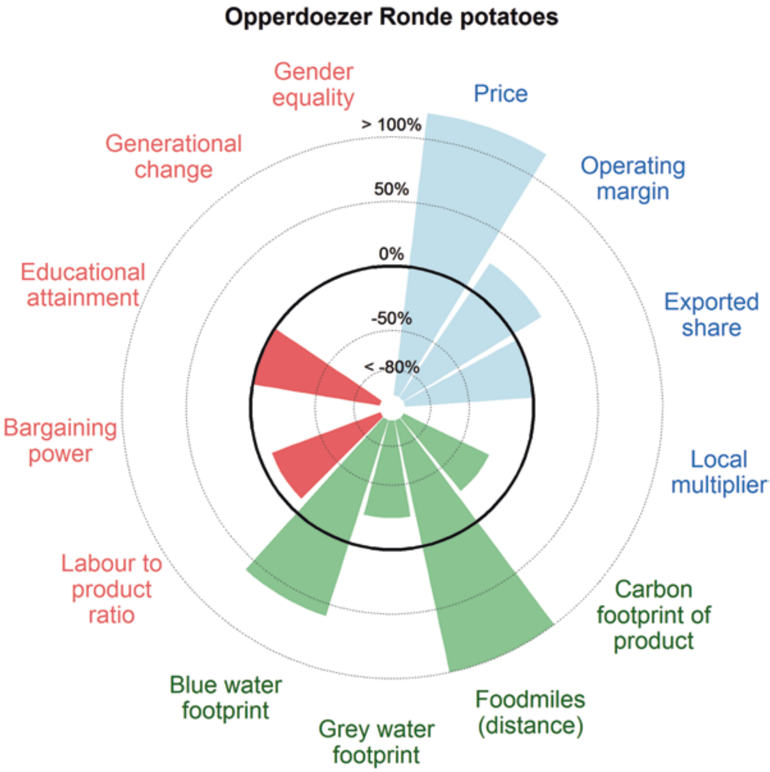

Fig. 3 Sustainability performance of Opperdoezer Ronde (supply chain averages). (Each indicator is expressed as the difference between Opperdoezer Ronde and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

starch potatoes, both of which are important in the Netherlands. Figure 3 presents the score of the Opperdoezer Ronde on different economic, environmental and social indicators. We discuss the different indicators clockwise starting with the price and operating margin.

Price and Operating Margin

The price of the Opperdoezer Ronde is 4.6 times the price of regular consumption potatoes (0.74 €/kg versus 0.16 €/kg). However, combined with the lower yield (25 tonne/ha versus 54 tonne/ha), this results in a smaller difference in revenue per hectare (18.5 €/ha versus 8.3 €/ha). Slightly higher operating costs for the Opperdoezer Ronde make the difference in operating margins smaller than the difference in revenues (15,700 €/ha versus 5900 €/ha). However, the difference is still substantial.

Exported Share and Local Multiplier

The Opperdoezer Ronde is a very small product with an annual production of only 3000–4000 tonnes while total potato production in the Netherlands is more than three million tonnes. The production is sold only domestically, so there are no exports. Consequently employment and income generated are both small. The reference product is much bigger and a large share of it is exported (24% of its value). Interviewees report that because of the Opperdoezer Ronde, the village of Opperdoes has become more widely known and that this might have a positive effect on the number of tourists visiting the village, but the effect is probably small. However, because the Opperdoezer Ronde has been grown since 1860, it has become part of Dutch heritage.

Carbon Footprint

Without transport, the carbon footprint of the PDO is 30% higher than the reference – 84 and 65 kgCO_2e per tonne respectively. Indeed, the higher yield of the reference product more than compensates for its higher use of mineral fertilizers. The lower yield of the PDO largely stems from the technical specifications: as an "early potato", the Opperdoezer has a shorter growing period than regular consumption potatoes. The lower fertilizer use is an indirect consequence of this shorter growing period: the Opperdoezer would not have time to profit from higher amounts of fertilizers. For the same reason, the diesel use per hectare for cultivation and the electricity use for storage are also lower. However, both footprints are on the lower end of the levels found in the literature, which range from 80 to 360 kgCO_2e per tonne (Clune et al. 2017; Meier et al. 2015). Indeed, potato cooling, which usually accounts for around 50% of the energy demand is 100 times less carbon intensive in the Netherlands than in the UK (Hillier et al. 2011).

Food Miles

Concerning food miles, the PDO Opperdoezer potato supply chain was compared to the conventional fresh consumption potato chain in the Netherlands. The Opperdoezer Ronde is not exported so transport is limited to transport from the farms to the distributing company J.H. Wagenaar, transport from J.H. Wagenaar to retailers' distribution centres and from the centres to local retail shops. We were not able to estimate these distances, and obtained reliable data only for exports. There is a substantial difference between the FQS and its reference. Indeed, exports of Opperdoezer potatoes are considered negligible, while 30% of the Dutch conventional fresh consumption potato production is exported. On average, the FQS travels 0 km while its reference travels 2000 km for exports, and 570 km at the distribution level (P1-D1), assuming 0 km distance for products distributed on the domestic market. The PDO therefore releases far fewer emissions (0 $kgCO_2e$ instead of 30 $kgCO_2e$) than the reference. The higher emissions embedded in the reference can be explained by the emissions resulting from exports.

Grey and Blue Water Footprint

Overall, the Opperdoezer Ronde shows a higher water footprint value than its IJsselmeerpolders reference (Fig. 4). The reference product however consumes more blue water (surface or groundwater). The Opperdoezer Ronde shows a higher impact in terms of both green (rainwater use) and grey water footprint (water pollution by nitrates). What determines the difference in the blue water footprint is the amount of water required in the processing phase, which coincides with the storage phase before selling, because the Opperdoezer Ronde is not processed. If only the blue water footprint in the cultivation phase is considered, then the Opperdoezer Ronde shows a higher water requirement than the reference product (11.9 versus 9.37 m^3/tonne). However, this discrepancy is not due to the water required by the potato plants but it refers to the overheads, the water used for operations connected with potato production (e.g. fertilizer and phytosanitary production, energy production, diesel production, and so forth).

By looking at the different values of fertilizers and phytosanitary products applied, the reference product makes use of more of these substances than the Opperdoezer Ronde. For example, for nitrogen fertilizers the amount used for the reference product is one and a half times the amount applied to the Opperdoezer

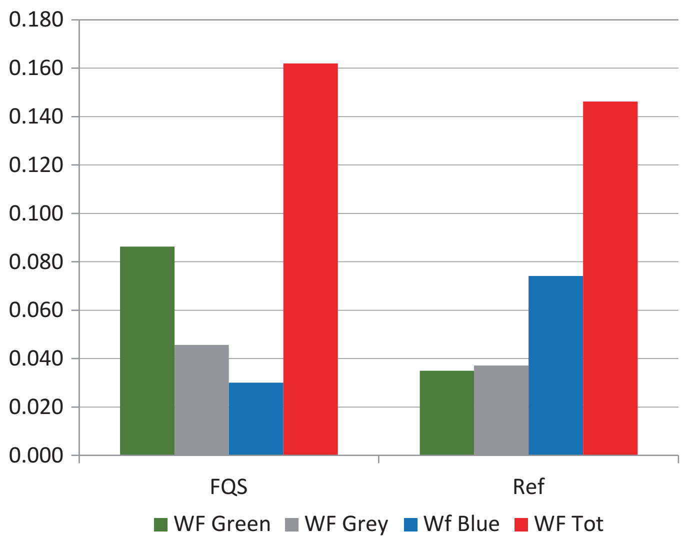

Fig. 4 Water footprint

Ronde. Hence, one would expect that blue water (overheads) and grey water footprint will be higher for the reference product. However, this is not the case because of the more than twice higher yield of the reference potato. In fact, yield is the most discriminating factor between the two productions, as most of the other parameters used to compute water footprint (soil and crop parameters), as well as meteorological data, were the same.

Water is not scarce in Opperdoes nor in the IJsselmeerpolders, so there is no irrigation. This also makes the green water footprint indicator (rainwater use) largely irrelevant. However, it is standard to have a drainage system for the fields. The use of fertilizers and plant protection products is especially relevant in the Netherlands given the concerns for water quality. The application of fertilizers and plant protection products is highly restricted by application norms. Most fertilizers come from artificial fertilizer. Given the shorter growing season, the use of fertilizers is lower than for the reference crop (145 versus 252 kg N, 65 versus 105 kg P_2O_5 and 23 versus 180 kg K_2O) but per kg of potatoes this is different because of the lower yields. The same goes for most plant protection products. One should also note that the land used to grow Opperdoezer Ronde is mostly used for a second crop later in the season.

Labour

The labour use ratio indicator, calculated on the basis of output, reflects labour requirements per unit of physical output (Just and Pope 2001). The allocation of labour to production is lower for Opperdoezer Ronde potatoes than for its non-PDO reference. At the "farm" level, it takes 27 hours of work to produce a tonne of Opperdoezer Ronde potatoes while the reference product requires 30 hours. The difference (−10%) indicates that the PDO product generates fewer jobs than the reference system. The main reason for the difference is the shorter growing season of the Opperdoezer Ronde leading to a lower requirement, which is not offset by the higher requirement from the small fraction of the Opperdoezer Ronde fields which are manually harvested. When there is manual harvesting, the work (up to 340 hours per ha) is largely done by high school youngsters, who can also find seasonal employment in the flower bulb industry. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 147% higher in PDO farms than in non-PDO ones. This difference is mostly due to the higher price of the Opperdoezer Ronde.

Education

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The educational attainment indicator, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level, and approaches 1 as the level of education increases. The interviews give no indication that there is a difference in the profile of education levels between producers of Opperdoezer Ronde potatoes and those in the reference sector. As indicated in the agricultural census, the level of education of farmers is dominated by secondary (29%) and tertiary (54%) school degrees.

Bargaining Power

There are 20–25 farmers co-operating closely in the co-operative 'Coöperatieve Pootaardappelteeltvereniging "De Opperdoezer Ronde" WA.'. The co-operative determines the level of production. In this respect they have market power. The co-operative deals with one wholesaler, J.H. Wagenaar. Given the one to one relation with the wholesaler it is difficult to determine the bargaining power of the co-operative towards the wholesaler. For the wholesaler, the Opperdoezer Ronde potato is only a small product. Given that the Opperdoezer Ronde is only a small product for J.H. Wagenaar, it is likely that the trading conditions are largely determined by the wholesaler. However, compared to the large amount of producers of the reference product it can be expected that the producers of the Opperdoezer Ronde have more bargaining power than the producers of the reference product.

Generational Change

The cooperative and the experts interviewed did not possess data on the age of farmers, nor did they feel confident to assess this aspect. However, from the interviews it appears that the number of producers of the Opperdoezer Ronde is constant over time, which indicates that there might be less generational change than for the reference product.

Gender Equality

Unfortunately the cooperative and the experts interviewed did not possess data on gender equality, nor did they feel confident to assess this aspect.

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PGI Kaszubska Strawberries in Poland

Agata Malak-Rawlikowska and Edward Majewski

The Polish Strawberry Market

Polish Regulations and Institutions Dealing with Food Quality Schemes

Polish farmers are trying to actively exploit the opportunities offered by EU's agricultural product quality policy. This is reflected by the steadily rising number of food products registered under the Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Speciality Guaranteed (TSG) schemes. According to the Polish Ministry of Agriculture and Rural Development in 2018 there were 36 products registered within these EU quality schemes in Poland.

In Poland, as in most EU countries, the PGI control system is based on private certification bodies recognized and supervised by the designated authorities. The Polish system consists of the following entities: Ministry of Agriculture and Rural Development – which authorizes the certification bodies to carry out inspections and issuing and revoking certificates of conformity in PGI and Agricultural and Food Quality Inspection (Głowny Inspektorat Jakości Handlowej Artykułów Rolno-Spożywczych GIJHARS) – which supervises the certification bodies and oversees Food Quality Schemes.

In 2018, there were four certification bodies authorized by the Ministry of Agriculture and Rural Development verifying compliance with specification of PDO, PGI and TSG products. The selection of certification body is made by producers, who cover the costs of the inspection. This inspection has the objective of

A. Malak-Rawlikowska (✉) · E. Majewski
Faculty of Economic Sciences – Warsaw University of Life Sciences – SGGW, Warszawa, Poland
e-mail: agata_malak_rawlikowska@sggw.pl

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checking whether the product complies with the declared specification. The scope and frequency of checks depend on the product's manufacturing process.

In January 2019, there were 766 producers of all PGI in Poland, up from 19 producers in 2008. The *Kaszubska Strawberry* was registered as PGI in November 2009 by a group of 18 producers. In 2018, there were 27 active producers in the group (GIJHARS 2019).

Government Support for PGI

There are no regular direct support measures for PGI producers except for organic farmers, who receive per hectare ecological production subsidies from the first pillar of the Common Agricultural Policy. However, PGI producers may apply for subsidies from the Fund for Promotion and Marketing of Food Products under the program of the Polish Ministry of Agriculture and Rural Development. Special support measures have been also designed under the Rural Development Program for the years 2007–2013 and 2014–2020, but these measures are not directly targeted at the development of PGI.

Conventional Strawberry Production and Market in Poland

Poland is a significant producer of soft fruits in the EU. Production of strawberries has been stable for many years and amounts to around **200 thousand** tonnes per year (IERGiŻ 2018).

The area of strawberries in Poland has ranged between 49 and 53 thousand hectares over last years (GUS 2019). Different weather conditions influence year-to-year fluctuations of production volume (Table 1).

Poland belongs to the leading strawberry growing countries in the world (Gołębiewska and Sobczak 2012), and is the second largest in the EU with 17.4% share of the market, after Spain (31.6%) (IERIGŻ 2018).

About 13 thousand tonnes of strawberries produced in Poland are exported yearly to different EU and Non-EU countries (GUS 2019). In 2016 about 60% of the export went outside EU – to Belarus, Norway and other non-EU countries (Table 2).

Table 1 Strawberry production in Poland

Year	Volume (thousand tonnes)	2014 = 100%	Area (thousand hectares)	2014 = 100%
2014	202.5	100	52.7	100
2015	204.9	101	52.1	99
2016	197.0	97	50.6	96
2017	177.9	88	49.6	94
2018	185.0	91	52.0	99

Source: Based on data from Main Statistical Office (GUS 2019)

Table 2 Exports of Polish Strawberry in 2016

Exports	Thousand tons	[%]
Belgium	717	5.30
Denmark	620	4.59
Netherlands	583	4.31
Baltic Republics	1106	8.18
Germany	1347	9.96
UK	232	1.72
Other EU countries	767	5.67
Belarus	7503	55.50
Norway	417	3.08
Other non-EU	226	1.67
Total	13,518	100

Source: Based on data from Main Statistical Office (GUS 2019)

The strawberry yields in Poland are low comparing to other EU countries. They oscillate around 9–10 tons per hectare, which is on average three times less than in Western Europe. This is related to the high fragmentation of strawberry farms in Poland (Gołębiewska and Sobczak 2012). About 50% of the production comes from small plantations (below 1 ha) with relatively extensive production system, including a low fertilization and insufficient level of protection against pests. The other category are larger scale (3–4 hectares) strawberry producers, which use modern production systems, including irrigation, and achieve higher yields. Since most strawberries in Poland come from field crops, the shortage of growing water caused by frequent drought periods is one of the key factors limiting yield. Large scale producers who have invested in irrigation systems and grow better yielding varieties of strawberries have a dominant position on the strawberry market in Poland.

In Poland strawberries for processing account for more than a half of production.

Kaszubska Strawberry Quality Attributes and Technical Specifications

"Nowhere are strawberries like in Kashubia" is the slogan used in Kaszubska Strawberry adverts. Kaszubska Strawberry is grown in the Kaszuby (Kashubia) region which is located in the northern part of the country, about 80 km from the Baltic coast. This is the region of the moraine hills with sunny slopes, surrounded by lakes and pine forests, "muscled by the wind from the sea". It should be emphasized that Kaszubska Strawberry is not a specific variety of strawberries. The indication can be used by farmers from the Kashubia region who are members of the Association of the Kashubian Strawberry Producers and comply with technical specifications (KSPT 2019) (Table 3). Three varieties are permitted by the PGI specifications: Elsanta, Honeoye and Senga Sengana (Drzewiecka and Śmiechowska 2016, KSPT 2019).

It is said that strawberries from this region are more aromatic than those harvested in other areas of the country. The firm juicy pulp takes on a pale pink to dark red color, depending on the variety. It cannot be confused with any other strawberry because of its intense aroma and sweet taste, reminiscent of a wild strawberry. Kashubian strawberry contains more sugar than other varieties, so it is popular fresh and also ideally suited making jams, preserves and juices.

The raw climate and the soil of the Kashubian Lake District affect the outstanding characteristics of the Kashubian Strawberry. The climate is slightly more severe than the climate of the surrounding regions: there are big fluctuations in temperatures throughout the year, precipitation is slightly above the national average, and winds blow mainly from the west. There is one of the shortest growing periods in the country, ranging from 180 to 200 days. The "thermal shock", or significant daily temperature variation makes the fruits sweeter and more aromatic. It is also important to grow strawberries in accordance with the principles of good agricultural practice (see Table 3 for examples of what this involves).

Table 3 Technical specifications of the Kaszubska Strawberry production

Territory	
Geographical area and its characteristics	Kashubian Lake District, located in Northern Poland in pomorskie voivodship (Fig. 1); the moraine hills ripened on the sunny slopes, surrounded by lakes and pine forests, freshened by wind from the sea
Varieties/breeds	Elsanta, Honeoye and SengaSengana – intense aroma and sweet taste
Climate	Raw climate and the soil cause the specific "thermal shock" (significant variation in daily temperature) makes the fruits sweeter and more aromatic
Soil and other growing conditions	Poor quality of soil. Soils of IV, V and VI soil classes predominate in the area. In the classification is used in Poland class I characterizes the best quality soils, class VI the poorest, with the lowest yield potential. Most Kashubian strawberry is grown on the slopes, so the bushes are exposed to sunlight, which guarantees formation of sugar in the fruit and ripening
Farming practices	
Fertilization, plant health, field operations	All treatments are performed in accordance with the principles of good agricultural practice. The number of chemical treatments is limited, and natural fertilizers (manure) are used with addition of mineral fertilizers. Natural materials (straw) are used in the process of mulching and covering seedlings against frost, which improve the quality of strawberries. All fruits must be harvested by hand
Other	Harvest starts quite late, about 2 weeks later than in Central Poland, the main area for strawberry production. It usually lasts from the beginning of June to the end of July
Transportation	
Transportation	Strawberries are usually transported in small vehicles: Minibuses (up to 2 tonnes), vans, sometimes even in private cars

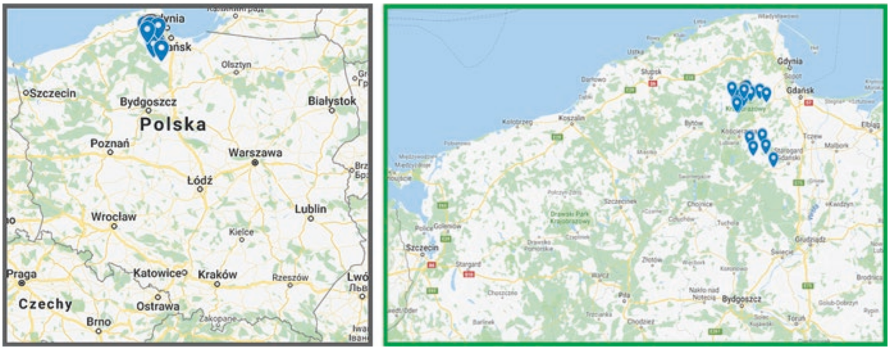

Fig. 1 Location of Kaszubska Strawberry farmers

Kaszubska Strawberry Value Chain

Value Chain and Its Components

The average size of farm is 14.86 ha, which is slightly larger than the average farm in Poland in 2016 (10.56 ha). All farms can be classified as mixed: with cereals and animal production, cereals and vegetables, or all these types of products. The average size of the Kaszubska Strawberry plantation (1.7 ha) is smaller than the reference product farm (2.47 ha). In the sample of PGI farms, the size of strawberry plantations ranged from 0.5 to 6 hectares, and only 17% of farms have plantations larger than 2 ha. For reference farms, based on information from the Association of Strawberry Producers in Poland, we assume that 85% of farmers have on average 1.5 ha of strawberries and in the remaining group of 15% of farms the average size of the plantation is 8 ha.

Most Kaszubska Strawberries are sold fresh to final consumers through the wholesale channel. Only 13.5% goes to processing, and there are no exports. This marketing channel differs notably from the reference strawberries from the central part of Poland (Table 4, Fig. 2).

The Kaszubska Strawberry Chain

The specificity of the product (fresh strawberries) forces the farmers to sell within a few hours of harvest, unless refrigeration systems are used. Producers of Kaszubska Strawberry do not have their own cold stores. Although producers are affiliated to the Strawberry Producers Association, there is no joint sale of the certified product. Each producer sells fruits individually. Approximately 42% of PGI strawberries are transported to the wholesale market in Chwaszczyna, located about 60–70 km away near Gdansk. The buyers at the market are mainly owners of small retail shops and stands on local, traditional markets.

Table 4 Structure of sales of Kaszubska Strawberry by chain type [%]

Chain type	Kaszubska Strawberry [%]	Conventional Strawberry [%]
On-farm sales	8.00	5.0
Retail D2	27.25	25.0
Wholesale market D1	42.5	30
Intermediaries P1	22.25	22.5
Exports D3	0.0	17.5
Total	100.0	100.0

Source: Farm Survey (12 PGI producers) and interview with the Head of the Polish Association of Strawberry Producers for reference data

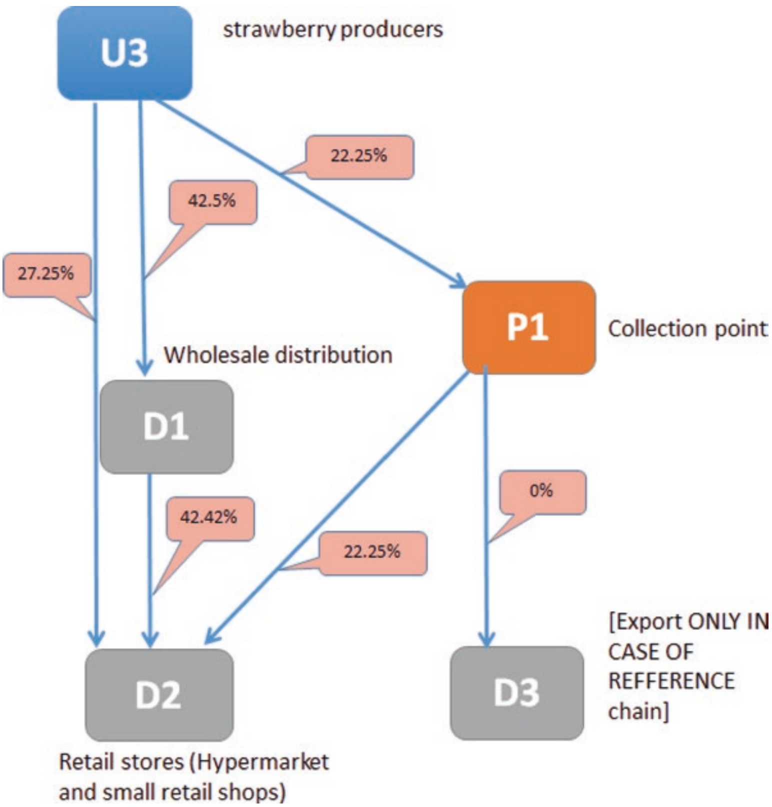

Fig. 2 Kaszubska Strawberry value chain

Farmers also supply small retail shops in Gdansk or neighbouring towns (27%). Around 22% is purchased by intermediaries who act as an additional link in the chain between farmers and retail markets. They capture part of the farmers' margin and importantly for the case of the PGI product, they are not interested in selling Kaszubska Strawberry with the certificate and under the PGI logo. For them, what counts is simply that the fruit is bought by consumers, who are not aware, on average, of the PGI label. The market potential of the certificate and the PGI logo is thus not adequately utilised. Farmers' relations with intermediaries are reported to be good, but intermediaries have a higher bargaining power.

Depending on the situation on the market, in some periods intermediaries also transport Kaszubska strawberries to other regions of the country.

More PGI strawberries, compared to the reference, is sold on-farm. This is because production is located in a region where tourism is important tourists and passing-by constitute a large proportion of clients.

Producers from the Kaszuby region face strong competition from Mazovia, which is a "strawberry basin" in central Poland. However, the favorable circumstance is that the strawberry harvest in Kashubia starts later, when the harvest in Mazovia is ending. Before start of Kashubia harvest, producers from Mazovia transport large quantities of strawberries to the area of northern Poland, including Kashubia and the Gdansk-Sopot-Gdynia aglommeration.

Leaders of the Association of Kaszubska Strawberry Producers have made several attempts to distinguish PGI strawberries in the past, for example by using standard packaging bearing the Kaszubska Strawberry logo and a PGI certificate. These efforts hwever have never achieved large-scale succes. The same wooden baskets ("Łubianki") holding ± 2 kg are used many times, by different producers, including those who have no PGI certificate. And some sellers break the rules and sell under the name Strawberry from Kashubia even even if they have no certificate.

As a result, the Kaszubska Strawberry is currently sold by most producers as a regular strawberry in baskets without any special designation. Only a few farmers attempt to promote their strawberries as certified. However, because they are harvested later than in other parts of Poland, the Kaszubska Strawberry has a slightly better price than that of conventional strawberries produced in central areas of Poland. Although the superior taste of Kaszubska Strawberries is recognized by many consumers, this price difference cannot be attributed to the PGI certificate.

It could be the case that traders who buy Kaszubska Strawberry and pay farmers the regular price of a "normal" strawberry, differentiate the product as PGI certified and sell it on at a higher price. If this were the case, all the financial benefits of PGI certification would be consumed by intermediaries and not the actual certificate holders. Farmers in fact pay an annual PGI membership fee of around €250, which is not compensated for by a higher farmgate price of the Kaszubska Strawberry.

The situation of Kaszubska Strawberry producers recently worsened when the local processing plant filed for bankruptcy. When in business, the plant bought significant quantities of strawberries, but was poorly managed. The nearest processor is now about at a distance of about 350 km, and cooperation is more difficult.

Some growers have considered processing strawberries themselves, but lack resources and courage to go into this relatively risky business. Their home made jam is delicious, and cannot be compared with jam sold in Warsaw.

As they are unable to promote a brand name under the PGI logo, some farmers are disstsified with the certification system, and in the 5 years after 2014, when the maximum number of 51 members was reached, several resigned. After 5 years of participation in the system farmers are no longer eligible for a subsidy covering the cost of obtaining the certificate. Although the subsidy was only about €200 per year, which is equivalent to 200–300 kg of strawberries, no longer receiving this payment was for some farmers one of the factors behind the decision to leave the scheme.

Interviewing Kaszubska Strawberry farmers, we observed that level of cooperation between producers is insufficient. This is probably a key factor in the limited success of the Kaszubska Strawberry PGI l scheme.

Sustainability Assessment of Kaszubska Strawberry Value Chain

In order to estimate sustainability of Kaszubska Strawberry, the specific methodology of Strength2Food (Bellassen et al. 2016) was applied (Fig. 3). For benchmarking purposes, the conventionally produced strawberry was used as the reference product. The data required by S2F methodology were collected from primary

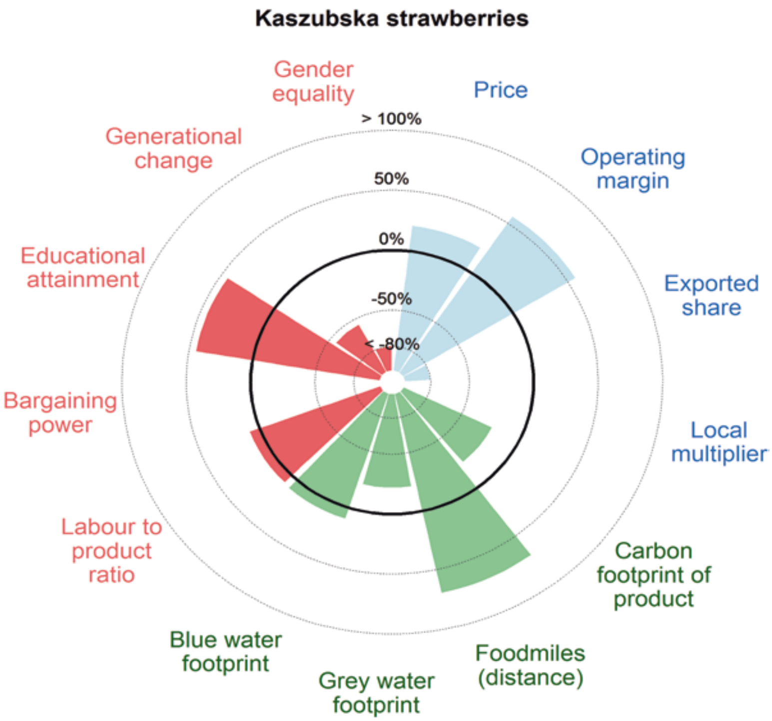

Fig. 3 Sustainability performance of Kaszubska Strawberry (supply chain averages). (Each indicator is expressed as the difference between Kaszubska Strawberry and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

sources (interviews with farmers) and from secondary sources (interviews with experts and conventional strawberry farmers). Additional secondary sources such as FADN and the Polish Main Statistical Office (GUS 2019) were also used. Sustainability indicators are presented in the Fig. 3. Each indicator is expressed as the difference between the PGI and its reference product. For environmental indicators for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower).

Economic Sustainability

Prices for Kaszubska Strawberries are higher than the reference by 20.5% (Table 5). However, the reason for this difference is probably the later harvesting period rather than the PGI logo. Profitability indicators are slightly higher. *Kaszubska Strawberry* is sold entirely on the domestic, local market, while 8% of the reference, fresh strawberries are exported (17.5% excluding strawberries for processing). About 60% of conventional strawberry travels to non-EU partners (Norway and Eastern Countries).

Environmental Sustainability

Carbon Footprint

The carbon footprint of *Kaszubska Strawberry* is 14% higher than the reference product (Table 6). The difference in per hectare emissions is in favour of the PGI, mainly because of the lower amount of fuel used for crop operations, but the higher yield of reference strawberries (8.9 vs 11 tons ha^{-1}) offsets this benefit. The lower amount of fuel used can be explained by the higher input of manpower for field operations, such as manual planting, and less mechanical weeding, and by easier logistics given that fields are located close to farms. Our estimates are at the lower end of the 0.1–1.2 tCO2e ton^{-1} range reported by Warner et al. (2010). In fact, Warner et al. (2010) find that pesticides, plastic use for greenhouses and bags and peat contribute substantially weight to the carbon footprint of UK strawberries but do not appear in our estimates. Fumigation is not necessary so pesticide use is much lower, and neither peat, greenhouses or crop bags are used.

Table 5 Economic sustainability indicators

Indicator name	Chain level	PGI	Reference	Difference %
Price	Farm	1.06	0.88	20.5
GVA	Farm	84.5%	76.1%	11.1
Net result	Farm	21.1%	9.7%	117.5
Export share	Value chain	0	17.5%	−100.0

Table 6 Carbon footprint indicators at farm level

Indicator name	Chain level	PGI	Reference	Difference %
Carbon footprint of land use ($kgCO_2eq\ ha^{-1}$)	Farm	1087	1183	−8.1
Carbon footprint of product ($kgCO_2eq\ ton^{-1}$)	Farm	121.8	107.1	13.7

Table 7 Food miles and transport related carbon footprint indicators

Chain level	Indicator name	PGI	Ref	Difference %
Value chain	Distance travelled (ton.Km ton^{-1})	257.70	855.10	−69.86
	Carbon emissions related to the transportation stage (kg CO_2 eq ton^{-1}) – Calculated with the cool farm tool	59.92	119.02	−49.66
	(carbon emissions related to the transportation stage (kg CO_2 eq ton^{-1} – Own estimation)	50.35	54.26	−7.20

Food Miles and GHG Emissions from Transport

Over the entire supply chain from farm to retail stage (U3-D2), Kaszubska strawberries travel distances 3 times shorter (257 vs 855 km) and generate 50% fewer emissions (60 vs 120 kg CO_2 eq) than conventional strawberry, using Cool Farm Tool estimates (Table 7). The authors' own estimates (total fuel consumption multiplied by the coefficient converting fuel into emission of CO_2 equivalent),[1] based on detailed information regarding fuel use for specific means of transportation, distances and quantities transported, show CFP about twice as low for the reference chain. This difference may be due to the fact that although reference strawberries travel longer distances, our own estimates using the types of transport and size of loads were determined with greater precision, and reference product loads for example were significantly larger.

Water Footprint

The main driver of the difference in green water footprint (rainwater use), is yield (Table 8). The 11 ton/ha of the reference product makes its water footprint per unit product lower than that of PGI, which yields 8.92 ton/ha. Blue water footprint (surface and ground water use) on the contrary is higher for the reference product (8.5%) This outcome is because a larger amount of water is used to irrigate reference strawberries. Note also that inputs (fuel, fertilizers, pesticides) contribute to the blue fraction at the farm level. These inputs weigh more heavily on PGI strawberries, again due to higher yield of reference strawberries. The contribution to blue water footprint made by irrigation (i.e. water directly used on strawberries) more than compensates for this. The grey water footprint (water pollution by nitrates) is higher for

[1] 2.67 kgCO2eq/ltr of diesel oil, DEFRA 2013.

Table 8 Water footprint

Indicator name	Chain level	PGI	Reference	Difference %
Green WF	All	0.429	0.349	23.0%
Blue WF	All	0.029	0.032	−8.5%
Grey WF	All	0.072	0.059	21.5%
Total water footprint	All	0.530	0.440	20.5%

Table 9 Labour productivity and educational attainment indicators

Indicator name	Chain level	PGI	Reference	Difference [%]
Labour to product ratio	Farm	0.166	0.153	8.5
Profit to labour ratio	Farm	6400.95	5805.77	10.3
Educational attainment	Farm	0.65	0.45	44.4
Wage level	Farm	4587.90	4203.50	9.1

the PGI, although the amount of nitrogen applied through organic and mineral fertilization is almost the same for the two products. Differences in the value of green, grey and total water footprint in favor of reference strawberries can be attributed mainly to their higher yield.

Social Sustainability

Labour Productivity and Educational Attainment

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is a bit higher for Kaszubska Strawberry compared to the reference product. The difference (8.5%) indicates that the PGI product generates more jobs than the conventional system, due to lower yields per hectare (Table 9). The **profit-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 10% higher in PGI than in non-PGI farms. These differences are mostly due to slightly higher prices of Kaszubska Strawberry related to harvesting 2 weeks after the peak season in Poland.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator,** which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator is higher for PGI-strawberries. The level of education is dominated by initial secondary (50%) and short tertiary (30%) education.

Table 10 Generational change and gender inequality

Indicator name	Chain level	PGI	Reference	Difference [%]
Generational change[a]	Farm	133.33	300	−55.6
Gender inequality[a]	Farm	0.89	0.11	709.1

[a]Indicator value calculated replacing 0 with 0.001

Generational Change and Gender Inequality

At the farm stage, the generational change indicator[2] is higher for the reference strawberry (Table 10). However, because the generational change indicator of both products is higher than 100%, both products are performing well and show a high employment level of 15–35-year-olds compared to 45–65-year-olds.

The gender inequality indicator is high and shows a low level of social sustainability of Kaszubska Strawberry, which mainly reflects extreme levels of inequality and very low levels of farm ownership by females.

Bargaining Power Distribution

The indicator on bargaining power distribution cannot be calculated because, the Kaszubska Strawberry supply chain is mainly a short supply chain of just one level. A very large part of output is sold directly to retailers, and only a small share is sold through intermediaries or processed.

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[2]Percentage ratio between the number of employees in the 15–35 age bracket and the number of employees in the 45–65 age range.

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Organic Raspberries in Serbia

Žaklina Stojanović, Bojan Ristić, and Jelena Filipović

Introduction

According to the FAO, on average about 80,000 tonnes of raspberries are exported annually from Serbia amounting to a value of 165 million USD (Zaric et al. 2013). A recent international overview (Otasevic 2016) implies that during 2015 all raspberry producers besides Serbia recorded a significant decrease in raspberry production. The most significant decrease, amounting more than 50%, occurred in Poland, due to unfavourable weather conditions, new plant diseases and challenges related to the labour force.

This paper will examine ***organic raspberry*** production (it is the subject of this case study, and it will be recognised as CS from now on) in the Region of "Šumadija and Western Serbia". A suitable *counterpart* appears to be conventionally (non-organically) produced raspberry from the same region, which will be investigated in order to establish a reasonable comparison of performances of these two products.

Generally, Serbian raspberries boast an excellent reputation. Registration with a geographical indication additionally protects local products from Arilje within the country of Serbia. Additionally, there is the willingness to pay higher prices for organic raspberries than for PGI labelled raspberries. This could imply that a combination of strategies, rather than focusing on PGI labelling only, may be more beneficial for Serbian producers (Radic and Canavari 2014). The encouraging fact is that the land under organic production in Serbia is steadily increasing, in the fruit sector in general but particularly in raspberry production.

Raspberry production in Serbia in the period 2005–2013 year ranged between 68,000 and 90,000 tonnes because production depends greatly on weather conditions. According to Stojanovic and Radosavljevic (2013) and Stojanovic et al. (2015), the largest production of raspberries was reached in 2011 (90,000 tonnes),

Ž. Stojanović (✉) · B. Ristić · J. Filipović
Faculty of Economics, University of Belgrade, Belgrade, Serbia
e-mail: zaklina@ekof.bg.ac.rs

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whereas the lowest production values were recorded in 2012 (70,000 tonnes) and 2013 (68,000 tonnes). Over 90% of the total raspberry production in Serbia (organic and conventionally produced) is exported in frozen form. It is evident that fresh raspberries sold at the farm gate, or the green markets, or somewhere else, represent only a small fraction of Serbian total production. The same conclusion could be reached for domestic consumption, which is a paradox in comparison with total production globally.

Fruit production has the largest share in total organic production in Serbia (46.36%), while organic raspberry production accounts for approximately 13% of total fruit organic production (März et al. 2013). Almost all of the organic production is export-oriented. The first raspberry farms, designed to comply with organic production standards, were registered in Serbia in 1999. Based on available data it can be estimated that annual exports from Serbia are 1500 tonnes of organic raspberries which only make up to 2% of total Serbian production (Centre for Organic Production[1]). The region in question (Šumadija and Western Serbia) is particularly suitable for organic production, and it seems that this is especially the case of a hilly area in the Arilje municipality which forms part of this region.

Besides the introduction, this paper is organised into four related chapters. The second chapter examines the distinguishing features of the Serbian organic raspberry, focusing attention on the technological characteristics of production, the geographical area of production and the prevailing export pattern, because of the predominantly export- oriented nature of the business. The third chapter gives a detailed description of *elements* of the organic raspberry supply chain, their connections, performance and interrelated functioning. The fourth chapter looks at the detailed technical specifications of the FQS. The fifth is based on the measurement of CS sustainability performances, while the last chapter concludes with final remarks and policy recommendations.

Distinguishing Features of Serbian Organic Raspberry Production

The subject CS is summer-fruiting raspberry which bears one crop per season during June–July. This sort of raspberry is self-fertile and of only one variety. They are best pollinated by bees, and start to produce fruit a year after planting. Full fertility can be reached in the third year after planting. The fruit picking season lasts for 30–40 days.

Both sectors, organic and conventional, are export-oriented. The product is predominantly exported in frozen (bulk) form. Both products share the same technology patterns for freezing, storage and transportation. Raspberries are frozen at a temperature of −40 °C and stored at temperatures between −18 and −20 °C (which also applies to transportation to the downstream markets).

[1] See: www.organiccentar.rs/baza-proizvoda/malina.html

The critical differences between the two indicated productions take place at the farming level – conventional pesticides and fertilisers (chemicals) are forbidden in organic production. More intensive labour production is to be expected for organic CS than for its counterpart as the resulting yields per hectare should be relatively lower and price premium relatively higher in the case of organic production.

Figure 1 shows the geographical area of the region mentioned, relevant both for CS and its counterpart.

The green part of the map shows the Region of Šumadija and Western Serbia. This is one of the five statistical regions of Serbia. It is also a level-III statistical region according to the European Nomenclature of Territorial Units for Statistics (NUTS) and takes in some north-western and south-western parts of the country as well as the central area (Šumadija). This region has a hilly topography and a mild continental climate which becomes a mountain type of climate in the southern parts.

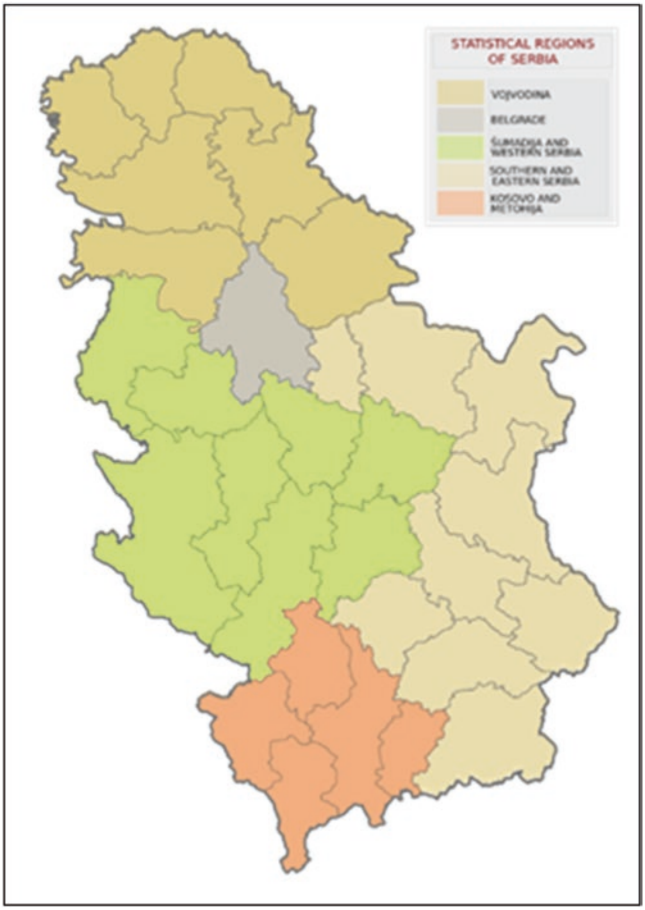

Fig. 1 The geographical area of CS

Table 1 Exports in 2016 (raspberry)

Countries	Percentage
All countries	100
European Union (28)	89.59
Germany	34.21
France	23.83
Belgium	7.93
United Kingdom	4.92
Austria	4.68
USA	3.38
Sweden	3.18
Netherlands	2.78
Italy	2.52
Poland	2.17
Switzerland	1.93
Canada	1.93
Russian Federation	1.09
All other countries	5.45

Source: SORS (2016)

The area is predominantly rural with a large rural population.[2] The population structure is characterized by a significant proportion of elderly people (20.6%); with a high proportion of the population being illiterate.[3]

The rural population is larger than the urban population only in this region in Serbia (52.6% of the total population is rural). However, the rural area is characterised by small farms in general (average farm size is around 3 ha, and there is a significant portion of very small farms up to 1 ha – around 12%) and dual farm production systems. When it comes to raspberry production, the average farm size is even lower, approximately 0.25 ha. Despite topographical limits and the relatively low population density (60 people/km^2), the region has a significant percentage of land suitable for agriculture (66%). The agricultural potential of this land is high, with fertile soils and above all favourable climatic conditions for raspberry production.

As noted, most of total production (organic and conventional) is exported; more than 90% of the total Serbian production of raspberries is usually sold as bulk. Table 1 gives detailed insights into Serbian exports in 2016 according to official statistics. The EU is the primary destination for Serbian raspberries; leading export destinations for Serbian raspberries are Germany, France and Belgium. Serbian raspberries can also be found in the USA and Canada and the Russian Federation.[4]

[2] From 41% to 100% of rural population in LAU1 unit level.

[3] 37% did not finish primary school; 35% have a secondary school education and extremely low portion has higher education (3%). Source: Statistical Office of the Republic of Serbia (SORS), 2014.

[4] Table 1 shows a detailed pattern of Serbian non-organic frozen raspberry export. Due to the lack of separate data for organic production in official statistics, this can be used as if it were for CS because it could be reasonably expected that the final destinations are the same.

Technical Specifications of the FQS

This part focuses on the key technical specifications of the FQS. Table 2 shows the key technical specifications for organic raspberry production in the region.[5]

Organic Raspberry Value Chain

First, it should be noticed that there is no significant difference in the organisation of value chains for organic and conventional production. Actors are almost the same. The main difference can be found in the farming stage of the value chain. In this part of the chapter, we will highlight the main elements and organisation of the organic raspberry value chain with emphasising put on the explanation of the main differences among CS and its counterpart.

Value Chain and Its Components

Figure 2 depicts organic raspberry value chain, namely, its elements and their order. This is the short chain model, while it is both national and international by its nature, due to its exporting component.

The U1 level is referred to as ***input suppliers***. Organic production needs to follow special rules when it comes to the use of pesticides and fertilisers. According to information collected by interviews conducted with organic producers, they mainly use natural manure for fertilisation, but some fabricated pesticides can be used for organic production as well. The fabricated fertilisers are imported and more expensive, which might be an obstacle for their broader application.

The results show that producers do not use fabricated pesticides, but instead, they prepare some mixtures with nettle and water for that purpose. Therefore, the use of fertilisers and pesticides could be considered as the main difference between the CS and its counterpart. In the counterpart case, fabricated pesticides and fertilisers are standard, and yields are highly dependent upon their usage. Fuel and other sources of energies, mechanisation (usually small tractors, and other implements for cultivation) and seedlings come from the same sources for both kinds of production (seeds are different for organic and conventional production). For example, seedlings are domestically produced at most. Therefore, this part of the chain is partially based on import. A significant portion of planting materials is produced in Serbia.

[5] Given that 90% of all organic raspberry production in Serbia originates from the Region of Šumadija and Western Serbia, it can be considered the "Serbian organic raspberry", as it has been named in this paper.

Table 2 Technical specifications

Territory	
Geographical area	The region of Šumadija and Western Serbia (see Fig. 1)
Varieties/breeds	Between 90–95% of Serbian raspberries are the North American "Willamette". Other raspberry varieties include "Meeker", "Promise" and "Gradina" from Europe. "Polana" and "Polka" varieties can also be found in the fields. The distribution of types of seedlings is the same regardless of type of production of raspberries.
Arable farming practices	
Fertilisation	In organic production, the use of NPK fertilisers is forbidden. Manure is, therefore, the most used fertiliser, in order to reduce the occurrence of weed seeds (horse manure) or increase the level of nitrogen in the soil (livestock manure). The amount of organic matter in the soil is increased by introducing the amount of livestock manure from 22 to 44 t/ha.
Plant health	In organic farming weeds are usually suppressed manually; the use of herbicides is not allowed. This also applies to the use of other fabricated pesticides. In conventional production pesticide usage is permitted.
Field operations	The previously-used system of bushes was abandoned. Now raspberries grow exclusively in rows. For example, row spacing should be from 2.2 to 2.5 m for the Willamette variety, and from 2.7 to 3 m for the Meeker variety (Willamette and Meeker are the most commonly used in practice). The performance of both organic and conventional production depends on appropriate cultivation technology. It is always easier to suppress weeds before planting than after plantation. Some farmers (max 50%) use small tractors (up to 40 hp) for field operations The logical substitute for small tractors is manual labour, as most small farmers cannot afford mechanisation.
Other	The best soils for both types of production are highly permeable soils (sandy or muddy clay) that contain high levels of organic matter (>3%), and whose acidity (pH) is between 5.5 and 6.5. Heavier, less permeable soil increases the possibility of root disease, but this can be mitigated to some extent by selecting resistant varieties of raspberries.
Process	
First stage	Farming by organic standards (no pesticides, or chemical fertilisers, land converted to organic production and certified). The harvesting and transportation to intermediaries in a short time frame is described previously in this paper, and is the same for counterpart production.
Second stage	Raspberries are selected and then frozen at −40 °C and stored at between −18 and −20 °C, usually in large boxes which can be aslo be packed in smaller packages based on demand specification.
Transportation	As is the case for storage, the temperature should be between −18 and −20 °C.
Conditioning	Storage and transport in the deep-frozen regime is not limited as in the case of fresh raspberries. The lifespan of an adequately stored product is up to 30 months.

Field research fo S2F and Poljoberza.net (2016)

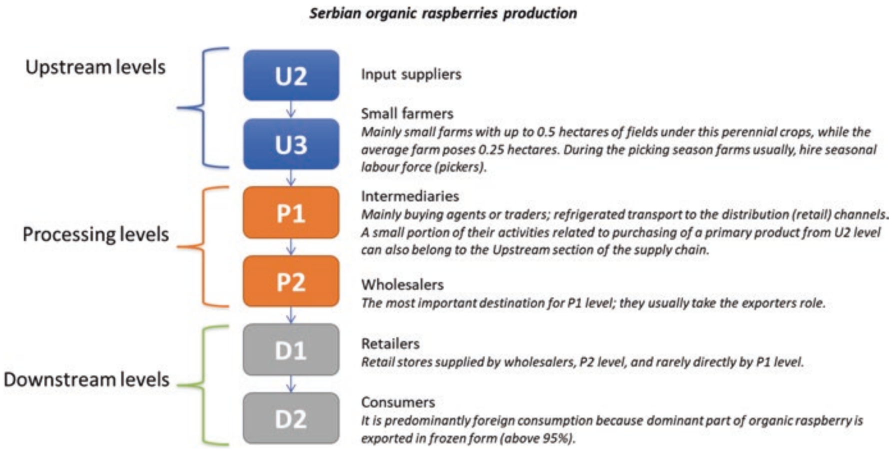

Fig. 2 Organic raspberry value chain

The importance of the Fruit Research Institute from Čacak (a town in the central part of Serbia) with up to 600,000 certified seedlings annually should be emphasised. Only a small portion of imported seedlings is used in the case of the organic raspberries supply chain (up to 5%). According to the conducted interviews for this CS, it seems that farmers have no trust in the healthiness of imported seedings given that some of them were faced with the problem of the root decay recently, while this disease came with the imported seeding material.

The raspberry sector is characterised by labour-intensive production, especially in the case of organic production. Workforce on such farms is mostly made up of the family members and when it is necessary during the fruit picking season, seasonal workers, who come from different parts of the country. Logically, water and land as production inputs are local by their nature.

U2 represents ***organic farmers***. This sector mainly consists of small farms of up to the 1 ha of fields under these perennial crops, while the average farm possesses 0.25 ha. Serbian raspberry farms are small, usually, family-owned seasonal business. There are 253 producers in the Region of Western Serbia and Šumadija. Figure 3 shows its geographical distribution on the map of the region. During the picking season, which lasts up to the 40 days, farms usually hire seasonal labour force (pickers). The picking process is the same in both CS and counterpart cases. The only difference is probably the fact that organic production is more labour intensive in their fight against weeds and other pests, because of the different non-chemical treatment in pests control.

P1 level refers to the ***intermediaries***, mainly buying agents or traders. They conduct primary processing of raspberries, such as selection, packaging, freezing and storage. Refrigerated transport to the distribution (retail) channels is also a part of their activities. A small portion of their activities related to purchasing of a primary product from U2 level can also belong to the upstream section of the value chain. Small intermediaries are rarely exporters, provided that only the small portion of the

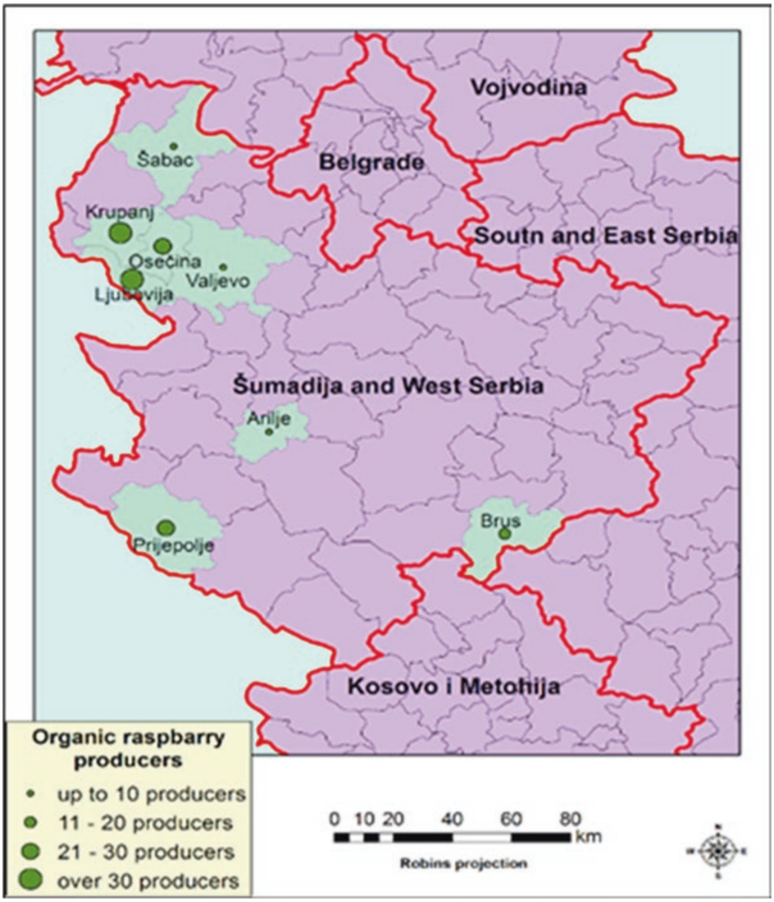

Fig. 3 Geographical distribution of organic farms

big ones can make contact with the foreign markets. The first 13 companies export more than 50% of raspberries slightly both in terms of quantity and value (RS Commission for Protection of Competition 2017). In those rare cases, P1 and P2 levels should be considered integrally. Most of the small intermediaries are at the same time farmers, so in these cases, U2 and P1 level are vertically integrated.

Raspberry is usually transported as a fresh product in small vehicles (trucks up to 5 tonnes, vans and tractors) from U2 to P1 level. Because of the fragile nature of the product transport in closed cargo is appreciated. It is estimated that every hour in transportation costs 1 day of storage of fresh raspberry and the maximum number of days is 7.

Consequently, transportation of more than 1 h is not an option in the case of organic raspberry. The average speed of the loaded trucks on Serbian roads is approximately 50 km/h. That is the reason why the majority of cooling storages are located close to the farms. Only some bigger farms are vertically integrated and pos-

Fig. 4 Geographical distribution of intermediaries

sess their own cooling houses near their farms. Others, which are not integrated, have to transport their product to P1 level or directly to P2 level. The technology of the primary processing is the same for both CS and its counterpart – the same selection pattern, temperature of freezing, storage and transport. However, it is vital to separate these two quite similar distinctly, but at the same time different products. In the focused region, there are approximately 136 cooling storages. Figure 4 gives their geographical distribution, which is interesting to compare with the content of Fig. 3.

The U2-P1-P2 connection (farming, primary processing and export) may be considered the most important for this CS (organic raspberry), and the same could be aid for its counterpart as well.

Having in mind that above 90% of total production is exported, it can be concluded that downstream levels (D1 and D2) can be partly explained by an export pattern shown in Table 1. A tiny part of organic production is consumed domestically. Majority of that consumption is registered as a part of the household consumption and the remaining portion as a part of the farm's gate selling, which is generally rare in practice. Almost the same can be stated when it comes to the counterpart case.

From the economic and social point of view, it is essential to consider the distribution of bargaining power in farmers-intermediaries' relation, which is presented in the next section.

Governance and Bargaining Power of Farmers and Intermediaries

Given the structure of the value chain, there is no governance activity by organisations designated to carry out activities of coordinating the value chain concerning specific objectives such as quality management and commercial promotion. It is the market that carries out its coordination action, leaving the role of defining prices and commercial strategies to large intermediaries. The main consequence is the low bargaining power of small producers and small intermediaries.

Small farmers highlight that the wholesale purchase price of the organic raspberry is 20% higher than for the standard one, reaching the level of 2 EUR/kg (compared to 1.67 EUR/kg for the standard one) in 2016. Not surprisingly, the retail price for organic raspberry is even higher and amounts to 2.44 EUR/kg (Mijajlovic 2016). The local companies which provide cold storage represent dominant wholesalers, but quite often they are also in charge of certification. Serbian organic raspberry is appreciated in the international market as well, reaching the price of 5.87 USD/kg (against 3.65 USD/kg for conventional raspberries), according to the latest data of Fruit Research Institute from Čacak (Otasevic 2016). By these simple relations, it can be noticed that organic farmers receive just a small fraction of the price premium reserved for the unique features of their product – organic label. If we add logically expected smaller yields per hectare in organic production in comparison to the conventional one, organic production seems less profitable for farmers than conventional production.

Because farmers are small, they are unorganised and therefore not able to reach higher prices for their high-quality product (they bear position of price takers). The major part of the total value added of organic label is claimed by big intermediaries, with large capacities for sustainable export of this product. Not just farmers, but small intermediaries can also be found in an unfavourable position when it comes to the distribution of total value added created in the raspberry business.

Furthermore, it is evident that there exist a limited number of organisations (or cooperatives) that can help farmers to sell their raspberries at wholesale markets. The Federation of Associations of raspberry producers of Western Serbia has

Table 3 Capacity structure of intermediaries

Groups of intermediaries	Capacity (in tonnes)	Number of cold storages
I	3000–5000	9
II	1000–3000	21
III	0–100	106
Total		136

Source: Field research for S2F

functioned since 2012. Its goals are a single purchase price over the whole territory of Serbia, construction of private cold storages in municipalities where they do not exist, direct contact with foreign buyers and lobbying for the state subsidies.

As regards cold storage facilities at P1 and P2 levels, we should bear in mind that the observed cold storages are not just specialised in raspberries, but are used for other fruit that requires freezing or refrigeration. Therefore, Table 3 summarises some critical facts concerning the capacity structure of intermediaries in the geographical region of interest. The intermediaries (cooling storage) could be categorised into three distinct groups based on their capacity. It appears that the minority of them possess a majority in total capacity. Hence, it can be expected that at most 30 of them can export. This number may be even lower.

The market and consequently bargaining power are concentrated in that part of the chain. Small intermediaries are in the chain as well as the price takers, given that while they are unable to export to the foreign markets, they sell processed raspberry to the major intermediaries and expect some price premium for their efforts in the processing stage. Besides the given price, farmers have to accept all other conditions and terms of trade with the intermediaries, which puts them in the worst position of all in the value chain in terms of bargaining power and ability to influence other elements in the chain. The case is the same both for organic and conventional production.

Sustainability Assessment of Serbian Organic Raspberry

In order to estimate the sustainability of Serbian organic raspberry, the specific methodology of Strength2Food (Bellassen et al. 2016) was applied. For the benchmarking purposes, the conventionally produced Serbian raspberry was used as the counterpart. The key indicators of the performances are depicted in Fig. 5. Some, most relevant, will be underlined in the next paragraphs.

It should be noted that necessary data for S2F methodology was collected both from the primary sources (interviews with farmers and experts and calculations based on available secondary sources) and from secondary sources (SORS, FADN, Republic Hydrometeorological Service of Serbia, FP7 GLAMUR project and Agromarket).

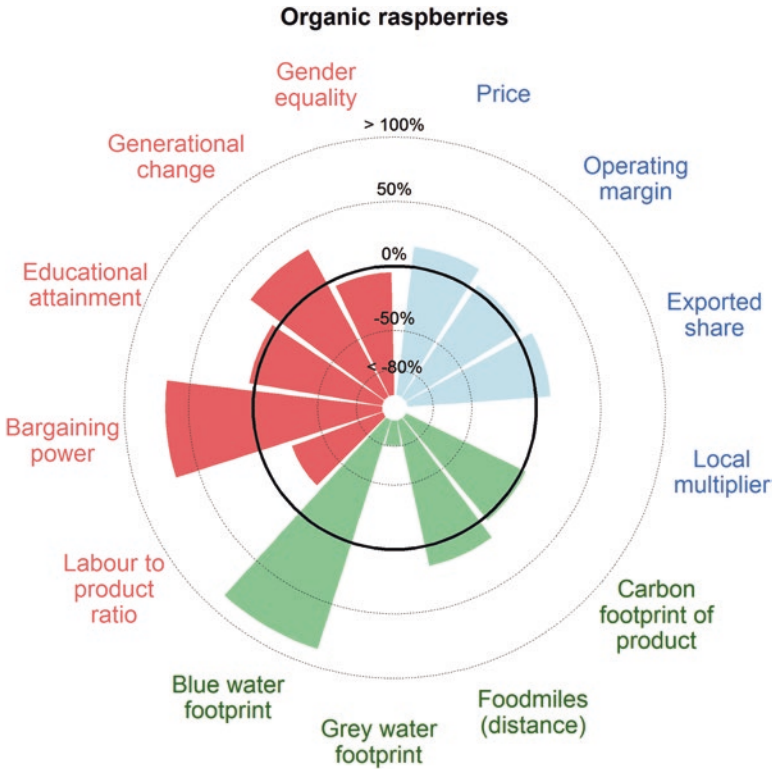

Fig. 5 Sustainability performance of organic raspberries (supply chain averages). (Each indicator is expressed as the difference between organic raspberries and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

It is observable that profitability is higher for the organic raspberry than for the conventional one. However, surprisingly, the price is only 20% higher for the organic than for conventionally produced raspberries, which is explained by the differing bargaining powers of actors at various stages of the value chain – exported organic raspberry records a mark-up of 60%. As noted, both organic and conventional raspberries are export-oriented products. Serbian organic raspberries perform worse than the reference regarding profit to labour ratio.

The carbon footprint of organic raspberries is 5% lower than the reference (316 vs 333 kgCO2e ton of raspberry-1). The difference in per hectare emissions is much higher, mainly due to the absence of mineral fertilisers, but the much higher yield of conventional raspberries (2.7 vs 5.7 t/ha) largely offsets this benefit. Relatively large processing emissions due to freezing, which are the same for organic and conventional products, also reduce the advantage of organic raspberries in relative terms. The comparison with the literature is challenging as the carbon footprint of raspberries has never been investigated to our knowledge.[6] In the food miles case, organic raspberry has almost the same performance than its reference, while significantly better performance is recorded in the water footprint dimension because of the differences related to the production technology (organic vs conventional).

The allocation of labour to production is lower for organic raspberries than for its non-organic reference (conventional raspberries). At the farm level, it takes 145 h of work to produce a ton of raspberries when the reference product requires 192 h. The difference (−25%) indicates that the organic product generates fewer jobs than the reference system. The turnover-to-labour ratio indicator provides insight into labour productivity. The average turnover per employee is 60% higher in the organic farm than in conventional ones. These differences are mostly due to the farm's structure, the technical specification of the product and for a part to the geographical conditions. As for the other indicators linked to the social dimension, bargaining power is described in section "Governance and Bargaining Power of Farmers and Intermediaries". Lack of bargaining power of farmers about the intermediaries is the same typical obstacle for farmers in both cases (organic and conventional). However, it seems that it is less severe for organic production.

The educational attainment indicator, which refers to the highest level of education that an individual has reached, allows us to measure specific components of social capital indirectly. This indicator is close to 0 if the majority of workers have primary education and approaches 1 as the level of education increases. There is no difference in the profile of education levels between producers from organic and those of the conventional sector. Educational attainment is dominated by primary (40–42%) and secondary (51–50%) levels. The educational structure is almost the same for the both products.

Conclusion

Organic production in Serbia is still in its infancy. However, the area certified as "organic" in Serbia, including the focus of our analysis – fruit production (berries – raspberries), is growing steadily. Both organic and conventional raspberries are generally exported as a bulk commodity (frozen), while fresh products are sold at the gate or the green markets, representing only a small fraction of total production.

Despite raspberry nomination as "Serbian red gold", the sector suffers due to its fragmented structure. Consequently, most of the total added value for the organic label is claimed by the large intermediaries. Note also the higher profitability of the FQS product compared with the reference product. Producers of organic raspberry command prices which are 20% higher than the reference product. This situation suggests an unwillingness on the part of traders/exporters to reward producers for

[6] Estimates are within the range of 0.2–0.8 $tCO2e\ ton^{-1}$.

Table 4 Overall performance of the organic and reference product

Indicator	Organic	Reference product
Economic indicators		
Price	+	
Operational margin	+	
Export (in volume)		+
Environmental indicators		
Carbon footprint		+
Food miles		+
Water footprint	+	
Social indicators		
Labour to product ratio		+
Bargaining power	+	
Educational attainment	+	
Generational change	+	
Gender equality		+

Source: Field research for S2F

improving their range of supply. At the same time, organic raspberries are a small portion of the total volume of sales contracted with foreign buyers (Table 4).

Bearing in mind the higher efficiency of conventionally produced raspberries, the FQS carbon footprint is higher than for the reference product, while in terms of food miles the performance of both products is comparable. Only in one component of the water footprint (grey water, calculated at the farm level) does the FQS product significantly outperform its reference.

The Serbian organic raspberry performs less well than its reference for labour to product ratio, indicating a lower capacity for job creation at the local level. At the moment, organic production seems to be an attractive alternative only for the most important producers who are market oriented. Therefore, due to more well-educated management and better organisation, the turnover-to-labour ratio is higher in the organic farm than in conventional one.

The lack of bargaining power of farmers with intermediaries is generally considered a considerable obstacle both for organic and conventional farms. However, it seems that organic farms are at an advantage on the market as the large traders are forced to offer a wider variety of berries to foreign buyers, and in this case, the producers of organic raspberries are in a fortunate position. As far as educational entertainment is concerned, the majority of workers have primary or secondary education. Less educated farmers are not very disposed to change their practices which may be an important obstacle for the development of the organic raspberry sector in Serbia. Regarding gender issues, there is a situation of equality in both sectors of our analysis. However, as far as generational change is concerned, organic raspberry farming has a greater capacity for the employment of younger workers.

Finally, it should be noticed that the number of raspberry producers continues to grow, with the same trend in the organic raspberry sector. The producers pointed out that the main challenge they face is keeping up with this trend. Despite the concern over climate change, there are insufficient funds allocated to the improvement of risk control practices either at the local, regional or national level. The marked increase in growing areas is, however, accompanied by total absence of any planning or strategy. This leads to detrimental effects on yield and farming income. Finally, hiring labour during the fruit picking season is a challenge, and there is a shortage of high-quality seeds for high-quality production. Particular attention should be paid to food safety issues. An institutional framework has been adopted, but the implementation of food safety rules is still in its infancy. Improvements are expected in the near future. Both products need to address the same issues. Traders, as well as processors in the food chain, strongly argue for strict adherence to internationally standardized rules. On the other hand, the major exporters of Serbian raspberries do ultimately adopt international standards.

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PDO Zagora and PGI Kastoria Apples in Greece

Konstadinos Mattas, Efthimia Tsakiridou, Christos Karelakis, Nikolaou Kallirroi, Alexandros Gatsikos, and Ioannis Papadopoulos

Apple Production

The apple tree (Malus pumila Mill) belongs to the Rosaceae family and originated in Central Asia thousands of years ago. Apple trees have been grown and cultivated in Asia and Europe for thousand years. The Greeks and Romans brought apples to Europe and the crop arrived in the New World centuries later. Nowadays, apple fruit is a significant commodity and numerous varieties are cultivated worldwide. The most common apple varieties are: Starking Delicious, Red Delicious, Red chief, Starkrimson, Golden Delicious, Granny Smith, Pink Lady (or Cripps Pink), Gala, Mutsu, Firiki, Gala Schniga, Odysseus, Super Red chief, Fuji kikiu, and Jonagold. These varieties have been further developed and there are many other sub-varieties. Apple varieties can be distinguished into groups associated with the colour and harvesting period. Apple fruit varieties have different macroscopic characteristics such as colour, taste and toughness.

The parts of the apple tree are the tree buds, the leaves, the blossom, the fruit and the roots. Each part is important in producing quality apples, although the blossoms during the flowering period are particularly so because this stage considerably affects the total production and the overall quality of the apples. The flowering period of the apple trees is in the spring, after the end of the hibernation period, and is the most important period for harvesting. Apple trees can survive very low temperatures, even down to −40 °C in winter, although during the flowering period the critical temperature is −2 °C. Lower temperatures may damage or even destroy blossom fertility. So, during the critical flowering period climate conditions (temperature, humidity, etc.) are of vital importance in order to ensure quality and profits in apple production.

K. Mattas (✉) · E. Tsakiridou · C. Karelakis · N. Kallirroi · A. Gatsikos · I. Papadopoulos
Aristotle University of Thessaloniki, School of Agriculture, Department of Agricultural Economics, Thessaloniki, Greece
e-mail: mattas@auth.gr

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Apple production is also determined by the established orchard plant system. A common orchard plant system for apples is the 4 × 4 where an apple tree is at 4 m from the next tree and the rows are 4 m wide. In recent years, agronomists have proposed, and farmers have applied, narrower plant systems such as 1.5 × 4–5 i.e. 1.5 m distance on the row and 4–5 m distance to rows. Plant systems vary and farmers apply the one best suited to their needs, machinery and management system. The best plant system and apple variety depend on local climate conditions as well market trends and agronomists' advice.

Apples are the fourth most important crop in Greece, after olives, citrus and peaches. During the last 9 years, apple production increased by 9%. As shown in Fig. 1, total apple production in Greece in 2016 was 278.92 thousand tonnes, a 9% increase compared to 2008. The highest production was in 2015 with 289.98 thousand tonnes (EUROSTAT 2016). The apple market price in Greece (2016) varied from 0.60 to 1.10 euro/kilo (OAKA 2017). However, producers' final price share is 21.9% of the final price (Karantininis 2017), and their price ranges from 0.20 to 0.30 euro/kilo. In interviews, Kastoria apple producers state that this price is very low and close to the marginal cost.

Statistically, total apple production in Greece in 2014 was 252,240 tonnes and the apple trees planted numbered 8,682,855 (ELSTAT 2014) According to FAOSTAT estimations for the years 2015–2016, the harvested area in Greece for the years 2015 and 2016 was 12,077 ha. Farms in Greece are classified as small when they are of less than 4.6 ha in size (Karantininis 2017). Farms with less than 2 ha account for 53.6% of the total 648,610 farms (EUROSTAT 2013). The total production of the PGI Kastoria apples is 48,452 tonnes with a national share of 19.2%. The total production comes from the 1,134,653 trees cultivated which represent a national share of 13.07% of total apple trees (ELSTAT 2014). Apple farms in Kastoria are more productive than in other regions, due to the advanced know-how in the production phase and the climate conditions.

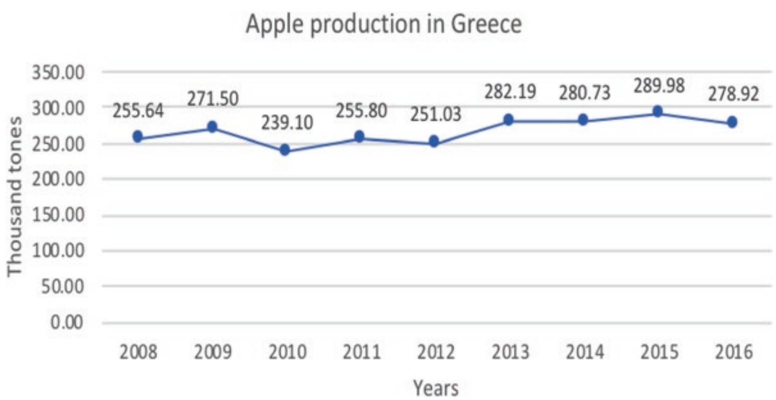

Fig. 1 Apple production in Greece during the years 2008–2016 (1000t). (Source: Eurostat NELLA GRAFICA TONNES non TONES)

Apart from climate conditions, orchard treatment and the agronomic consultancy services are also important aspects in the increase in apple production. Farmers across Greece procure their agrochemical products – e.g., pesticides, fertilizers – through local agrochemical stores. Agronomists working in these stores usually provide external services such as field visits, advice on disease treatment and overall orchard management free of charge in Kastoria as in other areas. Furthermore, there are cooperatives, such as GEOK Kastoria, which provide advisory services, agrochemical products and training sessions to members, paid for through the sale of products to farmers. A combination of climate data and advisory services supports the farmers and the overall supply chain efficiently.

Characteristics of the PGI Kastoria Apples

History of Kastoria Apples

Kastoria's regional economy is oriented to fur, tourism and traditionally to agriculture. In agricultural production, Kastoria is well known for PGI Kastoria apples and PGI peas "Gigades" (Giants). Thanks to the unique climate and soil conditions, apple production is associated with high quality products and special flavour/taste. However, climate conditions make total agricultural production volatile, and this affects farmers' income and the economic conditions in the region. Apple is sensitive to climate change, and the volatile climate conditions influence the total production as well as quality. Extremely cold months may considerably affect total apple production especially in critical periods such as the flowering period in spring, a critical period which determines the overall apple production (Aggelopoulou et al. 2011).

Apple production started in Kastoria approximately in 1910 in the north-east villages of the region. Twenty or thirty years later farmers from the villages close to the lakeside initiated large scale apple production in Kastoria, which still accounts for more than 80% of total apple production. The ancestors of today's apple cooperatives in Kastoria set up the first farmer consortiums back in 1925, 1926 and 1958 in the villages of Tiheo, Maurohori and Polikarpi respectively (GEOK historical records). The cooperatives and apple companies which started apple production in Kastoria are GEOK; Kastor Milina; Agrosan and OR.MI.. Apple producers in Kastoria cultivate several apple varieties. PGI Kastoria red apple varieties are Starking, Starkrimson, IDR Delicious and Red Chief and PGI Kastoria yellow/green apple varieties are Golden Delicious, Jonagold and Granny Smith.

Description of the PGI Kastoria Apples

The PGI Kastoria apple was recognized in 2002 with the Agricultural Fruit and Vegetable Company of Kastoria (GEOK) as an applicant and the Prefectural Government of Kastoria as an inspection body and with AGROCERT as a public authorized inspection body for products with FQS in Greece. Apple trees are grown mainly in lake and riverside areas, which are the GEOK's area of operations (districts of Kastoria, Vitsios, Agia Trias, Orestias, Agion Anargyron and Iona Dragoumi). The height above sea level of the cultivation zone ranges from 630 to 850 m. The soil is alluvial and sedimentary, of light consistency, well-drained and slightly acidic.

Climate conditions in the region of Kastoria are continental, with low temperatures in winter which fully meet the apple tree's needs for cold weather for the period of hibernation. Summers are cool due to the geographical latitude, the height above sea level and the waters of the lakes and rivers, with high temperature differences between day and night, a factor that greatly favours the formation of plentiful pigmentation (anthocyanins) in the fruit. The combination of the continental climate in Greece allows the differentiation of the apple's attributes. In particular, PGI Kastoria Apples are harvested when the concentration of soluble constituents reaches 12.5 Brix for the red varieties and 14.5 Brix for the yellow varieties, the resistance of the flesh to pressure (toughness) is 7–8 kg and the internal ethylene concentration is 1 ppm.

Compliance with specifications is checked by agronomists who oversee the control and the sampling procedures for the incoming apples. The harvesting period starts in August for the early varieties and lasts until October for the late varieties. In order to ensure apple quality, the apples are picked by hand, put into plastic containers (<10 kg) and transferred to big wooden crates (bins) or smaller plastic (<20 kg) containers with extreme care. Crates or containers are transferred directly, on the same day, to the facilities of the cooperative/ company. The companies apply sorting, packaging and storing techniques in order to extend the apples' life cycle to the fifth to sixth month of the following year. Table 1 presents an overview of the specifications of PGI Kastoria apple.

The cultivation methods are the result of long experience and know-how, which help to produce well-proportioned, sizeable and homogenous fruit. These methods principally include suitable thinning at the right time, appropriate fertilization and compensatory irrigation in summer. Kastoria agronomists responsible for the FQS of the Kastoria apple report that a thousand producers in the area cultivate approximately 13,500 ha of apple orchards, on average 13.5 ha per holding for the year 2016. Total apple production in Kastoria increased only by 7.8% in 2014 compared to 2013; total apple production in 2014 was 48,452 tonnes and in 2013 was 44,949 tonnes (ELSTAT 2014).

Unfortunately, national data for apple prices and apple losses during the harvest period are unavailable and it is therefore not possible to construct a price indicator or calculate climate impact on apple quality. However, Kastoria farmers in interviews reported that in general in 2015 and 2016 the yields were high (4t/ha^{-1}) and consequently the prices were low (0.25–0.30 euro/kg). GEOK on the other hand, after great effort, sold the apples at lower prices in order to meet market trends and sell the entire apple production. In 2017, because of low temperatures in the critical months of March (−3.2 °C) and April (−2.7 °C), production decreased by 50% and GEOK representatives expected prices to exceed 0.40 euro/kilo.

Table 1 Summary of the technical specifications

Territory	
Geographical area	Producers in the region of Kastoria cultivate 13,500Ha of PGI apples. The production takes place mainly in the districts of Vitsios, Agia Trias, Orestias, Agion Anargyron and Iona Dragoumi, villages/areas in Kastoria
Varieties/ breeds	Red apple varieties: Starking; Starkrimson, IDR delicious and red chief yellow/green apple varieties: Golden delicious; Jonagold and Granny Smith
Arable farming practices	
Fertilization	After soil and leaf analysis, agronomists design a specific fertilization plan for every producer
Plant health	Phytosanitary products are in the basis of agronomist visits to orchards. The phytosanity plan is designed for every producer according to the special needs of the orchards, annual climate conditions and seasonal problems
Field operations	Pruning takes place at the end of winter
Other	High planting density; high yields (4 tonnes/ha); weed management includes manual and mechanical treatments
Process	
First stage	Sorting and packaging of the apples
Second stage	Storing in refrigerant chambers
Transportation	Every producer transfers the apple production daily to the cooperatives or the firms. Firms or cooperatives use logistic companies to distribute the final production
Conditions	Produced in the region of Kastoria and compliant with EU plant production rules

Geographical Area of PGI Kastoria Apples

Kastoria is a region located in the north-east of Greece on the border with Albania (Fig. 2). The city of Kastoria – the capital of the region of Kastoria –lies on the lake of Orestiada. The population of the Kastoria region is 50,332 (ELSTAT 2011) in an area of 1720 km^2, with a density of 29 citizens per km^2. The population of the city of Kastoria is 13,387 in an area of 57 km^2 and density of 235 citizens per km^2. The morphology of Kastoria could be classified as mountainous, although the lake of Orestiada influences the climactic conditions yielding unique microclimate characteristics – high humidity levels, plenty of water and cold winter – in the agricultural areas of the region.

Climate Conditions in Kastoria Region

Climate in Kastoria is continental with low temperatures in winter and cool months in summer. For details of climate in Kastoria – and particularly in the villages of Tichio and Polykarpi – Table 2 displays five climate indicators for the year 2016 – average temperature, humidity, wind, sun hours and rain. The average temperature is low during winter (0.8–7.5 °C) and cool during the summer months

Fig. 2 Geographical area of PGI "Kastoria apples". (Source: www.kastoria.gov.gr)

Table 2 Monthly climate conditions in Kastoria for the year 2016

	Average temperature (°C)	Average humidity (%)	Wind (m/s)	Sun hours (hrs)	Rain (mm)
January	2.3	74.8	2.8	79.3	57
February	7.5	70.9	2.9	94.5	29
March	8	73.4	2.8	96.8	63
April	18.1	64.6	3.5	133	40
May	14.1	73	3.6	144.3	110
June	19.4	71.4	3.6	147.5	40
July	21.8	67.5	2.5	154.5	21
August	20.7	70.1	2.3	151	32
September	16.1	80.5	2.2	107.8	169
October	11.4	81.8	2.4	90	70
November	6	80.2	2.5	83.8	76
December	0.8	67.6	3.1	84	4

Source: Meteorological stations in Kastoria region

(19.4–21.8 °C). The average humidity is higher during autumn, when most of the production is harvested, and the wind is stronger during April, May and June, critical months when blossoms are becoming fruits. The total rainfall is 711 mm and the total sun hours are 1365.5. The combination of cool temperatures, high sun hours,

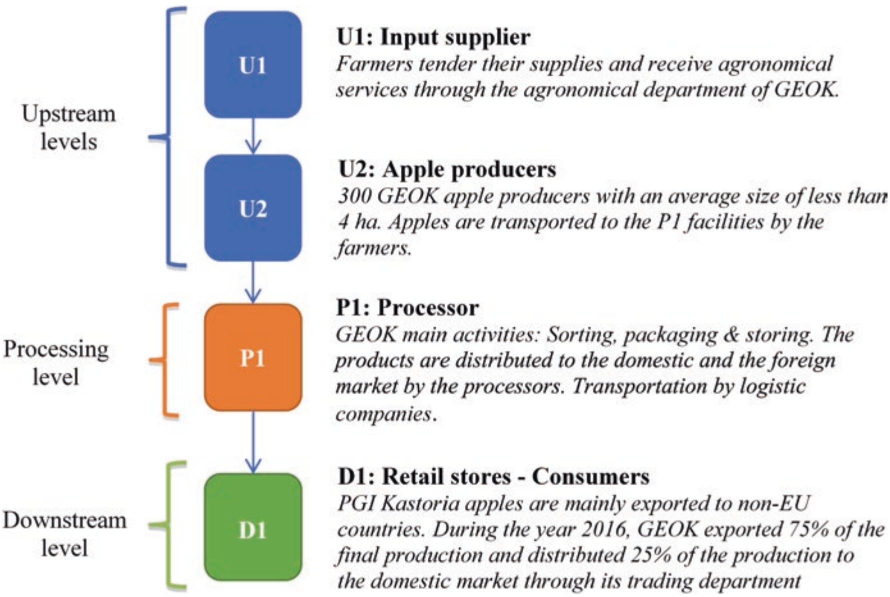

Fig. 3 PGI Kastoria apple value chain

the humidity and large amounts of water contribute to the good quality and unique characteristics of the apples.

PGI Kastoria Apples Value Chain

The value chain of the PGI Kastoria apple is presented in Fig. 3. Participants of the value chain are: input suppliers; farmers; processors (cooperatives and companies); wholesalers /traders; and retail stores (mainly super markets) and consumers.

U1 represents agrochemical suppliers which in the region of Kastoria are SMEs. In some cases, such as GEOK, the inputs are provided by P1. Moreover, U1 includes agronomical services provided by specialized advisors. The average cost of the inputs accounts for 20–25% of the total production cost for farmers and depends partly on annual climate conditions. EU regulations regarding maximum residue levels and permitted agrochemical products are applied.

Most farmers and workers have only a high school level of education. Agriculture is a discipline that requires continuous training, but most of the workforce is employed during the harvesting period and no training activities are implemented. During the harvesting period, farmers pick the apples by hand and send the apples to cooperatives or companies on the same day. Field workers are mainly experienced foreigners who are hired during the harvesting and pruning seasons. However, in recent years many local families have taken part in harvesting as a result of the economic crisis. Pruning activities on the other hand require experience. The labor cost represents 25–30% of total production costs, and wages range from 25 to 30 euro/day. The labor cost falls to 20–25% when farmers' family members work during the picking season.

Most of the farmers are equipped with machinery. A truck or tractor platform is used to transport apples. Carrying capacity depends on mode (car or tractor) and the apple containers, which can be large wooden bins (400 kg/bin) or small plastic containers (17 kg/c). Because of transportation cost and time concerns, farmers minimize journeys by loading the vehicle to 100% and make 1–2 journeys per day. They distribute the empty containers to the fields each day (picking preparation). The distance from the farmers' facilities to the P1 facilities varies from 3 to 15 km.

P1 represents the processors of the PGI Kastoria apple value chain. There are five main processors in Kastoria. The largest is GEOK with 300 members/producers, while the second processor has 34 members, 50 ha and approximately 3000 tonnes production. When apples are delivered by farmers, processors sort and package the production. The sorting procedure involves quality separation. In particular, the smallest apples weigh less than 80 g, the second category weigh 80–100 gr, the third weigh 100–125 g and the eighth and ninth categories include the biggest apples ranging from 218 to 353 gr. Apples are packed according to size and then sent to cold storage. The storage is adjusted specifically to the apple characteristics in order to keep them for 6–8 months.

Total production cost is 0.20–0.25 euro/kg and the procured apple cost is 0.25–0.30 euro/kg. Total cost ranges from 0.45 to 0.55 euro/kg without transportation and logistics costs. GEOK revenues in 2015–2016 were 7,335,416 euro and production was almost 15,000 tonnes, and average selling price was 0.48 euro/kg. The price of the PGI Kastoria apple was low but GEOK directors stated that price levels were adapted to the market and lowering market price was unavoidable in order to sell all the production. This was the main reason for the low economic performance during the previous year.

Transportation is by private logistic and shipping companies. Distribution on the domestic market is by truck by contracted companies. Individual farmers sometimes deliver/sell their apple production to wholesalers in Kastoria, but the amount/percentage of the total apple production per wholesaler is too low to be recorded. In general, the value chain of the PGI Kastoria apple is characterized as small and well structured.

D1: Distribution of the PGI Kastoria apple by GEOK cooperative to the retail stores and finally to consumers. Transportation is by private logistic and shipping companies. A quarter (25%) of the GEOK apple production is distributed to Greek supermarkets. Exports account for 75% of the PGI Kastoria apples (2016). Most the exports were to Egypt (59%) and Jordan (11%). Exports to EU countries account for only 4.06% of the total production. Bulgaria receives 4% and Serbia less than 1%.

Governance of the PGI Kastoria Apples

Introduction of GEOK KASTORIA

The PGI Kastoria apple was registered on the initiative of GEOK (Agricultural Fruit and Vegetable Company of Kastoria) in 2002. GEOK was recognized as a producer group in 1981 with 610 apple-producer members. The company is a primary company and was established after the merger of the precursors of the consortiums of Polikarpi, Tichio, and Mayrochori. Nowadays, apple producer members have decreased to nearly 300 with a total area of 500 ha and 200 ha newly planted. The owners of GEOK now number 867 local producers but only about 300 of them are active. In 2016 they produced 15,000 tonnes of apples.

GEOK is located on the eastern side of the lake and the city of Kastoria (Fig. 2). GEOK owns facilities for sorting, packaging and refrigeration of 10,000 tonnes capacity. Apples are collected, conserved, sorted, packaged and standardised at GEOK's modern cold storage and sorting facilities. The inspection staff of the regional agricultural directorates monitor production, standardisation and distribution, which is based on ministerial decisions.

Services and Activities of GEOK KASTORIA

GEOK provides sorting, packaging and controlled atmosphere cold-storage services. It also provides producers/members individual agronomic services such as field visits, pesticide and fertilization plans and agrochemical supplies. GEOK agronomists provide full time services all year round. Table 3 presents an example pesticide plan drawn up by GEOK for an anonymous apple producer. It provides full details (e.g., date, time, weather, active substance, dose, PHI safety limit, guidance for the proper implementation) and reveals the efforts made in order to produce a PGI product.

Table 4 presents a fertilization plan drawn up for the same apple producer. The exact amounts of nitrogen, phosphorus and potassium, were estimated after soil laboratory analysis, and iron, zinc, boron and others were estimated after leaf diagnostic analysis during the previous year. GEOK agronomists calculated the amounts of fertilizer required and indicated specific fertilizers (type and commercial products) for the apple trees. Further details are shown in Table 3.

GEOK monitors the FQS and keeps records of every member through these agronomical services. It also helps producers to lower their production cost by selling on agrochemical products as inputs at lower prices. It simultaneously provides important services to the members in order to preserve the quality of the products.

According to GEOK Kastoria agronomists, the area harvested by GEOK producers for 2016 was 6000 ha, and a further 2000 ha have been newly planted, with a total apple production of 15,000 tonnes, on average 50 tonnes per apple producer. The production of the newly planted trees is due to start in 2020 and reach maximum

Table 3 Example of a pesticide plan for an apple orchard given to an apple producer by GEOK

Date	Weather	Active substance	Commercial product	Target	Dose
18/3/2017	Cloudy	Copper (50WP)	Hydroplus	Venturia (Fusicladium), Oidium	200 cm^3/100 lt. water
24/3/2017	Sunny	Paraffin oil	Support	Mites (Aphis pomi)	1.500 cm^3/100 lt. water
24/3/2017	Sunny	Pyriproxifen	Admiral	San Jose	25 cm^3/100 lt. water
6/4/2017	Sunny	Dithianon 70WG	Delan	Venturia (Fusicladium)	75gr/100 lt. water
6/4/2017	Sunny	Pethriopyrad	Fondelis	Venturia (Fusicladium), alternaria	75 cm^3/100 lt. water
28/4/2017	Sunny	Thiacloprid 48SC	Calypso	Mites (Aphis pomi), Cydia pomonella	20 cm^3/10 lt. water

Table 4 Fertilization plan for an apple orchard drawn up for an apple producer by GEOK

Date	Weather	Fertilizer	Kg per Ha^{-1}	Implementation
9/4/2017	Sunny	Cyfamin	TBC[a]	Spray
22/4/2017	Sunny	Azteca	TBC[a]	Spray
30/4/2017	Sunny	Aminoton	TBC[a]	Spray
19/5/2017	Sunny	Azteca	TBC[a]	Spray
2/8/2017	Sunny	Fesil (Fe)	TBC[a]	Spray
28/8/2017	Sunny	Disper chlorofyl	TBC[a]	Spray
2/9/2017	Sunny	Disper size	TBC[a]	Spray

[a]*TBC* to be calculated. The specific dose of the fertilizers to be sprayed will be identified after a new leaf diagnostic analysis

yields in 2023. Apple production in Kastoria is forecast to rise steeply in the next few years.

Furthermore, GEOK provides trading services in order to place PGI Kastoria apples on internal and overseas markets. In 2016, GEOK sold 15,000 tonnes of PGI Kastoria apples on the domestic market and overseas and 90% of this volume is a subject to long-term contracts. On the domestic market, 25% of GEOK's total quantity (approximately 3750 tonnes) was sold to supermarkets. The other 75% (approximately 11,250 tonnes) was mainly exported to non-European countries. GEOK exports to Egypt were 8825 tonnes at an average price of 0.55 €/kg, to Jordan (1665 tonnes) with an average price of 0.60 €/kg, to Bulgaria (590 tonnes) with an average price of 0.40 €/kg, to Albania (136 tonnes), Georgia (85 tonnes) and Serbia (20 tonnes) with an average price of 0.40 €/kg. PGI Kastoria apples are transported with third-party transportation companies in containers with a capacity of 22,000 kg.

Financial Prospects for GEOK KASTORIA

Table 5 reports GEOK financial balance sheets. EBT (Earnings before tax) and EAT (Earnings after tax) are negative, although the accounting indicators, as always, need further explanation due to the fact that gross value-added indicator is always positive. In particular, GEOK has a debt of 22,687 euro and its interest payments are high, but in June 2011 it took out a further loan and debt decreased to 750,000 euro. Debt repayment is fixed in ten annual interest-bearing instalments of 105,500 euro per year. Subtracting 105,500 euro from the accounting indicator of "debit interest and associated costs" the actual GEOK EBT in the first period (2011–12) was −81.467 euro, in the second period −311.673 euro, in the third period −39.679 euro, in the fourth period −71.529 euro and in the fifth period (2015–16) −639.408. GEOK poor performance in 2016 is explained by the fact that production was high and market prices were low. Costs and sales were increased, but low product prices made revenues lower than expected.

GEOK representatives and the 2015–2016 financial analysis predict that in the next few years when the debt is repaid, the cooperative should return to positive financial results and increase its profitability. Moreover, the company is subsidized by the EU and the Ministry of Agriculture.

Personnel of GEOK KASTORIA

The workforce of GEOK counts 10 permanent employees with six agronomists, and during the harvesting season August to March the workforce is increased by 130 workers. The total workforce of GEOK during the whole year is approximately 140

Table 5 GEOK financial balance sheets for the periods 7/2011–6/2016

	Jul 2011–Jun 2012	Jul 2012–Jun 2013	Jul 2013–Jun 2014	Jul 2014–Jun 2015	Jul 2015–Jun 2016
Turnover (net) (+)	3,731,433	7,484,626	10,152,150	8,180,703	7,335,416
Production cost (−)	2,994,076	6,352,553	8,567,931	6,286,885	6,225,451
Gross value-added	737,357	1,132,073	1,584,219	1,893,818	1,109,964
Management cost (−)	350,064	N/A	N/A	223,374	223,560
Trading cost (−)	525,097	1,509,418	1,725,876	1,868,491	1,852,531
Other costs (−)	15,653	6890	N/A	5106	4092
Other income & earnings (+)	191,567	198,049	N/A	237,124	436,310
Debit interest and associated costs (−)	486,744	1,562,023	1,337,302	1,241,386	1,322,196
EBT	−462,711	−1,768,196	−1,271,481	−1,207,415	−1,856,104
EAT	−462,711	−1,768,196	−1,271,481	−1,207,415	−1,856,104

employees. Women account for 80% (112) of the total workforce. Of the women, 4.5% (5 of 112 women) and 32% of the men (9 out of 28) that work at the cooperative have an upper secondary education.

The cost of wages GEOK absorbs 20% of GEOK turnover. The workforce of GEOK and the producers are local people, so the social and economic impact of GEOK is important. The performance of the cooperative is crucial for the community of Kastoria as well as the performance of the PGI Kastoria apple. GEOK supports the local female workforce and its impact on local and rural families is significant.

Characteristics of the PDO Zagora Apples

History of Zagora Apples

Zagora is located in Middle-west Greece and has a population of 5809 (density 39c/km^2). The region's economy is based on agricultural production (apples and cherries) and tourism. The coordinator of the PDO Zagora apple quality scheme is the Zagora Cooperative. The Agricultural Cooperative of Zagora-Pilio is one of the oldest cooperatives and was established in 1916 by 199 people of Zagora. In 1985, the cooperative entered a new phase of organized commercial enterprise. The brand was registered and every authentic Zagora apple bears a sticker. In 1996 the European Union recognized the apples as "Protected Designation of Origin" products. Th Zagora Cooperative produces apples of high quality, tested and certified with the qualification of Protected Designation of Origin (PDO).

Description of the PDO Zagora Apples

Producers in the village of Zagora, Pilion (Greece) cultivate 850 ha of PDO Zagora apples. The total production ranges from 10,000 to 14,000 tonnes because of the climate variation. Agronomists from the cooperative design a specialized fertilization plan for every producer for fertilization after soil and leaf analysis. Phytosanitary products are used after agronomist visits to producers' fields. A phytosanitary plan is designed for each producer according to the special needs of the orchards, the annual climate conditions and seasonal problems. The cost of these services is covered by Zagora through the profits from agronomical inputs sold to producers.

Before harvesting, the characteristics of the apples are inspected by agronomists who oversee the control and the sampling procedures. The harvesting period starts in August for the early varieties and lasts until October for the late varieties. In order to ensure apple quality, the apples are picked by hand, put into plastic containers (<10 kg) and smaller plastic (20 kg) containers with extreme care. Crates or containers are transferred directly on the same day to the facilities of the cooperative.

The cooperative then sorts, packages and puts the apples into storage to extend the apple life cycle to the fifth to sixth month of the following year. Table 6 presents an overview of the specifications of PDO Zagora apple.

Because of pedo-climatic conditions and the land structure of the region, Zagora producers cultivate apples in terraces. Spraying and fertilizer is applied by hand with long hoses from tanks. The land structure and consequent absence of mechanization of the PDO Zagora apple orchards increases working hours required for application of the mandatory cultivating techniques (spraying, fertilizing and harvesting).

Geographical Area of PDO Zagora Apples

Zagora is located in Mid-west Greece with a population of 5809 (density 39c/km^2) and the region's economy relies mainly on agriculture production (apples and cherries) and tourism (Fig. 3), (Municipality of Zagora, 2018). Zagora is the largest

Table 6 Summary of the technical specifications

Territory	
Geographical area	Producers in the village of Zagora, Pilion (Greece) cultivate 850 ha of PDO Zagora apples. The total production ranges from 10,000 to 14,000 tonnes (13,000 tonnes in 2016) Farmers and the Zagora Cooperative are the only actors in the supply chain
Varieties/breeds	Starking delicious & golden delicious
Arable farming practices (all practices carried out by hand, not mechanical equipment)	
Fertilization	After soil and leaf analysis, agronomists design a specialized fertilization plan for every producer
Plant health	Phytosanitary health of the apple trees inspected by Cooperative agronomists A phytosanitary plan is designed for each producer according to the special needs of the orchards, the annual climate conditions and seasonal problems
Field operations	Pruning takes place at the end of the winter
Other	Low planting density (planting in terraces); lower yields (1.35t/ha). Weed management includes manual weeding. Irrigation with 50 m^3/ha^{-1} of water if necessary
Process	
First stage	Sorting and packaging of the apples. Each producer transfers the apple production daily to the Zagora cooperative
Second stage	PDO apple products are refrigerated in Cooperative storing chambers
Transportation	Cooperative uses logistics companies to distribute the final production from the Zagora to the two main fruit and vegetable wholesale markets of Athens and Thessaloniki
Conditioning	In Zagora

Source: Publication of an application for registration pursuant to Article 6(2) of Council Regulation (EEC) No 2081/92 on the protection of geographical indications and designations of origin

Fig. 4 Geographical area of PDO "Zagora apples". (Source: www.dimos-zagoras-mouresiou.gr)

village in Pelion, and produces the varieties "Starking delicious" and "Golden delicious", from which PDO Zagora apple is produced, as well as the varieties of "Royal Gala", "Reinette du Canada" and the "PDO Fyriki Pelion". The commercial name is "Zagorin", with Protected Designation of Origin recognized by the European Union, as reported by local and cooperative representatives during the researchers' visits. The pedo-climatic conditions of Zagora, Pilio, give the advanced specific characteristics to this PDO apple p (Fotopoulos and Krystallis 2003). Today, the Agricultural Cooperative Zagora collects, preserves, packages and distributes almost 100% of apple production in the region (Fig. 4).

Climate Conditions in Zagora Region

A very important factor in apple production is meteorological conditions. Table 7 displays four climate indicators of climate conditions in Zagora for the year 2016: average temperature, wind, sun hours and rain. The average temperature is low during winter (5.4–11.6 °C) and cool during the summer months (23.3–24.2 °C). The total rainfall is 1500 mm and the total sun hours are 3229. The combination of cool temperatures, high sun hours, humidity and large amounts of water contribute to the good quality and unique characteristics of the apples produced.

PDO Zagora Apples Value Chain

Figure 5 presents the value chain of the PDO Zagora apple.

U1: The Upstream level U1 is represented by the Zagora cooperative which supplies the producers with empty plastic crates (20 kg). Additional input suppliers of

Table 7 Monthly climate conditions in Zagora for the year 2016

	Average temperature (°C)	Rain (mm)	Sun hours	Wind (km/hr)
January	7	76.6	259	5.6
February	11.6	121.4	250.5	4.4
March	10.4	501.6	226	4.6
April	16.4	9.8	291	4.3
May	17.3	86.8	295	4.9
June	23.3	106.2	294.5	3.8
July	24.6	22.6	310	4.2
August	24.2	35.2	304	3.5
September	19.7	112.4	276.5	3.5
October	14.7	292.4	246.5	3.2
November	10.8	116.4	231.5	3.6
December	5.4	97.6	244.5	5.9

Source: Meteorological stations in Zagora region

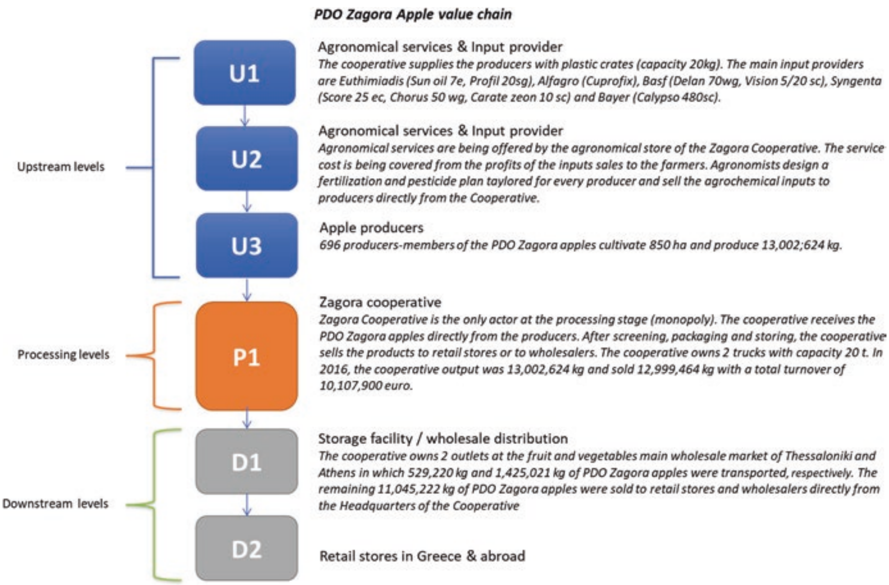

Fig. 5 The Value Chain of the PDO Zagorin apple

agrochemical products used by PDO Zagora producers through the Cooperative of Zagora are Euthimiadis (Sun oil 7e, Profil 20sg), Alfagro (Cuprofix), Basf (Delan 70wg, Vision 5/20 sc), Syngenta (Score 25 ec, Chorus 50 wg, Carate zeon 10 sc) and Bayer (Calypso 480sc).

U2: The main actor in the Upstream level U2 is the Zagora cooperative, since agronomic services are supplied free of charge by cooperative agronomists. Services include the design of specialized fertilization and pesticide plans for producers as well as sales of agrochemical products (U1). The cost of the agronomic services is covered by the cooperative through profits from sales of agrochemical products. Table 8 shows an example of a pesticide program for apple producers in Zagora.

U3: This level is represented by the producer-members of the PDO Zagora apple. All producers benefit from agronomic services and sell their PDO apple production to the cooperative. The five farmers interviewed produced 27 tonnes from 2 ha in 2016 (Table 5). On average there are five workers per farm during the pruning and picking seasons. It is noteworthy that the cost of the foreign workers is 40 euro/day while cost of family labour is 30 euro/day. According to the farmers interviewed, the cost of foreign workers is calculated to be 32% of total wage cost. On average, foreign workers are employed during the harvesting period and work for a total of 173 hours while family labour on all cultivation activities totals 992 hours (85% of the total 1165 hours).

As regards fertilization, 1200 kg of dried manure from local sheep and goat breeders is applied every 3 years. Annually, the producers also apply 10 kg of N/ha^{-1} and 7 kg of P/ha^{-1} as well as fertilizers based on Boron (B) and Calcium oxide (CaO) (Table 9).

P1: Zagora Cooperative is the only actor in the processing level of the value chain. The cooperative receives the apples, and proceeds to screening, packaging and refrigerating the PDO Zagora apples at the storing facilities. The cooperative owns two trucks to transport the production to the Cooperative's wholesale market stores in Athens and Thessaloniki.

D1: The cooperative owns two wholesale market stores at the main Fruit and vegetables markets in Thessaloniki and Athens. During 2016 1,954,242 kg of PDO Zagora apples were transported to these stores. The rest of the production was distributed on the domestic market (7,984,212 kg) through wholesalers and retail stores in Greece – mainly to Athens (72.92%) and Thessaloniki (27.08%). Lastly, the exports of the PDO Zagora apples (23.55%) account for 10.81%.

D2: The distribution of PDO Zagora apples to retail stores is carried out through the two main market stores (Athens and Thessaloniki) as well as from the headquarters of the Cooperative in Zagora.

Governance of the PDO Zagora Apples

ZAGORA Cooperative

Coordinator of the PDO Zagora apple quality scheme is the Zagora Cooperative. The Agricultural Cooperative of Zagora-Pilio is one of the oldest cooperatives and was established in 1916 by 199 apple growers of Zagora. In 1985, the cooperative entered a new phase of commercial enterprise. The brand was registered and today every authentic PDO Zagora apple bears a sticker. In 1996 the European Union recognized the apples as "Protected Designation of Origin" products. The

Table 8 Average pesticide program of a PDO apple producer

Date	Enemy	Industrial name	Active agent	Dosage (gr)/100 l Water	Water/h	PHI (days)
7/3/2016	Wintering insects	Sun oil 7 E	Paraffin oil	1500	16	20
7/3/2016	Aphids	Profil 20 SG	Acetamiprid 20%	30	16	14
7/3/2016	Venturia inaequalis	Cuprofix 20 WG	Bordeaux mixture in 20% Cu	600	16	15
11/3/2016	Venturia inaequalis	Cuprofix 20 WG	Bordeaux mixture in 20% Cu	600	50	15
11/3/2016	Wintering insects	Sun oil 7 E	Paraffin oil	1500	50	20
11/3/2016	Aphids	Profil 20 SG	Acetamiprid 20%	30	50	14
19/3/2016	Venturia inaequalis	Delan 70 WG	Dithianon	75	17.6	21
19/3/2016	Venturia inaequalis	Score 25 EC	Difenoconazole	15	17.6	35
30/3/2016	Venturia inaequalis	Delan 70 WG	Dithianon	75	17.6	21
11/4/2016	Venturia inaequalis	Chorus 50 WG	Cyprodinil	45		
11/4/2016	Aphids	Mavrik	Fluvalinate	50	17.6	90
27/4/2016	Cydia pomonella	Coragen 20 SC	Chlorantraniliprole	20	17.6	14
27/4/2016	Venturia inaequalis	Vision 5/20 SC	Nethanil/	100	17.6	56
10/5/2016	Aphids	Calypso 480 SC	Thiacloprid	20	17.6	14
10/5/2016	Venturia inaequalis	Delan 70 WG	Dithianon	50	17.6	21
26/05/2016	Venturia inaequalis	Score 25 EC	Difenoconazole	15	17.6	35
26/05/2016	Cydia pomonella	Karate Zeon 10 CS	Lambda cyhalothrin	10	17.6	7
17/06/2016	Venturia inaequalis	Flint 50 WG	Trifloxystrobin	10	17.6	14
17/06/2016	Cydia pomonella	Imidan 50 WP	Phosmet	120	17.6	28
12/7/2016	Cydia pomonella	Coragen 20 SC	Chlorantraniliprole	20	17.6	14
18/8/2016	Cydia pomonella	Bulldock 2,5 SC	Beta-cyfluthrin	50	23.5	7

Source: Agronomist of Cooperative of Zagora

Table 9 Farmer profile

Producers	Area (ha)	Production (t)	Turnover (euro)
K.B.	4	20	9200
A.V.	2.5	45	20,700
P.G.	0.8	18	8280
K.T.	2	40	18,400
G.K.	0.7	12	5520
Average	**2**	**27**	**12,420**

Source: Interviews with five farmers of the Zagora Cooperative

Cooperative produces apples of high quality, tested and certified as Protected Designation of Origin (PDO), and is the only actor in the PDO supply chain. This distinction certifies that the PDO Zagora, marketed as "PDO Zagora apple", is a product of high quality.

Financial Prospects

The 2016 turnover of the Zagora cooperative was 10,107,900 euro. During that year the cooperative sold 12,999,465 tonnes of PDO Zagora apples, which is higher than the average sales, 12,296,478 kg, of the previous 5 years. The average sale price of PDO Zagora apples in 2017 was 0.81 euro/kg and on 2016 the average sale price was 0.78 euro/kg.

PDO Zagora apple production accounts for 93.7% of the cooperative total apple production. Long term agreements with domestic retail stores and wholesalers abroad account for 85% of the PDO Zagora apple sales. During 2016, apples were procured from producers at an average price of 0.46 euro/kg, and production costs at Cooperative level account for 24.8% of turnover (2,506,919.92 euro) of which 82.3% is the cost of packaging materials. The annual investment share of turnover is 11% of the cooperative's turnover and 5% rent of premises, and 30% of the turnover covers cooperative's loans.

Personnel of the Cooperative of Zagora

The workforce of Zagora counts 167 permanent employees with two agronomists, while during the harvesting season August to March the workforce increases by 120 workers. Men are 72% permanent staff and 33% seasonal staff, while women are 28% permanent staff and 67% seasonal. Among women, 40% have an upper secondary education. As regards the age of employees, 28% are under 35, and 72% over 35 years old. The cost of the wages is 15.38% of turnover in 2016. The employees come from Zagora or neighboring villages.

PDO Zagora Apple Exports

Overall, Greece ranks as the 63rd largest exporting country in the world and according to the Economic Complexity Index (ECI), the country ranks the 54th most complex economy in the world. Greece is a developed country in Europe whose economy is based on service and industrial sectors.

The adoption of different quality assurance schemes, such as the Protected Denomination of Origin (PDO) scheme of the European Union, is a response to the growing demand for certified quality food products among consumers. In 2016, Zagora Cooperative exported 23.55% of the total production (12,999,464 kg) to EU and non-EU countries and 76.45% was distributed to Greek consumers. Exports to EU countries are 19.16% while exports to non-EU countries are 80.84% of total exports (Table 10). The trade name "Zagorin apple" has become a favourite among Greek consumers, and the domestic sale price is higher than the export sale price. Another important reason is that the sale price is linked to the quality of the PDO apples. In particular, high quality apples in terms of size and color are mainly distributed on the domestic market while lower quality apples are exported, mainly to non-European countries (Egypt, Albania).

The export value share (€) is calculated at 1,092,924.18 euro and sales on the domestic market during 2016 were 9,014,976.98 euro. In conclusion, 80.96% of the total production share is consumed by European consumers, both Greek and abroad, while a percentage of 19.04% (2,474,539.20 kg) PDO Zagorin apples were sold to non-European consumers during the period 01/07/2016 – 30/06/2017.

Sustainability Diagram Based on Strength2Food Indicators – PGI Kastoria

The comparison between PGI Kastoria apple and the reference conventional apple of Agia, using the Strength2Food method (Bellassen et al. 2016), is summarized in Fig. 6. In particular, the economic aspects of the research reveal that the selling

Table 10 Exports and production distribution of PDO Zagorin apples (2016)

EU/ non-EU	Country	Quantity (kg)	Export share (%)	Value (€)	Share value (%)	Avg. price (€)
Non-EU	Egypt	2,337,300.00	76.36%	850,376.23	8.41%	€ 0.364
	Albania	128,637.40	4.20%	48,448.67	0.48%	€ 0.377
	Ethiopia	8601.80	0.28%	7311.55	0.07%	€ 0.850
EU	Bulgaria	414,962.80	13.56%	124,154.04	1.23%	€ 0.299
	Romania	89,223.00	2.91%	25,374.73	0.25%	€ 0.284
	Cyprus	82,284.80	2.69%	37,258.96	0.37%	€ 0.453
Domestic	Greece	9,938,454.98	–	9,014,976.18	89.19%	€ 0.907

Source: Interviews with the accountant of the Zagora Cooperative

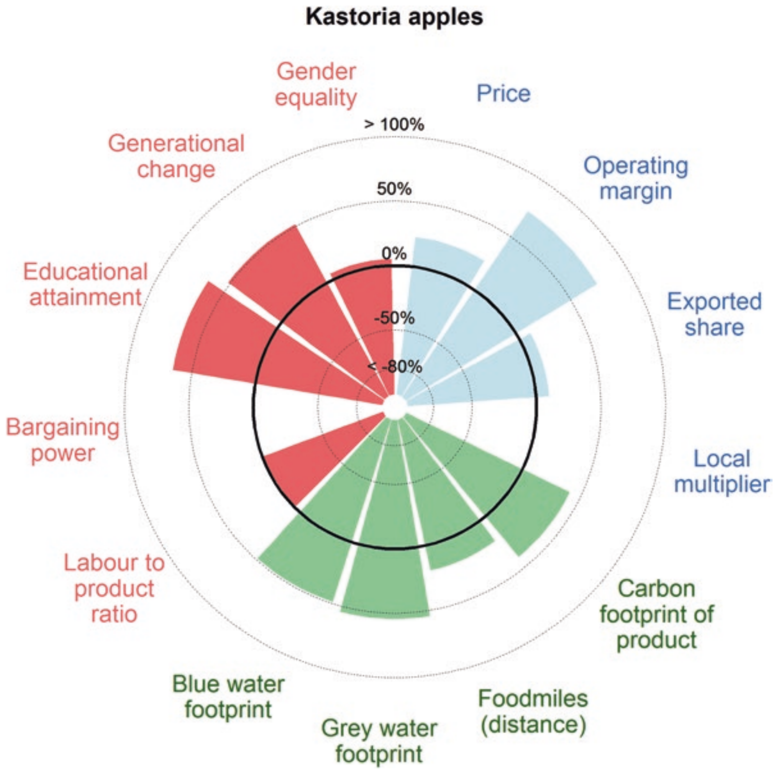

Fig. 6 Sustainability performance of PGI Kastoria apples (supply chain averages). (Each indicator is expressed as the difference between PGI Kastoria apples and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

price and the operating margin of the PGI Kastoria apple is the better than the reference case. However, the reference case exports higher volumes than the GEOK cooperative. This is because the PGI Kastoria apple selling price on the domestic market is higher than the selling price of the conventional apple, so GEOK strategically orients apple distribution slightly towards the domestic market rather than overseas.

As regards to the environmental aspects, the PGI Kastoria apple carbon footprint is lower than the conventional apple footprint mainly because of the higher yields and the lower use of agrochemical inputs. Similarly, the food miles of the PGI Kastoria apple are lower than the reference case. The PGI Kastoria apple makes a lower grey and blue water footprint but a higher green water footprint than the reference case. (Less is better). The larger green footprint is explained by the higher evapotranspiration of the PGI Kastoria apple, attributed to the higher yields compared to the reference apple.

The red area of Fig. 6 presents the social indicator results of the PGI Kastoria apple in comparison with the reference conventional apple. Referring to the

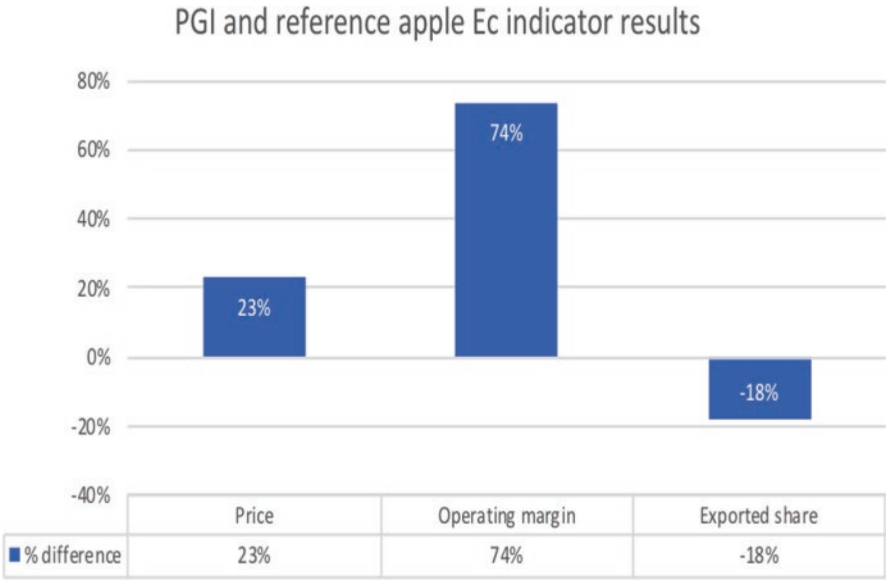

Fig. 7 Economic indicator results of PGI Kastoria apple and its reference conventional apple

generational change indicator, the PGI Kastoria apple is more sustainable than the reference case since the workforce of the FQS is younger than the reference. The *turnover to labour ratio* is higher for the PGI since it requires more working hours for the production of one ton of apples, and it thus creates more jobs than the reference case. Lastly, the educational attainment results indicate that the employees of the PGIs have a higher level of education than the reference case while the gender equality results are similar between the two cases.

Price, Margin and Exports

The economic indicator analysis reveals that the price premium (100%) is identical at upstream and processing levels for PGI Kastoria. Profitability, in terms of GVA and GMO, is similar for PGI Kastoria apple and the reference product at upstream level. At the processing level, the profitability of the FQS product is higher than that of the reference product, because of the significant weight of intermediate consumption to produce the reference product. About a quarter of the production is exported, mainly outside Europe. Figure 7 shows the results of the economic indicator variables between the PGI Kastoria apple and the reference conventional apple.

The results of the Economic indicator show that economic performance is better for the FQS apple than the reference product. However, conventional apples are more exported mainly because of their lower selling apple price.

Environmental Indicator Results

Carbon Footprint

The carbon footprints of the Kastoria apple and its reference, 100 and 177 kgCO_2e ton^{-1} respectively, are within the literature range of 70–890 kgCO_2e ton^{-1} (ADEME 2017; Clune et al. 2017). Two main factors explain the 44% lower footprint of the PGI: lower use of fertilizers and higher yield. The higher yield is mainly attributable to better pedo-climatic conditions, but the lower use of fertilizers is more related to the PGI, because while the technical specifications do not mention fertilizers, FQS farmers all use a refined fertilization strategy based on measured leaf nitrogen content. This strategy is widely adopted because it is paid for by the local cooperative as part of the quality management of the PGI product.

Food Miles

Concerning food miles, the PGI Kastoria apple supply chain was compared to the conventional apples produced by the Kissavos cooperative in the Agia region. Over the entire supply chain, from crates to distribution units (U1-D1), there is a 20% difference in favor of the FQS. PGI Kastoria apples travel slightly shorter distances (1900 km instead of 2400 km) and release slightly fewer emissions than the reference (130 kg CO_2 eq instead of 170 kg CO_2 eq). This difference can be explained by the shorter distance traveled by exported Kastoria apples, a small share of which are exported but only to neighboring countries, while conventional apples are exported to more distant locations. Moreover, the FQS experience lower emissions released per tonne of product exported due to a lower share of road transport. Exports impact the entire supply chain since they concern a large share (75%) of the total production. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 98%). Regarding food mile indicators, PGI Kastoria apples are more sustainable than the reference in terms of distance traveled, as well as in terms of emissions released at the transport stage.

Water Footprint

The green water footprint accounts for the greatest share of the indicator. The highest value shown by the FQS product compared to REF depends on the different climatic conditions. Due to these conditions, evapotranspiration is higher for FQS. This more than compensates for the difference in yield, which is in favor of the FQS, and would make its water footprint lower. The other two metrics represent a low fraction of the overall water footprint. The grey water footprint of REF is double that of FQS. Input of mineral nitrogen seems to be the major driver for this

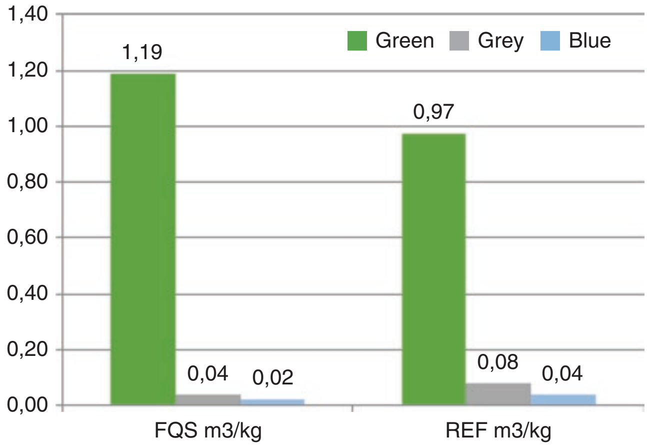

Fig. 8 Water footprint of PGI Kastoria apple

value, but the difference is also due to the lower yield of REF. The LCA component of blue WF is higher for REF than FQS. The FQS has lower inputs of mineral nutrients but it also uses manure, while REF does not (Fig. 8).

Social Indicator Results

The social indicator analysis compares data from the PGI Kastoria apple and the conventional apple of Agia. It was not possible to construct the berganing power indicator for two reasons: (a) the indicator, by construction, is based on the assumption that levels in the supply chain are independent from each other. For both Kastoria and Zagora, U3 level producers are also members of the cooperatives (P1). Hence, the fundamental assumption of *independence* at the P1 level from the U3 level is not valid; (b) Evolutions in the supply chain, and, therefore, its sustainability, mostly depend on cooperatives' internal strategy and organization. It is thus very likely that calculations and interpretation of the results based on available data is misleading.

Employment and Social Capital

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). At farm level, it takes 214 hours to produce one ton of Kastoria apples while the reference product requires 184 hours. The difference (16%) indicates that the PDO product generates more jobs than the reference system. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is slightly lower on PDO farms than on non-PDO ones. The productivity levels are much higher at the processing level, with a relative difference of 168% in favour of the PDO Kastoria apples. These results are mostly due to the farm/firm structure, to product specifications and partly due to geographical conditions.

Both Putnam (2000) and Halpern (1999) identified education as a key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator,** which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education level indicator is very low at farm level and slightly higher in the PDO sector. On farms producing apples in Kastoria, most workers have a primary (49%) or secondary (46%) level of education; on farms producing conventional apples, 80% of workers have a primary level. At the processing level, the education level indicator is higher and almost identical for PDO and non-PDO products. The small difference (6%) is due to 10% of employees who hold at least a first level degree.

Generational Change and Gender Equity (Table 11)

This evidence suggests that:

– The apple farming stage is the most sustainable of the two for both products, with Kastoria apple being more sustainable than the counterpart apple, according to the Generational Change indicator. This suggests that this stage of the supply chain of both products employs many more young people than older ones. However, because the raw data were collected by means of direct interviews with only seven or eight apple farmers, the high values of the indicator should be interpreted with caution.
– Focusing on the Generational Change indicator, the Kastoria apple is also more sustainable than the counterpart apple at the processing stage. However, absolute levels of sustainability are low, because the value of the indicator is low for both products. Nonetheless, this may have fairly limited implications, because of the few activities carried out at the processing stage on the fresh product.
– Looking at the Gender Inequality index, apple production – both GI and counterpart – appears largely unsustainable due to high levels of the indicator along the whole supply chain. The low level of female entrepreneurship along the supply chain and the low level of female secondary education achievements at all levels of the supply chain drive the value of the indicator.
– The supply chain of the Kastoria apple is more sustainable than the one for the reference apple only in terms of the Generational Change indicator for the whole supply chain (average across the stages). No difference is recorded in terms of

Table 11 Generational change and gender equity for PGI Kastoria apple

Index	Kastoria apple	Counterpart apple
U3 stage – Apple farming		
Generational change	250%[a]	200%[a]
Gender inequality	0.60[b]	0.62[b]
P1 stage – Apple processing		
Generational change	25%	14%
Gender inequality	0.85	0.83[b]
Supply chain average		
Generational change	**138%**	**107%**
Gender inequality	**0.73**	**0.73**

[a]Very high percentage due to data from a very small number of farmers interviewed (5). The value may not reflect the industry condition faithfully
[b]Indicator value calculated replacing 0 with 0.001

the Gender Inequality indicator. The sustainability of the supply chain of the Kastoria apple is high in terms of the supply-chain average Generational Change indicator, but low in terms of the Gender Inequality one.

Sustainability Diagram Based on Strength2Food Indicators – PDO Zagora

The comparison between the PDO Zagora apple and the reference conventional apple of the Kissavos cooperative in Agia, using the Strength2Food method (Bellassen et al. 2016), is summarized in Fig. 9. The economic results in the blue area reveal the superiority of the PDO Zagora apple on selling price and operating margin results. However, the PDO apples of Zagora are mainly sold on the domestic market, while the reference product shows higher exports but a lower selling price.

The environmental results of the PDO Zagora apple show that the carbon footprint is higher than the reference case. This is explained by the lower yields of the PDO Zagora apple and the lack of advanced mechanization in comparison with the reference case. On the other hand, the food miles (distance) results of the PDO Zagora apple are lower than the reference case. FQS shows a higher footprint than the REF product for green and blue water footprints, whereas the grey fraction is higher for the REF product, mainly because of the difference in yields (1.35 tonnes/ha for the PDO Zagora apple and 3.5 tonnes/ha for the conventional reference apple).

The social indicator results show that the PDO Zagora apple is more sustainable than the reference conventional apple. In particular, the *generational change* indicator is in favour of the PDO Zagora apple because the workforce in the PDO case is younger than the reference. The *turnover to labour ratio* is higher for the PDO since it requires more working hours for the production of one ton of apples, and thus creates more jobs than the reference case. Furthermore, the educational

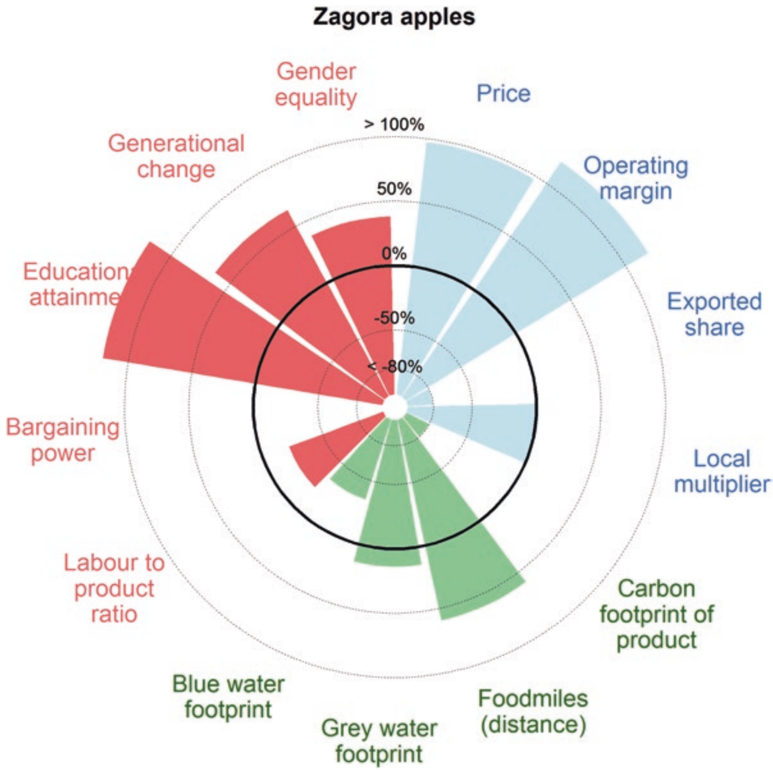

Fig. 9 Sustainability performance of Zagora apple (supply chain averages). (Each indicator is expressed as the difference between Zagora apple and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

attainment results indicate that PDO employees have more advanced education than the reference case. Lastly, the PDO provides more equal opportunities for male and female workers than the reference product.

Overall, the PGI Kastoria apple results indicate that it is more sustainable than the reference case. Detailed discussion of the indicator results is provided in the following sections on the economic, environmental, and social dimensions.

Price, Margin and Exports

The economic indicator analysis reveals that the price premium (100%) is identical at upstream level and processing level of the PGI Kastoria. Profitability, in terms of gross value added and gross operating margin, is similar for the PGI Kastoria apple and the reference product at upstream level. At the processing level, the profitability of the FQS product is higher than that of the reference product, because of the

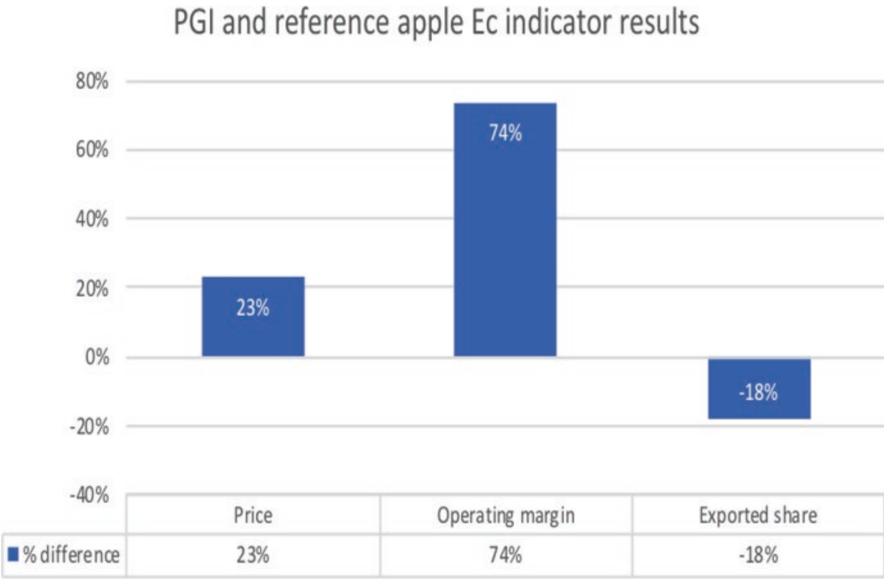

Fig. 10 Economic indicator results of PGI Kastoria apple and its reference conventional apple

significant weight of intermediate consumption to produce the reference product. About a quarter of the production is exported, mainly outside Europe. Figure 10 demonstrates the results of the economic indicator variables between the PGI Kastoria apple and the reference conventional apple.

The results of the economic indicator indicate that economic performance is higher for the FQS apple than the reference product. However, the conventional apples are more exported mainly because of the lower selling price.

The comparison of the EC variables between the FQS apples reveals that the price variable is higher for the PDO Zagora apple by 74% compared to the PGI Kastoria apple. This is mainly attributed to farm level difference, since the PDO Zagora apple has 100% difference with its reference product, and the PGI Kastoria apple only a 9% difference with the conventional apple. At P1 level, the difference of the PDO apple is 95% while the PGI apple shows a 38% difference with the conventional reference apple. The operating margin of PDO Zagora is 26% higher than PGI Kastoria. However, when it comes to the export share, PDO Zagora is 62% lower than the PGI Kastoria apple. This is because the PDO Zagora apple is mainly distributed on the domestic market.

As a result, the economic performance of PDO Zagora apple is better than the PGI Kastoria apple. The export share of the PGI Kastoria apple is higher than the PDO apple although this is mainly because the PDO succeeds in selling apples on the domestic market at a higher price, and distributes higher volumes to Greek retail stores.

Environmental Indicator Results

Carbon Footprint

The carbon footprints of the Zagora apple and its reference, 326 and 177 kgCO_2e ton^{-1} respectively, are within the literature range of 70–890 kgCO_2e ton^{-1} (ADEME 2017; Clune et al. 2017). The key driver of the 84% higher footprint of the PDO is its 61% lower yield. The lower yield is mainly attributable to less intensive practices imposed by the technical specifications: absence of mechanization for harvest, use of a refined fertilization strategy based on measured leaf nitrogen content, etc. In terms of fuel use, the absence of mechanization for harvest is offset by the higher fuel requirements of long-range hoses used instead of tractors for fertilizer and pesticide spraying. The carbon footprint comparison between the FQS apples shows that the PDO Zagora apple has higher environmental impact than the PGI Kastoria (177 kgCO_2e ton^{-1}).

Food Miles

Concerning food miles, the PDO Zagora apple supply chain was compared to the conventional apples produced by the Kissavos cooperative in the Agia region. Over the entire supply chain, from crates to distribution units (U1-D1), there is a 50–60% difference in favor of the FQS. The FQS travels 60% shorter distances (960 km instead of 2400 km) and releases half the emissions (85 kg CO_2 eq instead of 170 kg CO_2 eq) of the reference product. The shorter distance embedded in the PDO Zagora apples, as well as the lower emissions, can be explained by the smaller share of exports (24% for FQS vs 75% for its reference), and thus by shorter distances and lower emissions at the distribution level. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and more than 95% of the emissions generated for transport along the value chain. Regarding food mile indicators, PDO Zagora apples are more sustainable than the reference product in terms of distance traveled, as well as in terms of emissions released at the transport stage.

Water Footprint

The green water footprint has the greatest share of the indicator. The higher value shown by the FQS product compared to REF depends on the different climatic conditions. Due to these conditions, evapotranspiration is higher for FQS. This more than compensates for the difference in yield, which is in favor of the FQS and would make its water footprint lower. The other two metrics represent a low fraction of the overall water footprint. The grey water footprint of REF is double that of FQS. Input of mineral nitrogen seems to be the major driver for this value, but the difference is also due to the lower yield of REF. The LCA component of the blue

WF is higher for REF than FQS. The FQS has lower inputs of mineral nutrients, but it also uses manure, while REF does not. Therefore, PDO Zagora apple food miles are lower (39%) than in PGI Kastoria (Fig. 11).

Social Indicator Results

The social indicators analysis compares data between PDO Zagora apples and conventional apples of Agia. It was not possible to calculate the bargaining power indicator for two reasons: (a) The indicator, by construction, is based on the assumption that levels in the supply chain are independent from each other. In both cases, Kastoria and Zagora, U3 level producers are also members of the cooperatives (P1), so the key assumption of *independence* at the P1 level from the U3 level is not valid; (b) Evolutions in the supply chain, and, therefore, its sustainability, mostly depend on the cooperatives' internal strategy and organization. It is thus very likely that calculations and interpretation of the results on the basis of available data are misleading.

Employment and Social Capital

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). At farm level, it takes 333 hours to produce one tonne of Zagora apples while the reference product requires 184 hours. The difference (55%) indicates that the PDO product generates more jobs than the reference system. The **labour to product ratio** comparison

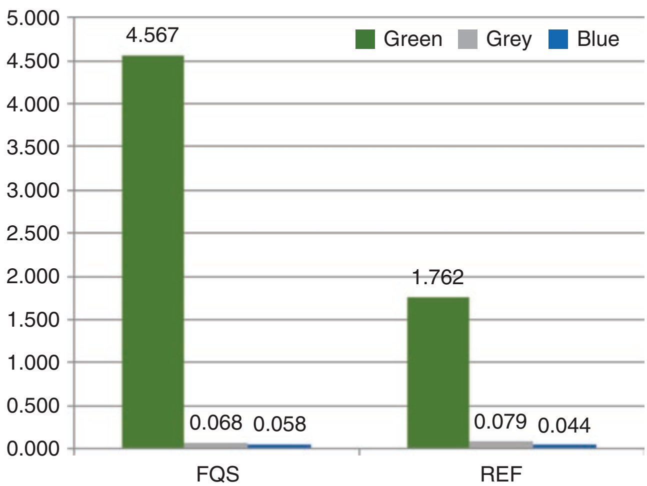

Fig. 11 Water footprint of PDO Zagora apple

between the two FQS apples indicates that the PDO Zagora apple is higher than the counterpart PGI Kastoria apple (48%).

The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is higher on PDO farms than on non-PDO ones. The productivity levels are much higher at the processing level, with a relative difference of 203% in favour of the PDO Zagora apples. These results are mostly due to the farm/firm structure, the technical specification of the product and partly to the geographical conditions; PDO Zagora apples are mainly grown on terraces in the mountainuous landscape of Zagora unlike the conventional apple which benefits from a more advanced cropping system. Comparing the two FQS apples, the turnover to labour ratio is higher in the case of PDO Zagora apple (20%) than for the PGI Kastoria apple.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator**, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator is higher for the PDO both at farm and processing level. The difference is 284% at farm level and reflects that 80% of PDO producers studied beyond elementary school compared to 20% for the reference. Comparison between the two FQS indicates that PDO Zagora apple results? per che cosa? are higher than the PGI Kastoria apple, at 35% and 12% respectively.

Generational Change and Gender Equity (Table 12)

This evidence suggests that:

- At the farm stage, both the Zagora and the reference apple are socially sustainable, according to the Generational Change indicator, because the calculated values are greater or equal to 100% for both products. Moreover, the reference product is more sustainable than Zagora, because the value of the reference product indicator is actually double the value of the Zagora one. However, these values are calculated on the basis of very few observations, and the "representativeness" of this evidence may be called into question. However, the Generational Change of PDO Zagora apple (64%) is higher than the PGI Kastoria apple (52%).
- On the other hand, at farm stage, the Zagora apple is more sustainable than the reference product, because the value of the Zagora Gender Inequality indicator is lower. Even in "absolute" terms, the Zagora Apple appears socially sustainable, because of the moderate value of the Gender Inequality indicator. This reflects the extremely low level of female farm ownership, the very limited educational achievement of male workers and low female participation in the agricultural workforce. However, the Gender Inequality indicator of PDO Zagora apple is higher than PGI Kastoria apple

Table 12 Generational change and gender equity for PDO Zagora apple

Index	PDO Zagora apple	Counterpart apple
U3 stage – Apple farming		
Generational change	100%	200%
Gender inequality	0.38	0.62 [a]
P1 stage – Apple processing		
Generational change	39%	14%
Gender inequality	0.92	0.83[a]
Supply chain average		
Generational change	**70%**	**107%**
Gender inequality	**0.65**	**0.73**

[a]Very high percentage due to data arising from a very small number of farmers interviewed (5). The calculated value may not reflect the industry condition faithfully
[b]Indicator value calculated replacing 0 with 0.001

– The apple processing stage of both supply chains is characterized by low levels of social sustainability, as assessed by both the Generational Change and the Gender Inequality indicators. In fact, the Generational Change indicators for both the Zagora and the reference product are much smaller than 100%, suggesting that the social sustainability of this stage of the supply chains is not guaranteed. However, the Zagora Apple is much more sustainable than the reference product, and the value of the Generational Change indicator for Zagora is almost three times as high.
– Likewise, the value of the Gender Inequality indicator is very high both for the Zagora and the reference product, suggesting that few opportunities exist across genders at this stage of the supply chains. However, in comparative terms, the reference product is slightly more sustainable than Zagora. This additional sustainability weakness characterizing the Zagora Apple is due to the marked difference in educational attainment across the workforce at the processing stage by gender.

In terms of **Social Indicators**, the PDO Zagora apple produces more jobs and has higher productivity than the PGI Kastoria apple. The employees of the PDO Zagora apple production supply chain are more educated and younger than the employees of the PGI Kastoria apple (U3 and P1 level). Lastly, the PGI Kastoria apple employs more women than the PDO Zagora apple. PDO Zagora apple performs better on social indicators than the PGI Kastoria apple except for aspects of gender equality.

Cooperative "Kissavos" in Agia

The cooperative of "Kissavos" establish in 2012 from 21 producers in Agia. Kissavos is located at the edge of Agia in a total area of one hectare. The facilities of Kissavos contain four refrigerate champers (ultra-low oxygen) with a total capacity of 3.616 m^3, sorting and packaging equipment as well as storages and offices.

The cooperative earned its popularity through the high rated services that include the distribution of the products in the domestic market and abroad. During the year 2016, 3.500t were distributed from the cooperative, a production that was procured from 120 producers – members of the cooperative. A share of 50% of the total production came from the red varieties, a 30% from green varieties and 20% from yellow varieties. In total, the cooperative handles twelve varieties and market the apple production in wooden or paper cases. The value chain of the cooperative of "Kissavos" in Agia, Larisa, as the most of the cooperatives in the region and in Greece, contain four key actors. In particular, the producers of Kissavos receive agronomical services and procure the farm-inputs from local SMEs and external agronomists in order to produce quality products and increase the yields of their orchards. The apple production is transferred directly from the farms to the cooperative and they are being paid at the end of the season. The cooperative "Kissavos" apply the services of sorting, packaging and storing at the procured products in order to expand their lifetime and market them for a longer time – up to six months. Furthermore, the cooperative runs the marketing department in which Kissavos acts as a processor and a wholesaler. Kissavos as a wholesaler, distribute the local products to the local and generally the domestic market as well as export the goods to European and non-European countries. Finally, the final products are being purchased by the consumers through the super markets or grocery stores.

Conclusion

The research focused on three cases of apple production in Greece, the PGI Kastoria apple, the PDO Zagora apple and the reference case of conventional apples in Agia (Kissavos cooperative). In both FQS cases, the cooperatives that participate in the research manage the FQS. As regards to the value chain, the farmers in all three cases – PGI Kastoria apple, PDO Zagora apple and conventional apples – are members of the cooperative and are located in the local area. When apples are picked, the farmers deliver them every day to the cooperative facilities using their own diesel-fueled vehicles, cars or tractors. The five producers interviewed per case are located less than 10 km from the cooperative, so at farm level transport is required for few kilometres.

There are differences in the structure of the farms in the three cases. Apple producers in Zagora cultivate apples on terraces, but PGI and conventional apple producers cultivate apples in sets (4 × 3 or 4 × 4). Farmers from both FQS make use of organic methods (manure) to enhance the fertility of the fields, but in the reference case more chemical inputs are used. Pesticide programs used in the three cases show that farmers make use of chemical substances rather than organic-based pesticide products. However, in the case of Zagora, pesticides are applied by the farmers with long hoses since tractors cannot enter the farms. As a result, Zagora producers spend more time in the fields than PGI Kastoria and reference apple producers, where mechanization enables them to spend less time and fuels in the fields.

Moreover, the labor cost in Zagora is higher than in Kastoria and Agia. In Kastoria and Agia the daily wage of foreign workers is 25–30 euro per day but in Zagora, where farmers do not always find workers available during the harvesting season, it is 40 euro. This impacts the rural life of farmers in Zagora, where cropping activities are mainly carried out by family members. Foreign labour covers only 15% of total working hours.

These differences impact the economic aspects of apple production. In particular, the production cost of the PDO Zagora apple is higher than the production cost of PGI Kastoria apple, which is closer to the conventional apples. This has led to the differentiation of the three value chains. In particular, the selling price of the PDO Zagora apple on the domestic market is higher than the selling price of the PGI Kastoria apple and the conventional apple. The average selling price of the PDO Zagora apple is 0.78 euro/kg while the PGI Kastoria apple is less than 0.60 euro/kg and the conventional apple from Agia 0.40 euro/kg. Another difference between the two FQS apples is export share. The PDO Zagora apple is distributed mainly on the domestic market at a high price of 0.9 euro/kg, and the PGI Kastoria apple is mainly exported to non-European countries. FQS representatives in interviews report that non-European buyers tend to choose these apples because of their characteristics and taste rather than the PGI and PDO certification.

The distribution strategy of the Zagora cooperative is mainly aimed at Greek consumers, who are aware of the FQS and the characteristics and taste of Zagora apples, and are willing to pay a higher price than for conventional apples. The strategy includes enhancing cooperative marketing, and activities include advertising, new packaging solutions such as recyclable plastic bags, in addition to the usual distribution of the conventional apples in bulk.

The cooperatives in all three cases have advanced facilities for sorting and refrigerating the apples in order to be able to sell the products all year round. The personnel of the cooperatives comes mainly from the local area, in all three cases. This enhances the economic and social impact in the local area. According to the cooperative interviewees, the number of employees is linked to the volume of the local apple production, since producers are mainly located in the local area. A key factor impacting total production is climate conditions. The development and growth of varieties with resistance to volatile climate conditions will improve the value chain and the social impact of the FQS apple leaders.

In conclusion, several suggestions can be made after the analysis of data collected. Marketing strategies need to be refined for the promotion of the apples. In addition, new apple varieties resistant to the climate conditions need to be introduced, and apple producers need to be trained in environmental farming practices. Agronomists currently employed by the cooperatives would be well placed to carry out these two suggestions and advance cropping techniques in a more robust production structure with environmentally friendly characteristics. Lastly, as regards marketing, the FQS certification should be advertised to make consumers and retailers aware of their significance and the comparative advantage over conventional apples.

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PGI Buon Ma Thuot Coffee in Vietnam

Viet Hoang and An Nguyen

Characteristics of the PGI Buon Ma Thuot Coffee

History of Buon Ma Thuot Coffee

Coffee was first introduced into the northern provinces of Vietnam, Tuyen Quang, Lang Son, and Ninh Binh in 1857 by the French. However, it was not popular and stable since coffee proved more difficult to grow than local crops. In the 1920s, the French expanded the coffee area to include the highlands of Dak Lak province in the Central Highland (VICOFA 2017). Coffee in Dak Lak grows well and has good quality with a distinctive flavor and taste thanks to the favourable conditions, the richness of the basaltic soil and the high altitude. From the beginning of the venture, the French explorers realized that Dak Lak was a strategic location in South Indochina but also had rich natural resources which were well suited to the cultivation of industrial crops, especially coffee (VICOFA 2017; Cheer Farm 2018).

Until 1931, the total area of coffee cultivation in Dak Lak (mostly located in Buon Ma Thuot – the central city or area of Dak Lak province) increased by 2130 ha, of which 51% of the area was for Arabica cultivation, 33% for Robusta coffee, and the rest for Liberica coffee. Coffee cultivation at this time was already industrialized and management standards reached a high level according to the document "Atlas of Dak Lak province" written in 1930, published in 1931. French plantation owners paid special attention to coffee growing and it became a key industrial crop in Dak Lak. As a result, coffee cultivation developed and expanded quickly. The quality and size of coffee cher-

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V. Hoang (✉) · A. Nguyen
University of Economics Ho Chi Minh City, Ho Chi Minh City, Vietnam
e-mail: viet.hoang@ueh.edu.vn

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ries grew. The flavor gained a special intensity and was preferred by consumers in France and other European countries. However, at this time the cultivation of Arabica coffee was hit hard by coffee rust disease which resulted in a drop in Arabica coffee yield. Many coffee farmers switched to growing Robusta coffee instead of Arabica coffee, thus the cultivation area for Arabica decreased to around 1% of the total cultivation area. Robusta coffee had a high yield with a better quality bean which also meant higher profits. As a result, Robusta coffee was grown and developed steadily through the decades becoming the key coffee plant in Buon Ma Thuot. The Robusta coffee plant has stronger resistance and can better adapt to the natural conditions of the region. By 1959, there were 49 coffee plantations in Buon Ma Thuot occupying a total area of 5200 ha. In 1975, the coffee area in Dak Lak rose to 8600 ha with an annual volume of over 11,000 tons, of mostly Robusta coffee (VICOFA 2017; Cheer Farm 2018).

During the war and the centrally-planned economic periods in Vietnam, the production of coffee in Vietnam, in general, and in Buon Ma Thuot, in particular, could not be developed, traded, and exported. Since Doi Moi (Innovation) in 1986, private enterprise has been allowed and farms (or crop lands) were shared with private farmers (not necessarily in collectives and cooperatives as before). Since the event, coffee production and trade in Vietnam in general, and in Buon Ma Thuot in particular, has steadily increased. Dak Lak province has implemented a new large-scale production plan with farmers' participation to specialize in coffee growing. With its history and experiences of over 70 years in coffee cultivation, coffee sector has consolidated its position in the manufacturing sector in Dak Lak province (VICOFA 2017; Cheer Farm 2018). Nowadays, it is generally agreed that Buon Ma Thuot city, Dak Lak province is the "**Coffee Capital**" of Vietnam for the quality of the coffee, the size of the area, and production.

To give added value to the coffee sector, to sustainably develop the coffee sector at a higher level, and to improve incomes for coffee farmers, Dak Lak province applied for the Protected Geographical Indication (PGI) of Vietnamese Buon Ma Thuot Robusta and obtained the PGI certificate of the National Office of Intellectual Property (NOIP) in 2005, with a protected area of 107,505 ha by Decision no. 806/QD-SHTT, dated 14 Oct 2005. According to the standards of the certificate, the processing of PGI coffee production consists of two main parts: (1) the procedure of planting, caring, and harvesting Robusta coffee; and (2) the procedure of processing, packaging, and preserving the green coffee beans. In 2010, Provincial People's Committee of Dak Lak issued a Regulation in the Decision No. 18/2010/QĐ-UBND to officially guide the control, management, and application of the PGI of Buon Ma Thuot Robusta coffee in Vietnam.

After losing the Buon Ma Thuot trademark in global markets with its high cost and the amount of time it took to get it back. Buon Ma Thuot Robusta coffee was then registered in 17 countries and obtained protection in 11 countries, including: Protected Collective Mark and Certification Mark in Germany, Netherlands, Belgium, France, Italy, Spain, Luxembourg, China, and Singapore; Protected Geographical Indication in Thailand and Protected Designation of Origin in Russia. The registration of Buon Ma Thuot coffee is being pursued in Canada and is in the process of completing the management and control system in accordance with regulations on the PGIs across the EU through the EU – Vietnam Free Trade Agreement (EVFTA) (Trinh 2016).

Description of PGI Buon Ma Thuot Coffee

Intrinsic Quality Attributes

According to the regulations of management and usage of the PGI for Buon Ma Thuot coffee, coffee bean quality is described as follows (PCDL 2010):

- *Colour*: grey-green, green or bluish-grey
- *Bean size*: 10–11 mm long, 6–7 mm wide, and 3–4 mm thick.
- *Smell*: specific smell of coffee at appropriate roasting time and temperature
- *Taste*: coffee drink has mild bitter taste, not harsh (specific)
- *Caffeine content*: from 2.0 to 2.2% of dry material or coffee bean (specific)

In general, the classification of Buon Ma Thuot Robusta coffee quality may be different and dependent on various standards of the coffee companies, coffee markets, and organizations (DOST 2017). The classification of the PGI Buon Ma Thuot coffee is based on the TCVN 4193-2005 (national standard). The TCVN 4193-2005 classifies the PGI Buon Ma Thuot coffee quality as follows (MOST 2013):

Moisture content ≤ 12.5 %

Grading:

- Special grade
- Grade 1: 1a, 1b
- Grade 2: 2a, 2b, 2c
- Grade 3

Total defective bean index: This index shows the maximum number of defects in a sample of a grade. In other words, how many errors or defects are found in 300 g of the coffee sample.

- Special grade: ≤ 30 defects /300 g of sample
- Grade 1:
  - 1a: ≤ 60 defects /300 g of sample
  - 1b: ≤ 90 defects /300 g of sample
- Grade 2:
  - 2a: ≤ 120 defects /300 g of sample
  - 2b: ≤ 150 defects /300 g of sample
  - 2c: ≤ 200 defects /300 g of sample
- Grade 3: ≤ 250 defects /300 g of sample

Rate of bean size on the screen:

- Special grade: Screen N^{0}18/N^{0}16: 90%/10%: 90% beans held back by screen No. 18 (7.10 mm holes). 10% beans passing through screen No. 18 and held back by screen No. 16 (6.30 mm holes)

- Grade 1: Screen $N^0$16/$N^0$12$\frac{1}{2}$: 90%/10%: 90% beans held back by screen No. 16. 10% beans passing through screen No. 16 and held back by screen No. 12 1/2 (5.00 mm holes)
- Grade 2: Screen $N^0$12$\frac{1}{2}$/$N^0$12: 90%/10%: 90% beans held back by screen No. 12 1/2. 10% beans passing through screen No. 12 1/2 and held back by screen No. 12 (4.75 mm holes)
- Grade 3: Screen $N^0$12/$N^0$10: 90%/10%: 90% beans held back by screen No. 12. 10% beans passing through screen No. 12 and held back by screen No. 10 (4.00 mm holes)

The specifications have also been used for the protection registration purpose in 17 countries and territories and for the Code of Practice in the process of completing the management and control system in accordance with regulations on protected GIs across the EU-Vietnam Free Trade Agreement (Trinh 2016).

Extrinsic Quality Attributes

The PGI certificate's inclusion on the packet helps consumers recognizes the Buon Ma Thuot coffee brand and promotes the reputation of Buon Ma Thuot coffee. Thus, the packaging and label of the PGI Buon Ma Thuot coffee contributes to its extrinsic quality. Various coffee enterprises in the province have used the product identification system of the PGI Buon Ma Thuot coffee logo on coffee packets, contracts, books, and documents and have obtained commercial benefits such as Coffee 15, Simexco, and Dakman Vietnam.

Two main colours in the logo of the PGI Buon Ma Thuot coffee are green and brown. The logo is the symbol of the roof of the indigenous people. The left of the roof has 5 tiles parallel with the roof. There are two coffee beans inside. The words "Buon Ma Thuot Coffee" form the house of indigenous people (Fig. 1). The PGI Buon Ma Thuot coffee logo is protected and only authorized organizations can use it legally.

In order to strengthen the trademark of the PGI Buon Ma Thuot coffee on roasted and ground coffee, the Buon Ma Thuot Coffee Association (BCA) has issued 2

Fig. 1 Logo of Buon Ma Thuot coffee PGI. (Source: Buon Ma Thuot Coffee Association (BMT-CA) 2018)

series of management tools including Quality Standards of the PGI Buon Ma Thuot roasted and ground coffee (Decision No. 28/QD-HHCPBMT dated 19/10/2016) and Regulations on using the Buon Ma Thuot coffee geographical indication for roasted and ground coffee (Decision No.29/QD-HHCPBMT dated 19/10/2016). For processors (roasting or/and grinding and other activities), using the logo of the PGI Buon Ma Thuot coffee may be defined or understood as follows (BMT-CA 2016):

– Using the logo on the packages of roasted and ground coffee products, business facilities, trade documents for commercial activities.
– Communicating and advertising their roasted or ground coffee products with the logo of the PGI Buon Ma Thuot coffee for commercial purposes.

A stamp or sticker with the logo of the PGI Buon Ma Thuot coffee (and maybe with a bar code) may also be used to distinguish the PGI Buon Ma Thuot coffee from other coffees. This stamp is for one-time use for eligible roasted and ground coffee products.

Geographical Area of the PGI Buon Ma Thuot Coffee

The special characteristics of the PGI Buon Ma Thuot coffee are generated from a specific and particular geographical location and the natural conditions of red basaltic soil, high altitudes, slope, temperature, sunlight, and rainfall. The PGI Buon Ma Thuot coffee territory is located in the various districts of Dak Lak province: Cu M'gar, Ea H'leo, Krong Ana, Cu Kuin, Krong Buk, Buon Ho town, Krong Nang, Krong Pak, Buon Ma Thuot city as regulated in the Buon Ma Thuot PGI regulation (PCDL 2010) with a total area of 107,505 ha. Red basalt soil in Dak Lak province is divided into four classes according to the gentle slope and the high fertility. This soil is well suited to a variety of industrial crops such as coffee, rubber, and cashew. Basaltic soils with slopes of less than 150 cm occupy about 92.39% of the area, in which layers of over 100 cm account for 84.83% of the land. Red basalt soil is highly porous and has a structure condiusive to making the soil highly absorbent. Rain water is absorbed into the soil in the form of underground water. In the dry season, farmers in Dak Lak usually face the problem of serious water shortages but the moisture remains over 70% in the 80 cm deep layer which ensures that perennial industrial crops grow well. In general, basaltic soils have more humus than other soils and a good structure; the proportion of solid soil in the layer is smaller (Pham 2012). In general, the PGI Buon Ma Thuot coffee territory is shown in Fig. 2 and meets the following conditions in detail:

– Coffee land: red basaltic soil
– Topographic: altitudes of 400–800 m
– The diurnal temperature variation:

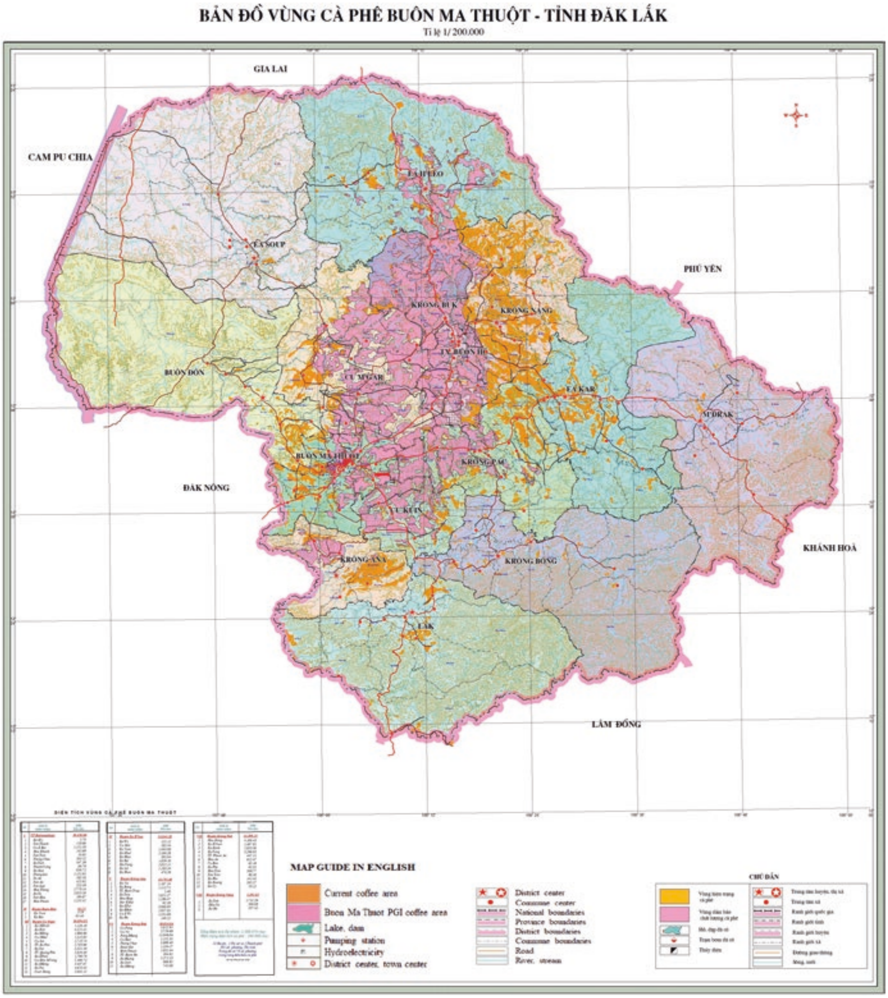

Fig. 2 Geographical area of the PGI Buon Ma Thuot coffee production. (Source: BMT-CA 2018)

- *From September to October: from 11.3 °C or higher*
- *From November to December: from 13.5 °C or higher*

– Soil depth: over 70 cm; slope: less than 15°
– Average sunshine duration: 2400–2800 hours per year
– Average monthly temperature: 24–26 °C
– Total average rainfall from May to September: ≥1000 mm
– Total average rainfall in January: ≤15 mm

Technical Process of the Buon Ma Thuot Coffee Production

According to Decision no. 674/QĐ-UB dated 20/04/2005 of PCDL, the PGI coffee production process has two main parts: (1) planting, caring, and harvesting Robusta coffee; and (2) processing, packaging, and preserving/storage of green coffee beans (Table 1).

The Buon Ma Thuot coffee has obtained various certificates and they are the important reference sources of the PGI code of practice (Trinh 2008). In general, the Code of Practice of the PGI Buon Ma Thuot coffee is based on the processes and documents of various certificates such as UTZ, 4C, Fair trade, and Rainforest Alliance. Therefore, much of the content of PGI is similar to that of other certificates. In comparison to the Non-PGI Buon Ma Thuot coffee without any certificates (UTZ, 4C, Fair trade, and Rainforest Alliance), the PGI Buon Ma Thuot coffee is standardized and monitored by two Codes of Practices: (1) Coffee planting, caring, and harvesting; (2) Coffee processing, packaging, and preserving/storage. The two processes of the Codes of Practice are as follows.

Procedure of Planting, Caring, and Harvesting of the PGI Buon Ma Thuot Coffee

– **Planting season:** Starts at the beginning of the rainy season and ends 2–3 months before the dry season, from May 15 to August 15, annually.
– **Land:** The terrain of the PGI coffee is composed of red soil from basalt rock land. During soil preparation, various methods are used to improve soil quality and treatment to avoid germs and pathogens.
– **Plant distance:** For terrain with an 8° slope or less, plant distance is about 3 m × 3 m. For terrain with a 8° slope or over, the coffee rows are arranged at a distance of 3 m × 2.5 m.
– **Seedling standard:** Seedlings must be Robusta. Seeds or plants must come from seed shops which are authorized to produce and sell seeds (registered).
– **Transplants** must meet the following criteria:

  • *Original plant:* Tree age: 6–8 months; Body height: 25–35 cm, straight stem; Number of real-leaf pairs: 5–7; Foot diameter: 3–4 mm; plant is not pestilent and is trained in the sun for 10–15 days before growing; size of soil pot: 14-15 cm × 24–25 cm.
  • *Grafted plant:* In addition to the standards of the original plants, grafted plants need to meet the following criteria: Grafted buds over 10 cm tall with at least one pair of fully developed leaves; buds are grafted min. One month before planting.

– **New planting:** Tree hole size is 60 cm × 50 cm × 50 cm. Mix topsoil with 5–10 kg of cattle manure and 0.5 kg of phosphate then fill in the hole. Cattle manure can be

Table 1 Summary of the technical specifications (Source: PCDL 2005)

Territory	
Geographical area	The total area of the PGI Buon Ma Thuot coffee is 107,505 ha in the districts of Dak Lak province: Cu M'gar, Ea H'leo, Krong Ana, Cu Kuin, Krong Buk, Buon Ho town, Krong Nang, Krong Pak, Buon Ma Thuot city.
Varieties/ breeds	Robusta coffee.
Arable farming practices	
Fertilization	*Organic fertilizer:* cattle manure, green manure or other organic fertilizers. *Inorganic fertilizer:* straight fertilizer (Urea, SA, Calcium Magnesium Phosphate, Potassium chloride) or compound fertilizer (NPK). Instructions for fertilisation are clearly and precisely explained in the Buon Ma Thuot coffee PGI documents.
Plant health	The following factors ensure coffee plant health: *Protecting trees from pests and diseases:* Coffee trees are subject to various kinds of pests and diseases. Any preventive measures and medicines used must comply with the regulations of the PGI Buon Ma Thuot coffee. *Land:* The soil must be free of pathogens before replanting. *Plant distance:* Planting on land with slopes under 8°. Coffee trees are planted at a distance of 3 m × 3 m. For land with an 8° slope, the coffee rows are arranged in contour lines at a distance of 3 m × 2.5 m. *Shelterbelt trees, shade trees* are grown simultaneously or before planting the coffee.
Field operations	The planting season starts at the beginning of the rainy season and ends 2–3 months before the dry season from May 15 to August 15 annually. Timely replanting of dead trees should be done 1.5–2 months before the end of the rainy season. The mixture of cattle manure and phosphate must be manured at least 1 month before planting. A volume of 10-15 m^3/ha of cattle manure is used every 3–4 years. Coffee branches are cut twice a year in the harvesting period. A basin to limit erosion in the rainy season and to contain water in the dry season must be built 1–2 months before the dry season. Weeding must be done 5–6 times a year. In the harvesting period, weeds need to be cleared 3 to 4 times a year. The coffee cherries are harvested by hand a few times in one season to collect ripe cherries. Harvesting must be stopped 3 days before and after flowering. The harvested cherries have a ripe ratio of 95% or more and the proportion of impurities is less than or equal to 0.5%. At the end of the harvesting season, the percentage of ripe cherries is over 80% and the percentage of impurities is less than or equal to 1%.

(continued)

Table 1 (continued)

Process	
First stage	*Wet method:* Preserving and preliminary processing: after harvesting, the fresh coffee cherries are stocked on a clean floor at a thickness of less than 40 cm without sunlight, at a temperature of less than 30 ° C. The time between harvesting and milling is less than 48 hours → Coffee cherries are soaked in a clean and odourless water tank for softening, cleaning and eliminating impurities or defective cherries. Wet milling: Coffee cherries are kept and fermented in cement tanks at a temperature of 35–38 ° C in 36–48 hours to remove the outer skin and pulp. The coffee beans are cleaned of impurities by water washing or by washing machine. Drying: the washed and cleaned coffee beans in layers are dried under the sun or by machine or both ways to reduce moisture to 12–13%. The output of the wet/washing process is parchment coffee. *Dry method:* Drying: after harvesting, the fresh coffee cherries are dried in the sun until the moisture reduces to 12–13%. The ground must be dry with low moisture content and not done in rainy weather. The output of this process is the dried coffee cherry.
Second stage	Cleaning and dry milling: Dried parchment coffee and the dried coffee cherry must be cleaned of impurities before milling. These inputs are milled by milling machine to remove the outer layer from coffee beans. The outputs of the second process are coffee beans or green coffee.
Third stage	Polishing: The coffee bean is polished to remove the silver skin and to make the coffee beans bright, glossy, and attractive to look at. The function of this step is to increase the purity and sensory value.
Fourth stage	Classifying: (1) Size classification by using screens with different-sized openings by rotating, shaking or vibrating. This step increases the accuracy of weight classification. (2) Weight classification by using a gravity separator. This step also makes colour classification faster. (3) Colour classification by using a colour sorter machine to sort beans into colours also removes defective beans.
Fifth stage	Packaging: After classification and quality inspection, the coffee beans must be packaged immediately. Packages must be dry and odourless. The packaging process must also meet PGI standards of net weight, sewing, labeling and others.
Sixth stage	Preserving: 60 kg jute sacking bags are used to package coffee beans and they are arranged in neat batches in the warehouse. They must not be put on the warehouse floor or stored with anything with an odour.

replaced by 3–5 kg of microbial organic fertilizer. Mixing and manuring must be done at least 1 month before planting. Timely replanting of dead trees should be done from 1.5 to 2 months before the end of the rainy season.

- **Basin creating:** A basin around coffee trees limits erosion in the rainy season and contains water in the dry season. Basins are made 1–2 months before the dry season. In the first year, the basin is dug in a 1 m wide square, and is 0.15–0.20 m deep. In subsequent years, the basin is extended under the canopy until it is 2.0–2.5 m wide and 0.15–0.2 m deep.
- **Shelterbelt trees and shade trees** should be planted around the farm or field either at the same time or before planting to protect coffee trees.

- **Harvesting:** According to the PGI regulations, coffee cherries should be harvested by hand several times in a season to collect the ripe cherries. Green (unripe) cherries should not be picked, the whole branch should not be pulled off, and branches should not be broken. Harvesting must stop for at least 3 days before and after flowering.
- **Technical requirements of the harvested product:** Harvested coffee cherries should have a ripe ratio of 95% or more and the proportion of impurities should not exceed 0.5%. The ripe colour needs to cover more than 2/3 of the cherry area. At the end of the harvesting season, the percentage of ripe cherries should be over 80% and the percentage of impurities should not exceed 1%. In reality, many farmers harvest coffee when it is still very unripe (about 60–70%) for fear of stealing. This is detrimental to the quality and quantity of coffee. It also prevents the processor from using the wet processing method.
- **Coffee cherry preserving/storage:** Coffee cherries must be transported to the processing facility within 24 hours. Transportation and packaging must be clean and free of fertilizer and chemicals. If coffee cherries cannot be processed they must be stored on dry, cool ground, and not be piled up more than 40cms. deep.

Procedure of Processing, Packaging, and Storage of the PGI Green Coffee Bean

There are two processing methods for coffee, wet and dry. The procedure for the processing, packaging, and preserving/storage of green PGI coffee beans by wet and dry methods is presented in the Fig. 3.

Buon Ma Thuot Coffee Value Chain

The core value chain of the PGI Buon Ma Thuot coffee includes four main actors as follows: farmers - upstream level; processors - processing level 1, roasters – processing level 2; and retailers - downstream level. The full Buon Ma Thuot coffee value chain consists of: (i) direct input suppliers such as seed, plant, fertilizer, pesticide, and water and (ii) collectors who buy unsorted green coffee beans (dry method) or coffee cherries (wet method) from farmers and sell to processors. Most of the PGI coffee processors purchase coffee directly from farmers while the Non-PGI coffee processors often buy coffee through collectors. Roasters purchase the green coffee directly from the green coffee processors and sells the roasted and ground coffee to retailers or café shops. The end-user markets include both local and global markets. The main difference between the PGI and the Non-PGI Buon Ma Thuot coffee value chains is that the PGI coffee processors and the PGI coffee roasters are separate, whereas the Non-PGI coffee processors and the Non-PGI

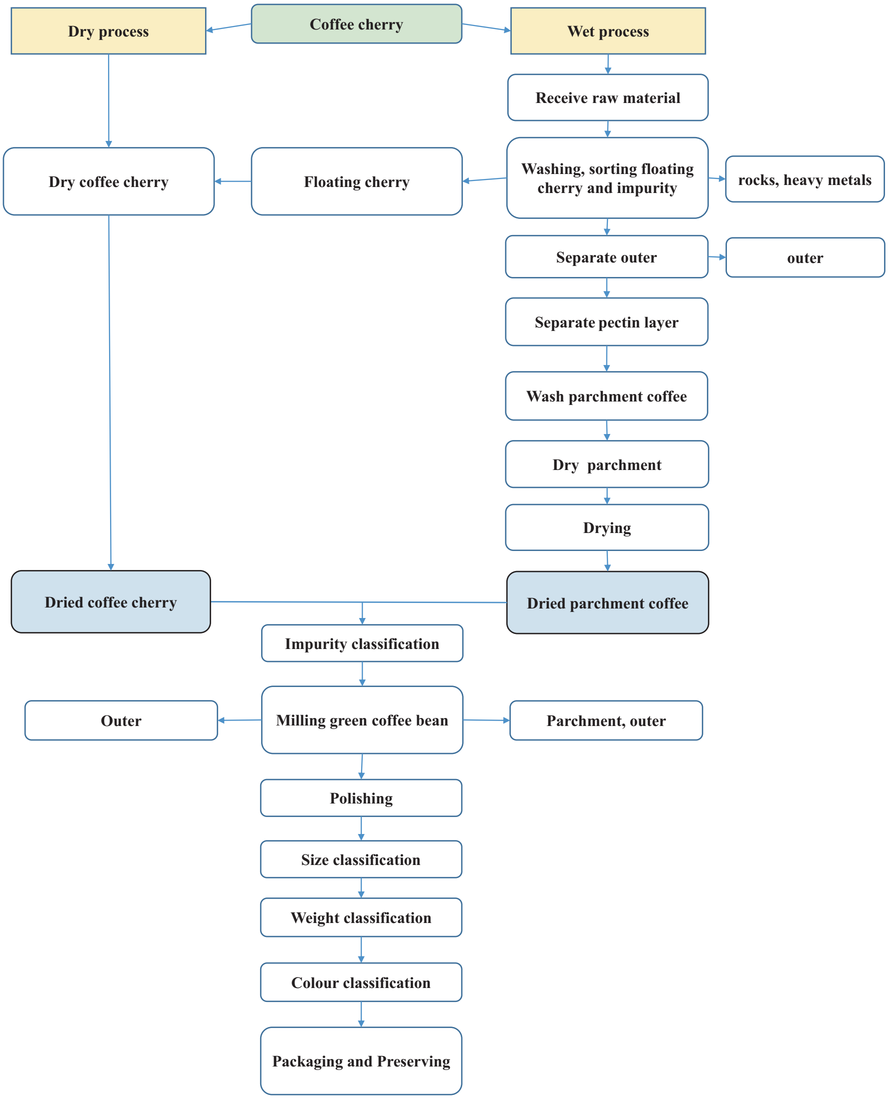

Fig. 3 Steps in technical process of Buon Ma Thuot coffee production

coffee roasters are usually combined. In addition, there are supporting and other supplying actors in Buon Ma Thuot coffee value chain such as: (i) Buon Ma Thuot Coffee Association including the Executive Board and Inspection Board. All members of the BCA are organizations and individuals producing and trading Buon Ma Thuot coffee inside and outside the Buon Ma Thuot area (ii) the indirect service and input suppliers such as finance, logistics, transport, marketing, and others; and

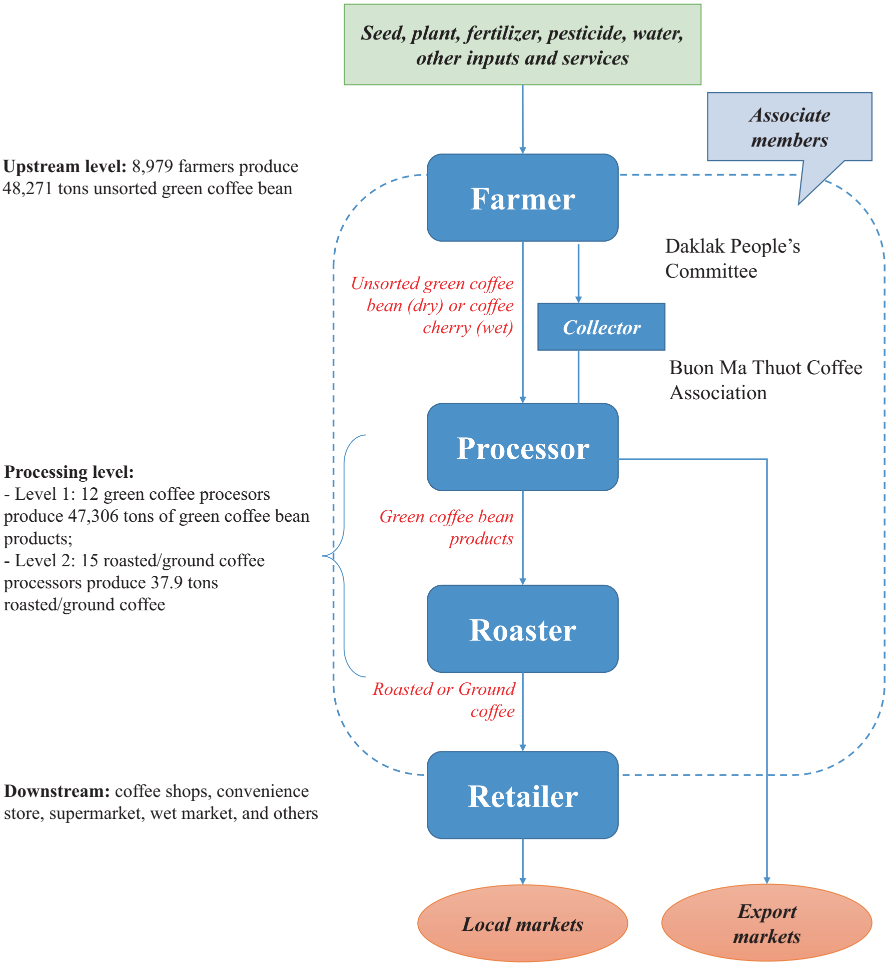

Fig. 4 PGI Buon Ma Thuot coffee value chain. (Source: The Authors 2018)

(iii) Daklak People's Committee (with its departments) with promotion and supporting policies and programs. The Buon Ma Thuot coffee value chain is described in Fig. 4.

The vertical integration of the various actors in the Buon Ma Thuot coffee value chain is presented in Fig. 5. There are five chains showing the vertical integrations in the value chain:

Chain 1: Farmer – Processor – Roaster – Retailer

In this chain, farmers, processors, roasters, and retailers are separate actors with or without contracts and official agreements. Farmers purchase inputs from suppliers to cultivate coffee and sell unsorted green coffee beans or coffee cherries to

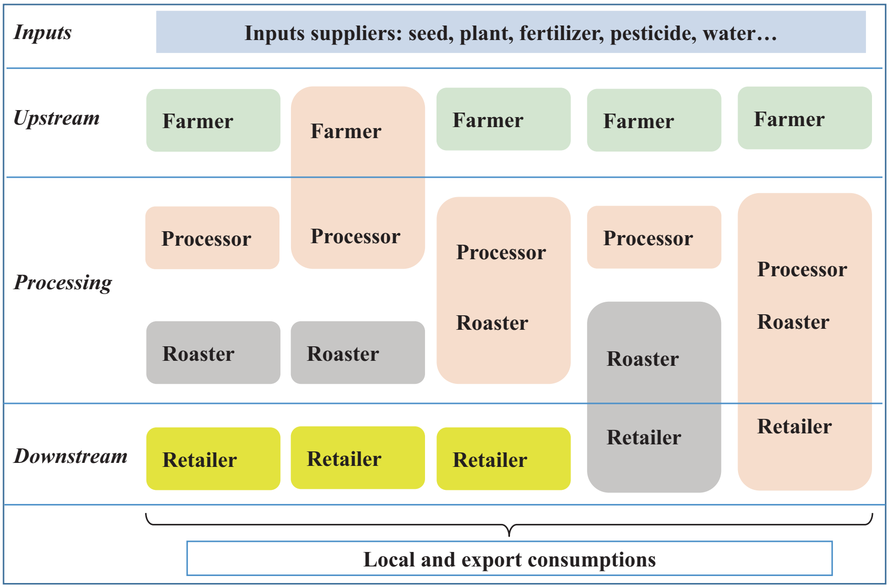

Fig. 5 Vertical integration in the Buon Ma Thuot coffee value chain. (Source: The Authors 2018)

processors. Coffee processors produce sorted green coffee beans and supply to the coffee roasters who produce roasted or ground coffee. Retailers such as coffee shops, super markets, convenience shops, wet markets, purchase roasted or ground coffee from roasters and sell to end-users.

Chain 2: Farmer & Processor – Roaster – Retailer
Some big coffee processors have their own land. They hire farmers who cultivate the coffee or they sign lump sum contracts with farmers to receive coffee at a previously agreed rate. As in the first chain, processors sell sorted green coffee beans for roasters. Roasters then sell their products to various retailers.

Chain 3: Farmer – Processor & Roaster – Retailer
The third chain is popular in the Non-PGI Buon Ma Thuot coffee chain whereas it seems to be unpopular in the PGI coffee chain. Farmers grow the coffee and sell their produce to the processors. Processors produce sorted green coffee beans then roast them and provide the roasted and ground coffee products to retailers or cafés.

Chain 4: Farmer – Processor – Roaster & Retailer
Farmers and processors are separate while roasters and retailers are combined. Roasters buy green coffee bean products from processors to produce roasted and ground coffee and have their own retail chains or coffee shops (cafés) to supply end-users.

Chain 5: Farmers – Processors & Roasters & Retailers
In this chain, the processor, roaster and retailer are integrated. Farmers sell coffee cherries to a company and the firm carries out all the other activities of primary

Fig. 6 The Governance of the Buon Ma Thuot Coffee PGI

processing, milling, sorting, polishing, roasting, and grinding. This chain is common in big enterprises.

Governance of the Buon Ma Thuot Coffee PGI

The governance of Buon Ma Thuot coffee geographical indication can be illustrated as in Fig. 6. The top or highest governance level is the People's Committee of Dak Lak province. The People's Committee is the executive arm at the provincial level appointed by The People's Council and is responsible for formulating and implementing policy. It may be thought of as the equivalent of a local cabinet.

The governance of the Buon Ma Thuot coffee Protected Geographical Indication involves internal and external management. The internal management of the Buon Ma Thuot coffee PGI aims to (i) control coffee farming and processing in accordance with the PGI coffee code of practices and (ii) to monitor the PGI use of registered actors. The BCA and its members are responsible for the internal control. The content of the internal management is as follows (1) the Buon Ma Thuot coffee cultivation area; (2) the coffee farming guide; (3) technology and recommended techniques for coffee farming; (4) information and technical advice; (5) guide to applying coffee standards; (6) checking of documentation to submit for PGI certification; (7) overseeing compliance with the PGI regulations; and (8) promoting the PGI coffee trade and brand. External management of the PGI coffee involves the supervision, inspection, and control of the quality and quantity of the PGI green coffee beans. External management also oversees compliance with the PGI practice code, for example, cultivation, harvesting, and processing procedures. External management is the responsibility of the local authorities, such as the Department of Science and Technology (DOST), Department of Agriculture and Rural Development (DARD), Department of Industry and Trade (DOIT), and others.

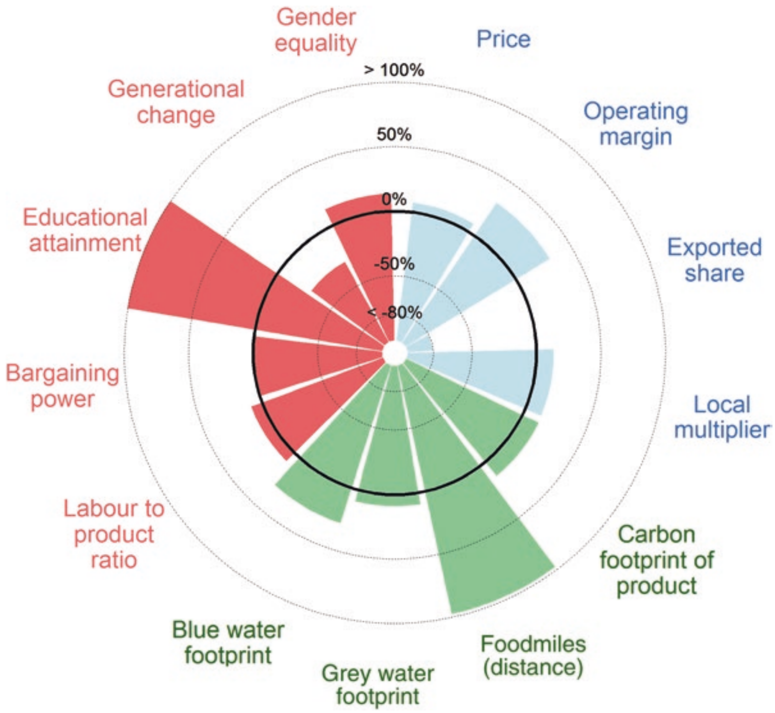

Fig. 7 Sustainability performance of PGI Buon Ma Thuot coffee (supply chain averages). (Each indicator is expressed as the difference between PGI Buon Ma Thuot coffee and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower)) (The authors 2018)

Sustainability Diagram Based on Strength2Food Indicators

The sustainability diagram is based on a comparison of economic, environment and social indicators for the PGI product, which is Buon Ma Thuot and its reference product, which is a Non-PGI coffee from Dak Lak province of Vietnam using the Strength2Food method (Bellassen et al. 2016). In general, the PGI Buon Ma Thuot coffee value chain performs slightly better than the reference chain, especially in foodmiles and educational attainment (Fig. 7).

Economic Indicators

Regarding **price premium**, there is no clear difference between the PGI and Non-PGI chains. The 7% higher price of PGI products is mostly driven by the higher price at processing levels. At processing level, the price of output is the price of roasted and ground coffee. The higher price of the PGI coffee is driven by the end-user orientation of the PGI coffee while the market orientation of the reference products is the wholesaler. At the farming stage, there is no difference in the price at U3 level. The fact is that the differential between the PGI and Non-PGI green coffee beans is 100-300VND per kg of commercial PGI coffee. Thus, the driver of high price premium is the specific value chain organisation itself instead of the technical specification of PGI.

Regarding **profitability** and **value distribution**, the larger operating margin is mostly driven by the difference at downstream level. This is due to lower rent costs in Dak Lak than Ho Chi Minh city, rather than the technical specifications of PGI. At farm level, the higher operating margin of PGI coffee famers is due to higher subsidies. PGI coffee farmers are usually trained by PGI-certificated cooperatives or processors with subsidies such as financial supports, technical training, fertilizers, farm tools, while the Non-PGI farmers have fewer subsidies. At processing level, the higher operating margin of PGI coffee processors is due to lower marketing cost. It is driven by the smaller scale of PGI coffee processors than the Non-PGI. It stems from the fact that the PGI coffee lacks commercial promotion and marketing activities and large-scale marketing campaigns on the media, especially on the international market, thus customer awareness of the PGI Buon Ma Thuot coffee is still very low and limited.

Regarding **international trade**, the lower export share is driven by the fact that the PGI product is only for domestic market in crop year 2016–2017 while 25% of the Non-PGI product is sold on the European market and 33% on the extra European market.

The **local multiplier effect** of the PGI Buon Ma Thuot coffee is 13.3% higher than its reference product: each euro of turnover for the PGI Buon Ma Thuot Coffee generates 1.30€ of re-spending in the same region versus 1.03€ for the reference. The main driver of these outcomes is the location of the unsorted green coffee bean suppliers, i.e. coffee farmers: in both cases, PGI and Non-PGI, farms are situated locally with a high share of local re-spending (100% in both cases). Indeed, without local coffee bean suppliers, the local multiplier would be reduced by 22% for the PGI coffee and by 18% for the Non-PGI product. The second main driver is the local payroll: in both cases without local workers the local multiplier would be reduced by 11%. The higher local multiplier effect is driven by the higher share of the turnover spent for local core input suppliers (coffee farmers) and the higher share of the turnover spent for local non-core input suppliers of PGI coffee processors. The first driver stems directly from the technical specifications since the PGI Robusta coffee has to be grown inside the province while 13% of conventional Robusta coffee was purchased outside the province. The second is mostly driven by the difference in marketing costs which are provided by non-local suppliers. The PGI marketing cost depends on the scale of PGI processors which are usually smaller than Non-PGI coffee processors and the driver, thus, stems from the scale of the enterprise itself rather than the technical specifications.

Environmental Indicators

The carbon footprint of the PGI coffee is 19% lower than its reference (2.1 vs 2.6 tCO2e ton-1 of ground coffee). Most of the difference comes from the lesser use of mineral fertilizers in PGI which is largely due to farmers belonging to PGI-associated cooperatives. These cooperatives give advice on optimizing fertilization and substituting mineral fertilizers with organic ones. This effect is reinforced by a lower electricity requirement for roasting PGI coffee, due to larger and more modern facilities than the reference. The differences between PGI and Non-PGI chains, however, are not derived directly from the PGI technical specifications. Both values are comparable to the 2.43 tCO2e ton-1 of packaged roasted coffee reported by Killian et al. (2013), using the same 0.75 kg roasted coffee to kg green coffee ratio as in Buon Ma Thuot coffee.

Concerning **foodmiles**, the PGI coffee covers 40 times shorter distances (210 t.km against 8400 t.km) and its emissions are almost three times lower (90 against 250 kg CO2 eq) than the Non-PGI product. Most of the kilometers covered and most of the emissions generated along the value chain (i.e. 90%) for both the PGI and Non-PGI products are concentrated at the distribution level. The longer distances covered in Non-PGI coffee is explained by the longer distance traveled by exported ground coffee and, to a smaller extent by the longer distance traveled on the domestic market. Distances for export significantly impact the results as 56% of the Non-PGI production is exported. Similarly, the higher emissions for the Non-PGI product can be explained by emissions resulting from exports. On the domestic market, PGI ground coffee covers distances four times shorter (200 vs 770 t.km) and emits 30% less emissions (90 vs 125 kg CO2eq) than Non-PGI coffee. The lower number of foodmiles has three drivers. Firstly, PGI green coffee beans were not exported to foreign markets in crop year 2016–2017 as the promotional activities of the Geographical Indication and the Buon Ma Thuot brand was not strong and effective enough, although enterprises have introduced, advertised and exported about 17,000 tons of PGI coffee beans after registering as PGI. Secondly, PGI coffee travels shorter distances than Non-PGI coffee as the coffee shops or their own retail outlets are mostly located in Dak Lak province. However, PGI retailers use light goods vehicles for the small amounts of coffee transported for each trip, and these are more carbon intensive than the heavy goods vehicles used for the reference product. Thirdly, distances and emissions are non-existent for Non-PGI, while PGI travels 13.5 km to the roasting taste owing to the difference in the supply organization. PGI coffee processors and PGI coffee roasters are separate actors, whereas Non-PGI coffee processors and Non-PGI coffee roasters are usually combined in one entity.

Non-PGI coffee requires more water than PGI coffee. The **green water footprint** accounts for the greatest share of the overall footprint for both PGI and Non-PGI, and the former requires a little more water to compensate for the evapotranspiration processes. There is no clear difference between the green share of the indicator due to the similar yield of the two production types (2.6 t/ha PGI;

2.58 t/ha Non-PGI) and the similar final product ratio (0.74 PGI and 0.75 Non-PGI). The **grey water footprint**, according to the most recent developments and recognized approaches in the literature, was computed using the amount of nitrogen fertilizers (both organic and mineral). Non-PGI production employs 327.9 Kg/ha of nitrogen whereas PGI makes use of a slightly lower amount: 294.9 Kg/ha. This higher nitrogen input makes Non-PGI impact on water quality higher, a difference that reflects in its higher grey water footprint. In terms of **blue water footprint**, the higher value shown by the Non-PGI production is due to the higher amount of water added as irrigation water (1350 m3/ha Non-PGI; 1223 m3/ha PGI). Also, the agricultural blue water footprint depends on water used to produce the various inputs to the system, such as fertilizers (production of), fuel (production of) for farming operations, electricity consumption. The higher amount of P and N mineral fertilizers that are employed in Non-PGI production are mostly responsible for the higher blue water footprint value, because large quantities of water are needed to produce the substances used in production. The final outcome is accounted for by the different amount of inputs that makes PGI production less demanding in terms of water requirement. Thus, the difference in the water footprint is mostly driven by the fact that PGI coffee farmers are encouraged to use organic fertilizers and pesticides rather than inorganic ones which have a higher nitrogen component.

Social Indicators

For labour requirements, the higher **labour to product ratio** is mostly driven by the fact that PGI coffee farmers require more labour than Non-PGI coffee farmers, especially for harvesting and hand-weeding. While this driver stems from the technical specifications, the higher labour/production ratio of PGI processing is explained by the smaller scale of the businesses themselves. For labour productivity, there is no clear difference in the turnover to labour ratio between PGI and Non-PGI coffee. This is mostly driven by the higher price of PGI compared with Non-PGI. Thus, PGI coffee has similar labour productivity to Non-PGI in spite of its higher labour requirement.

For **educational attainment**, the higher level of education is mostly driven by differences at the farming stage. PGI farmers are usually households who are more aware of environmental and social issues than Non-PGI farmers; some PGI farmers hold key positions in their communities, for example, director of the cooperative, head of the supervisory board of the cooperative, president of the commune… They usually have a higher secondary education grade. At processing level, direct labour in both supply chains have a lower educational attainment than indirect labour but most of the labour of the coffee processor is skilled labour, some firms even require all their labour to have a secondary school diploma or higher.

For **bargaining power equality**, there is no clear difference between PGI and Non-PGI products. Bargaining power is very evenly distributed along the PGI supply chain, even though the processing level of the PGI supply chain has a slight advantage over the farm level. This advantage is mainly due to the fact that there are fewer processors than farmers, although farmers also take advantage of the level of specificity of their production. Furthermore, all levels of PGI achieve high average scores, thus proving that bargaining power positions are robust along the FQS supply chain. On the Non-PGI side, bargaining power is very evenly distributed along the supply chain. There is, however, a slight advantage of processing levels over upstream levels, thanks to the fact that there are much fewer processors than farmers. Finally, a comparison of bargaining power distribution indicators shows that bargaining power is almost as evenly distributed in the PGI as in the Non-PGI supply chain (ratio FQS/ref. = ±1). This would indicate that PGI does not benefit from any sustainability advantage over Non-PGI.

For **age balance**, both products appear to be sustainable due to the high number of 15–35-year-olds employed compared to 45–65-year-olds. At the processing level in both supply chains, there are few workers over 45 years old, and some enterprises have no employees over 45; direct labour in coffee plants requires the strength and the stamina of youth. Most direct labour is young while indirect labour may be over 45 years old. However, Non-PGI Coffee appears to be more sustainable than PGI Coffee. What drives the difference is the higher number of 15–35-year-olds employed in green PGI processing as this requires more experienced employees.

For **gender balance**, higher gender equality is mostly driven by the difference at the processing stage. Most owners of Non-PGI processing firms are male. At other levels, gender equality is relatively similar for PGI and Non-PGI.

Conclusions

This study focuses on analyzing the impact of Protected Geographical Indication on the social, economic, and environmental indicators of Buon Ma Thuot coffee. The sustainability analysis of the PGI Buon Ma Thuot coffee shows that the PGI Buon Ma Thuot coffee generally performs better in economic, environmental, and social indicators than the reference. The price premium at farm level is very small while that at processing level is the highest. The operating margin is significantly different for PGI and Non-PGI at the retailing stage. Remarkably, there was no export of PGI coffee in crop year 2016–2017. All PGI coffee is consumed in the domestic market. All coffee export is Non-PGI. The European market accounts for 25% of Non-GI coffee export volume and the extra European market accounts for 33% of Non-GI coffee export volume. Locally, each euro of turnover for PGI coffee generates 1.30 € of respending in the same region versus 1.03 € for the reference. The PGI product performs better than the Non-PGI product for carbon footprint, food miles and water footprint. The bargaining power distribution of the PGI value chain is comparable to that of the Non-PGI value chain. The other social indicators also show that the PGI chain performs better than the non-PDO chain with the exception of the generational change indicator.

The impact, however, is still limited and small due to various constraints. Although the annual production of coffee attributed to Buon Ma Thuot PGI is about 48,691 tons, the actual trade volume of the PGI coffee is relatively small with approximately 1000 tons in 2016–2017 (PCDL 2017). The main constraints may be explained as follows: (1) the difference or characteristics of PGI coffee products are not really significant and clear; (2) the area of the PGI Buon Ma Thuot coffee is too large and not strictly controlled; (3) Buon Ma Thuot PGI has no clear or differentiated code of practice (mainly obtained from other certificates) and is up against various international coffee certifications such as 4C, UTZ, Fair Trade, and Rain Forest; (4) awareness of the PGI and Buon Ma Thuot brand is weak in both local and foreign markets; (5) PGI is still under the control and management of the government and marketing of PGI and the Buon Ma Thuot brand name is not sufficiently strong and effective; (6) Buon Ma Thuot PGI is officially applied to green coffee beans only, not yet for roasted and ground coffee; and (7) consumers in local markets, who are the main consumers of Robusta coffee, are not aware of PGI while consumers in foreign markets, who are aware of PGI, consume mainly Arabica coffee (most of exported Robusta coffee is used to produce instant coffee or mixed coffee in foreign markets).

The code of practice for the PGI Buon Ma Thuot coffee indicates characteristics of quality, color, appearance, smell, and taste. However, these characteristics are quite general, insignificant, and unclear. This makes it challenging for consumers to recognize and distinguish the PGI Buon Ma Thuot coffee from the Non-PGI coffee, and coffee from other regions. The PGI Buon Ma Thuot coffee is well-known for its history and its reputation as being the largest coffee growing area in Vietnam rather than for the product's flavor or its high quality. A very large geographical area of over 107,505 ha accounts for half of the total coffee growing area in Dak Lak province, while Buon Ma Thuot city, the region which has the conditions for growing the best quality PGI coffee, accounts for only 12.2% of PGI territory (GSO 2018). Buon Ma Thuot city and some districts in the PGI Buon Ma Thuot coffee area may be more than 50 km away from each other and have significantly different natural conditions. This makes it impossible for the quality and characteristics of PGI coffee to be homogeneous and distinguishable from other coffees. The solution for these issues may be: (i) re-planning the PGI area with the conditions most suited to producing a special, distinguishable coffee for flavour and characteristics. This process should focus on quality rather than quantity; (ii) clear definition and differentiation of the physical-chemical composition, and the characteristics of the PGI Buon Ma Thuot coffee products from the coffee of other regions, in local and international markets; (iii) the re-writing and editing of the code of practice for PGI coffee to differentiate it different from other certificates and clearer to applicants; (iv) certification of Buon Ma Thuot PGI should be given to coffee farmers as well as processors; (v) the application of PGI certification to roasted and ground coffee; and (vi) promoting awareness and the PGI Buon Ma Thuot coffee brand in both local and global markets.

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PGI Doi Chaang Coffee in Thailand

Apichaya Lilavanichakul

Characteristics of the PGI Doi Chaang Coffee

History of the Doi Chaang Coffee

Formerly, Doi Chang area was the producer of opium, the main ingredient of a drug. In 1983, His Majesty the King Rama IX encouraged Akha people to plant Arabica coffee since conditions of plantation in Doi Chang area is suitable for Arabica coffee to grow. This program aimed to improve social welfare and environmental quality in the area since shifting cultivation through slash and burn practices were common at that time. Initially this program did not have any positive impact for the society because of limited knowledge of coffee growers, but in 2002, coffee growers in Doi Chang villages started working towards a more sustainable growth for their product, led by the family of Mr. Panachai Pisailert together with Mr. Wicha Phromyong. They established Kafae Doi Chaang Original Co., Ltd. in 2003 with Mr. Pitsanuchai Kaewpichai as co-founder and business advisor. The company's main objectives were to assist Doi Chang coffee growers in getting a fair price for their production, develop the Kafae Doi Chaang brand in the country and internationally, as well as continue to develop the quality of Kafae Doi Chaang. Until now, the product of Kafae Doi Chaang has spread in various countries such as South Korea, USA, Canada, UK, and most of the ASEAN countries.

The registered technical specifications are summarized in Table 1.

A. Lilavanichakul (✉)
Department of Agro-Industrial Technology, Faculty of Agro-Industry, Kasetsart University, Bangkok, Thailand
e-mail: fagiayl@ku.ac.th

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Table 1 Summary of the technical specifications

Territory	
Geographical area	The production area for 'Kafae Doi Chaang' is located in Doi Chang mountain, delimited by Wawi sub-district, Mae Suai district, Chiang Rai province, Thailand at 1100–1700 m above sea level between latitude 19 deg, 48 arcmin, 48 arcsec North and longitude 99 deg, 34 arcmin East. Total area of Kafae Doi Chaang is 3040 ha.
Varieties/breeds	Kafae Doi Chaang refers to major Arabica varieties: Caturra, Catimor and Catuai.
Arable farming practices	
Fertilization	Chemical fertilization, organic fertilization, coffee cherries fertilization
Plant health	Coffee leaf rust
Field operations	As maturity period of cherries are different, selective hand-picking is used in harvesting stage to ensure that only ripe cherries are processed. This manual process takes long time. Unstable weather during harvesting season affects the period of sun drying process. Moreover, mechanical drying process cannot be an option because the quality obtained is not as good as natural drying process. Harvesting period is labor intensive activity. In this period, there is not enough labor to manually pick the ripe coffee cherries, so labor comes from other areas. Heavy rainfall leads to the rotting of the root. Thus, the crop yields decrease significantly.

Description of the PGI Doi Chaang Coffee

'Doi Chaang coffee' is an Arabica coffee which beans have a slightly larger/elliptical shape. It has a complex and flavourful profile. Typically, 'Kafae Doi Chaang' has the following characteristics: pure, refreshing coffee, sweetly acid and honey-toned in the aroma, with floral and coffee fruit (tart cherry) notes. Caffeine content is naturally low with medium acidity and body. These characteristics are generated through the cultivating, processing and roasting methods. Besides, the specific geographical location of the 'Kafae Doi Chaang' growing area, combined with climatic characteristics, distinctive physical relief and soil which has high organic matters, natural shade, and high altitude, give 'Kafae Doi Chaang' its world- class single-estate Arabica coffee.

'Kafae Doi Chaang' refers to both green coffee beans and roasted coffee only exclusively 100% 'Kafae Doi Chaang' whatever its state (green beans and roasted beans). Specification of each product can be described as follow:

- Green bean coffee

  (a) AA grade: green bean has the greyish green colour, diameter larger than 6.96 mm, the moisture content of 10–12%,
  (b) A grade: green bean has the greyish green colour, diameter between 6.10–6.96 mm, the moisture content of 10–12%,
  (c) Peaberry: the single, oval-shape bean, the moisture content of 10–12%.

- Roasted bean coffee
  (a) Doi Chaang Peaberry: a coffee cherry typically produces two flat-sided beans, but when the cherry produces only one single oval shaped bean, it is called a peaberry. The peaberry bean is much smaller with a more concentrated flavour. It represents only 5% of Doi Chaang annual crop. Doi Chaang Peaberry has a very characteristic intense fruity floral aroma and a heavy full-bodied profile. Rare and highly sought after, Doi Chaang Peaberry is slowly and carefully roasted for a vibrant and distinctive taste.
  (b) Doi Chaang Premium A grade (medium): Doi Chaang premium beans are roasted to a full medium to produce a fruity, sweet cup with a pleasant flowery fragrance. Well-balanced with a delicate body and rich undertones, Doi Chaang A grade (medium) offers an exceptionally vibrant beginning with a clean finish.
  (c) Doi Chaang Premium A grade (dark): Doi Chaang premium beans receive a long slow roast to create a dark, exotic cup with an intensely bold richness. Vibrant with an earthy fragrance, Doi Chaang Premium A grade (dark) roast has a full body with a pleasant, slightly tart acidity. A sweet taste with a hint of smoky flavor, it finishes with a hint of caramel and macadamia nut.

The external factors that influence the quality attributes of Doi Chaang Coffee include climate and topography, cultivation practices, processing practices, certifications, and packaging.

- Climate and topography: 'Doi Chang' is a high mountain rising to an altitude of 1100–1700 m above sea level and is suited for the cultivation of Arabica coffee. 'Kafae Doi Chaang' growing area is characterised by its production of coffee beans that produce a clean cup drink, of medium acidity and body and floral aroma. These features and qualities can be achieved by using the Arabica species of coffee (Caturra, Catimor and Catuai), combined with climatic characteristics, distinctive physical relief and soil with high organic matters.
- Cultivation practices: Doi Chaang coffee growers naturally cultivate a variety of Arabica plants under the canopy of sun filtered plum, peach, pear, and macadamia nut trees. The fallen leaves from the various fruit and nut trees create nutritious mulch for Doi Chaang coffee plants providing a subtle fruit and nutty taste to the coffee. The shade and high altitudes slow the growth of Doi Chaang coffee cherries creating a more complex, dense and intensely flavoured bean.
- Processing practices: The qualities of 'Kafae Doi Chaang' also depend on the following factors: wet process method (see more details in Table 2). Although the wet process is longer than dry process, washed Arabica coffee brings highest quality, milder, and rich in flavours and aroma.
- High level of production standards at each step: Attributes of 'Kafae Doi Chaang' are not only closely linked to the climate and topography, providing high organic matter soils, natural shade and high altitude, but they are also the fruit of high level production standards: carefully selected coffee strains, strict maintenance and meticulous harvesting combined with the high standard production processes. For harvesting methods, hand-picking is used for selecting only the ripe coffee cherries.

- Certifications: The presence of certifications system affects consumer quality expectations before purchasing a food product. It is an important extrinsic quality indicator since it gives an idea of the company's reputation. Typically, PGI certifications help the consumers to distinguish credence attributes that cannot be recognized by the consumer. Meanwhile, prices have a positive effect on consumer quality expectation. This enables producer to target specific consumer segments with high economic levels and to set premium price by offering high quality product. For 'Kafae Doi Chaang' product, the PGI certification allows it to be more accepted in the world market especially European and North America countries.
- Packaging: 'Kafae Doi Chaang' is packaged in valved bags which allow ventilation from inside the bags and prevent outside air from going in. The label bears the words 'กาแฟดอยช้าง' and/or 'Kafae Doi Chaang'. Kafae Doi Chaang logo portrays an elder from one of the leader groups in Baan Doi Chang Village who cultivate coffee. The portrayal was selected as a show of respect and gratitude for initiating coffee farming and passing this treasure on to future generations.

Geographical Area of PGI Doi Chaang Coffee

The production area for 'Kafae Doi Chaang' is located in Doi Chang mountain in Thailand, and delimited in Wawi subdistrict, Mae Suai district, Chiangrai province, at 1100–1700 m above sea level between latitude 19 deg, 48 arcmin, 48 arcsec North and longitude 99 deg, 34 arcmin Eastas shown in Fig. 1. Overall, the area consists of high mountains at slope gradients of more than 35%. There are narrow strips of flat land rising along mountain ridges and valleys. The slope gradients here are between 8–35% and there is approximately a 500 m difference in area altitude level. The soil is fine sandy loam or loam resultant from the degeneration of stones and minerals combined with particle pile-ups carried down from higher areas to lower lying spaces. The soil is high in organic matter and provides good drainage. Doi Chang is the mountain water source for many brooks and streams including the Huai Krai stream. In addition, there are large and small natural wells scattered throughout and providing water year round.

Technical Process of "Doi Chaang coffee" Production

Key stages of Doi Chaang production consists of seven stages: harvesting, washing, extraction, drying, hulling, sorting, and roasting. The green coffee bean is packed in jute bags and roasted coffee bean is sealed in valve bags. The label of 'Kafae Doi Chaang' refers to both green coffee beans and roasted coffee only exclusively 100% Arabica coffee from Doi Chaang area. Table 2 describes the key steps in technical process of "Doi Chaang" production.

Fig. 1 Geographical area of PGI "Doi Chaang coffee" production. (Source: Department of Intellectual Property 2019)

Doi Chaang Coffee Value Chain

Figure 2 shows diagram of Kafae Doi Chaang Value Chain. Stakeholders involved in this value chain can be described in 3 levels.

Level U3: Producers

The total area of Doi Chaang coffee plantation is approximately 3040 ha (19,000 rai). Most of the coffee plantation area is owned by coffee growers while the rest is owned by Kafae Doi Chaang Company. The company claimed that almost 80% of coffee growers in this area supply coffee cherries to Kafae Doi Chaang Company. The company does not specify the contract agreement with coffee growers. The number of coffee growers who become main supplier of Kafae Doi Chaang has increased since 2012. To date, total of registered coffee growers is approximately 570 members. Coffee growers come from five villages in Doi Chang area namely

Table 2 Steps in technical process of "Doi Chaang" production

Process	
First stage	Harvesting: coffee cherry flowers begin to bloom in February and the cherry fruit is ready for harvesting from November to March. Selectively hand-picking only the ripe cherries ensure minimal damage to the plants and that only the best coffee cherries are processed.
Second stage	Fully wet processing method: traditional processing method washes and flushes the bean from its fruit. Although time-consuming, the wet process method helps maintain the inherent qualities of the beans and the workers carefully monitor each step to ensure consistent and optimal taste.
Third stage	Extraction: firstly, the workers pre-wash the cherries in a tank of fresh spring water where all the ripe cherries will sink to the bottom and any unripe or overripe cherries will float to the top and be removed. Secondly, the workers remove the skin and pulp by putting the cherries through a pulping machine. Thirdly, the beans are fermented in water to remove the mucilage and enhance the beans aromatic and flavour qualities. Finally, the workers thoroughly hand wash the beans with fresh flowing spring water to remove all traces of the mucilage and then soak the beans in fresh natural spring water for another 20–24 hours before preparing the beans for drying. The mucilage and fermented by-products will be recycled as fertilizer for the coffee plants.
Fourth stage	Drying: the workers evenly spread the parchment-covered beans on patios to naturally sun dry over the next 7–8 days. During this time, the workers continuously hand rake and re-spread the beans to ensure they fully dry. In the evenings, the worker pile up and cover the beans to protect them from moisture. Once the beans are dried to an 11% moisture content level, they are warehoused for 6–8 months until we need them for roasting.
Fifth stage	Hulling: this final stage of processing is done just prior to roasting. The green coffee beans are removed from the final parchment layer by using hulling machine.
Sixth stage	Sorting: the coffee beans are initially sorted and graded by shaking the beans through different sized sieves and then hand-sorted to ensure only the finest grade beans are roasted.
Seventh stage	Roasting: the expert roast master freshly roasts only the best quality beans and control the roasting temperature to ensure the unique profile and exotic characteristics of 'Kafae Doi Chaang'. Coffee beans are freshly roasted, then cooled and sealed in high-grade valve bags, guaranteeing the freshness of 'Kafae Doi Chaang'. The roasting process does not necessary occur in the production area. Monitoring of roasted Doi Chaang speciality coffee outside Thailand is traced by the joint venture contracts with roasters in such countries.
Transportation	Green coffee bean is put into jute bags containing 50 kg or 60 kg. Roasted coffee bean is packaged in valve bags containing 250 g and covered in a cardboard. For domestic area, road transportation such as light and heavy duty vehicles are used depending on travel distance. For overseas area, the green coffee beans are shipped by sea using standard dry containers.
Conditioning	During storing and transporting, high ambient humidity and excessive residual moisture content in the beans can affect their quality. Thus, quality of the container should be ensured by doing periodic inspection. Maximum moisture contents of the beans should be specified in the purchase order (maximum 13%). Moisture absorbent material must be placed in the container. Cardboard lining of the container floor, walls, and door. Stowage 'below deck' to attenuate temperature change (Wintgens 2004).

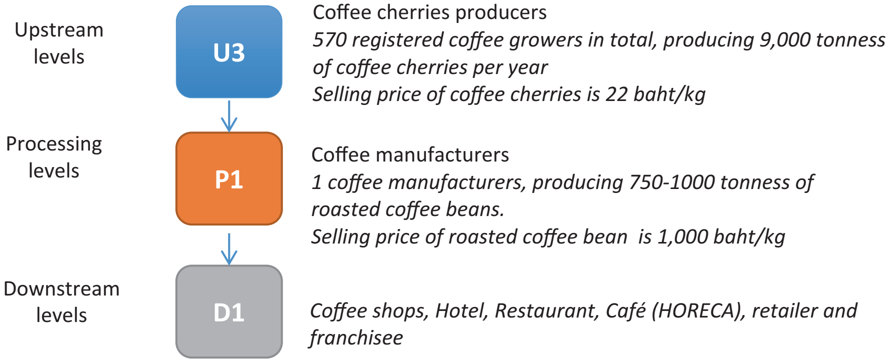

Fig. 2 PGI Doi Chaang value chain

Doi Chang, Doi Larn, Ban Mai, Hauisan, and Mae Mon. During harvest season (November–March), they deliver coffee cherries directly to the manufacturer without selling to the middle-man.

Level P1: Coffee Manufacturer and Distributor

At the manufacturer, coffee cherries are transformed into either green coffee bean or roasted coffee bean. Coffee processing and roasting are done at Doi Chaang plant. The manufacturer has two storage places with the capacity of 2000 tonnes and 35,000 tonnes, which both storages are located in Doi Chang, Mae Suai district. Both green coffee beans and roasted coffee beans are delivered to the distributor located in Bangkok. The annual production of green coffee bean is about 2000 tonnes per year depending on the customer orders, which, in general, the finished products divided into roasted coffee bean (70%) and green coffee bean (30%). A total of 70% of annual production goes to domestic market, while the rest goes to international market including Asia, America, and Europe. However, the proportion of Asian market excluding Thailand is only 10%.

From the distribution centre, green beans are shipped to overseas through port. The green bean coffee is only for particular countries such as United States of America (USA), Canada, United Kingdom (UK), and South Korea. Meanwhile, most of the roasted beans are distributed throughout Bangkok and some Southeast Asian countries such as Singapore, Malaysia, Laos, and Cambodia.

Level D1: Distribution Channels

Kafae Doi Chaang Company uses various distribution channels. Franchisee, individual Café, HORECA, and retailer are common distribution channels established in domestic market. In this market, franchisee and individual café have the biggest share market which account for almost 75%, while HORECA and retailer are only 15% and 10%, respectively. The company also expands its market by exporting its products outside Thailand. Following section is discussed about Kafae Doi Chaang's distribution channels mainly in domestic market.

- *Franchisee*

Franchise is a breakthrough started by the company since 2015. The company offers this business system for people who are interested in establishing Kafae Doi Chaang shop. Using this system, roasted bean coffee is marketed and supplied to franchisee under the contract. In domestic, total franchisee is about 22 outlets as of July 2017. On average, selling price of coffee products at franchise is 7000 baht/kg.

- *Individual Café*

Kafae Doi Chaang has been supplying more than 300 coffee shops in Thailand. Unlike franchisee system, this system allows each individual café to create their own brew coffee profile. The logo and packaging used by these coffee shops is also different when it compares to franchisee. This aims to distinguish Doi Chaang Café by original company (Franchisee) from Individual café. Selling price of coffee products at Individual Cafe is 5500 baht/kg.

- *Hotel, Restaurant, Café (HORECA)*

For Hotel, Restaurant, Café (HORECA), the main product is ground coffee and the whole bean coffee. As a part of the contract agreement, the company does not only supply coffee but also rent HORECA some coffee machines.

- *Retailer*

Most of the coffee product marketed in retail is whole bean coffee. The company builds contract agreement with numbers of modern trade (retailer). For retail distribution, consignment system is used by the company to get its coffee products on the shelf. Selling price of coffee products at retailer is 1222 baht/kg.

- *Exporter*

The Kafae Doi Chaang company built partnerships with international roasters, international franchisees, and independent coffee buyers. International roasters, independent coffee buyers, and some franchisees receive green coffee bean from the company and roast them afterwards. More than 38 franchise outlets have been spread across the Asian countries such as Singapore, Malaysia, Cambodia, Laos, and South Korea.

Another distribution channel is e-commerce, which the market share is quite small. The company also markets coffee bean products directly to consumers via online channel. It uses website platform to make it easy to access by customers.

Structure of Vertical Integration

Figure 3 describes strategy of vertical integration in Kafae Doi Chaang. In general, there are four possible chains identified from the Kafae Doi Chaang Chain.

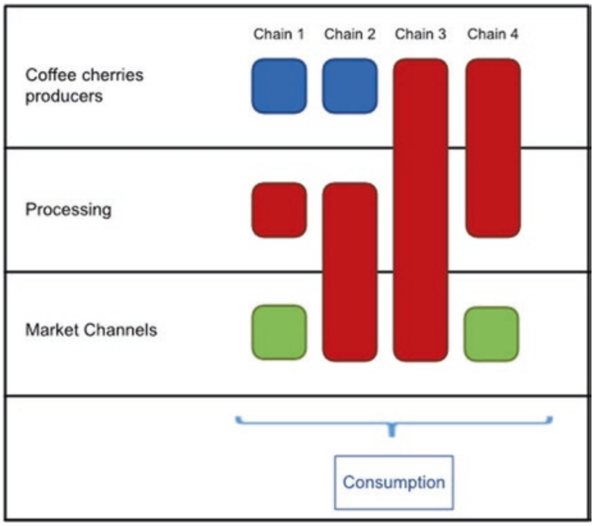

Fig. 3 Integration in a hypothetical supply chain

Chain 1: Coffee Cherries Producers – Manufacturer – Retailer/HORECA/ Individual Café

In this chain, manufacturer and distributor are integrated vertically, while other stakeholders, for instance, coffee growers, retailer, HORECA, and individual café operate individually. Manufacturer received coffee cherries from coffee growers. Finished products produced by the manufacturer are directly distributed by the distributor to market channels (retailer, HORECA, and Individual Café).

Chain 2: Coffee Cherries Producers – Manufacturer – Kafae Doi Chaang Shop/Franchise/Exporter

In chain 2, manufacturer, distributor, and typical market channel which is franchise, Kafae Doi Chaang Shop, and exporter are under Kafae Doi Chaang company. Meanwhile, the suppliers come from coffee growers in Doi Chang area. This chain is mainly used by the company as it supports company's goal to develop livelihood of Kafae Doi Chaang growers.

Chain 3: Coffee Plantation – Manufacturer – Kafae Doi Chaang shop/ Franchise/Exporter

Kafae Doi Chaang Company basically owns coffee plantation, manufacturer, distributor, exporter, and Kafae Doi Chaang Shop. For franchise, ownership of the coffee shop belongs to the licensee. However, the company has the right to manage its business in accordance with the contract of agreement. Thus, it enables the company to control all of the coffee business along the chain starting from upstream to downstream.

Chain 4: Manufacturer Farming – Manufacturer – Retailer/HORECA/ Individual Café

The company has ability to control its coffee business from upstream to distributor. Unlike chain 3, chain 4 does not allow the company to control downstream business which is retailer, HORECA, and individual café because those businesses do not work under Kafae Doi Chaang Company.

Market concentration

In general, roasted coffee market can be divided into two: regular coffee market and specialty coffee market, where Kafae Doi Chaang plays a major role in specialty coffee market. As a coffee supplier in Thailand, Kafae Doi Chaang noted that 15 companies are considered as its competitors. The top five among them are Aroma (KVN Import Export Co. Ltd.), BON cafe, K2, Great earth, and Coffee work. For the specialty coffee market, these 15 companies carries the market values of 3500 million baht. For the market share at processor level (middle stage of the supply chain), the total sale of Kafae Doi Chaang company is approximately 756 million baht, or accounting for 21.6% of total market share of specialty coffee.

Governance of the PGI Doi Chaang Coffee

In Thailand, Competent Authorities (CA), Department of intellectual properties (DIP), is in charge of GI Control System. To develop GI System, DIP collaborate with other government organizations or accreditation body (AB) such as TISI (Thai Industrial Standards Institute), ACFS (National Bureau of Agricultural Commodity and Food Standards). The accreditation body (AB) is preparing a system for accrediting control bodies (CB). Control Bodies (or external control) performing GI control on behalf of the CA in Thailand are TISI (Thai Industrial Standards Institute), ACFS (National Bureau of Agricultural Commodity and Food Standards). Rice Department, Queen Sirikit Department of Sericulture (Silk Department), and Based Economy Development Office (BEDO).

For GI control mechanism of Doi Chaang coffee, self-control, internal control, and external control are required to maintain and monitor GI logo as show in Table 3. During the early stage of internal control, DIP helped communities to set up internal control systems and provided support budget for internal control. For the role of Intermediate institutions linked to the FQS, Kafae Doi Chaang Company plays the major role in control the product quality. Public entities are Agricultural office and university that assist coffee growers and the company with coffee knowledge and technological support in order to get high quality coffee cherries and reduce costs, as well as quality improvement. Private entities are Singha corporation international roasters, and retailers that considers as a minor part of control mechanism. For retailers, the product quality specification depends on temporary contract agreement set by the retailer. At the farm level, monitoring can be performed by coffee growers and the company. Each individual coffee grower can benchmark his/her performance with the other group members.

Table 3 GI Control Mechanism of Doi Chaang coffee

Control system	Control by	Target	Duty
Self-control	Coffee growers	Coffee growers	To control their product according to specification (manual) which can be modified by group members.
	Kafae Doi Chaang Company	Coffee growers	
	Kafae Doi Chaang Company	Franchises	To control the product quality as well as visions and brand image.
Internal control	GI Committee at Provincial Level	Coffee growers	To check the running of autocontrol on the coffee growers (seeding, planting, farm management, and harvesting).
	GI Committee at Provincial Level	Kafae Doi Chaang Company	To check the running of autocontrol on the processors and manufacturers (collecting, quality control, processing).
External control	CB	Coffee growers	To verify compliance with specifications laid down and check the running of autocontrol To check the running of the internal controls.
	CB	Kafae Doi Chaang Company	

A few challenges cause GI control mechanism problems. First, some coffee growers that are not in the GI area try to sell their product to the coffee growers or the company because they receive a higher price. Second, some coffee grower groups have established in order to sell product to middleman or other companies. However, this case is considered as a small scale when compared to the total production.

Sustainability Diagram Based on Strength2Food Indicators

The sustainability diagram is based on comparison of economic, environment and social indicators for Doi Chaang coffee and its reference product, which is Arabica coffee located at Doi Phahee, Chiang Rai province, using the Strength2Food method (Bellassen et al. 2016) (Fig. 4).

Price
At the farming stage, coffee growers receive the selling price at 20–22 baht per kg of coffee cherries. At the processing stage, the selling price of single original roasted bean coffee is 1000 baht/1 kg. This selling price at processing stage depends on the distribution channels since the manufacturer provides some discounts for particular channel. The market share is mainly contributed by individual café followed by the franchise, HORECA, and retail with the average profit margin of 50%. At the downstream stage, the average selling price of roasted bean coffee is 1100 baht/kg with the average profit margin of 30–60%, depending on the distribution channel. The price premium of PGI coffee at each stage is as follows:

U level = 10%

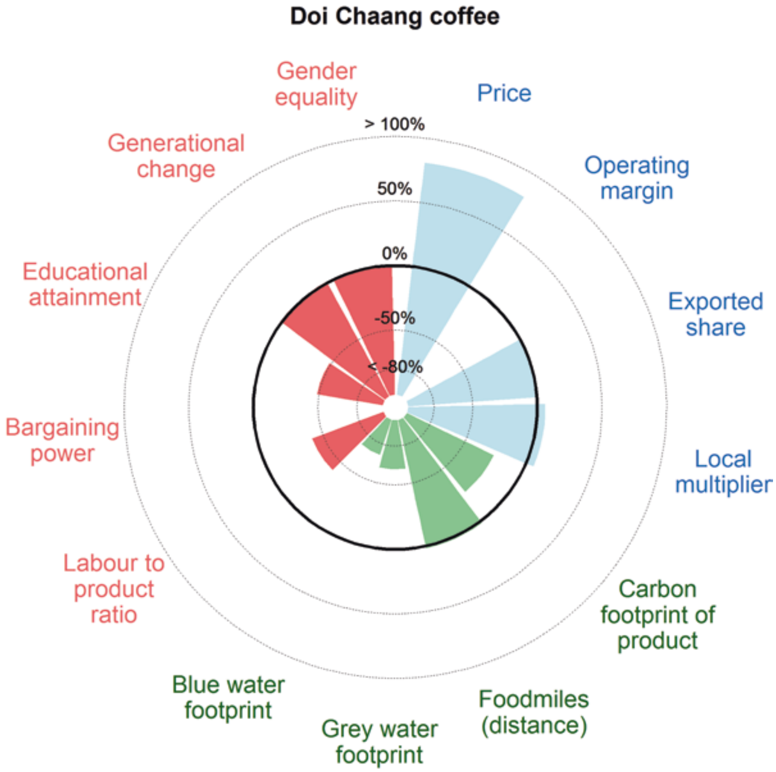

Fig. 4 Sustainability performance of PGI Doi Chaang coffee (supply chain averages). (Each indicator is expressed as the difference between PGI Doi Chaang coffee and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

P level = 150%
D level = 83%

Along the chain value, the price premium is inverted U-shaped, with a low value at upstream level (10%) and a very high value at processing level (150%).

The **gross operating margin** (GOM) could not be estimated. The data on the cost of intermediate consumption were not revealed with expert interview at both U-level and P-level. At U-level, most coffee growers cannot provide inputs, services and energy in the monetary value. At P-level, the manufacturer was not willing to reveal the cost of services and energy used in the production.

The **local multiplier effect** of PGI Doi Chaang Coffee is 6.3% higher than its reference product: each euro of turnover for Doi Chaang Coffee generates 1.54 € of responding in the same region versus 1.39 € for the reference. The main driver of these outcomes is the location of the coffee cherries suppliers, i.e. coffee farmers: in both cases, PGI and non-PGI, farms are all located within the local area with a high share of responding at local level (greater than or equal to 70%). Indeed, without local cherries suppliers, the local multiplier would reduce of −50% for both the

PGI and non-PGI product. If we assume, a null local responding for second tier suppliers the local multiplier would reduce of −19% for the Doi Chaang Coffee and −17% for the non-PGI product.

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is lower for Doi Chaang coffee than for its non-PGI reference. At the farm level, it takes 440 hours of work to produce a tonnes of Doi Chaang coffee cherries when the reference product requires 540 hours. The difference (−19%) indicates that the PGI product generates less jobs than the reference system. The difference is even greater at the processing level since it takes 202 hours of work to prepare a tonnes of PGI-coffee against 563 hours for the non-PGI coffee. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 35% greater in PGI farm than in non-PGI ones. Productivity levels are much higher at the processing level with an advantage for PGI coffees. These differences are mostly due to the better farm managements and experience of coffee growers for PGI farms compared with non-PGI farms, as well as the close relationship among coffee growers and the processing level in PGI products. Moreover, the geographical conditions for PGI farms (i.e. road, infrastructure) are more developed than that for non-PGI.

According to the monography, the same actor (i.e. Kafae Doi Chaang) controls most of the supply chain and apply a strategy of vertical integration. This means that the main structure operates at both the U3 and P1 level. As, by construction, the So2 indicator assumes that different levels of a SC are operated by different structures, this would then mean that, in this case, the calculation of **bargaining power distribution** would lead to misleading conclusions.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator,** which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The education attainment indicator is slightly lower for PGI-coffee. The level of education is dominated by initial primary (60%) and secondary (35%) education. At the processing level, the educational attainment level indicator is still much lower for PGI-coffee compared to non-PGI regional coffee.

A high value of the **Generational Change Index** (actually, a value greater than 100%) suggests that the stage of the Supply Chain considered employs more young workers than older ones. Beside indicating a higher probability of survival of the Supply Chain of the product considered in the economy, it could also indicate that the activities carried out at the stage of the Supply Chain considered could require (innovative and unique) skills and knowledge more abundant in young employees than in older ones.

The **carbon footprint** (excluding transport) of the PGI coffee is 26% higher than its reference (7.6 vs 6.1 $tCO_2e\ ton^{-1}$ of ground coffee). The bulk of this difference is due to higher yields for the reference coffee, although the higher use of fertilizers for the PGI coffee also plays a role. Because of lower yields and higher fertilizer use, these values are at the higher end of the literature range (perimeter restricted to the farming and processing stages) despite the efficient aerobic wastewater treatment: 7–8 tCO2e ton^{-1} of coffee parchment in Kenya where yields are almost twice higher (Maina et al. 2016), 1.68 tCO2e ton^{-1} of green coffee in Costa Rica (Killian et al. 2013) where yields may reach 9 ton of coffee cherries per hectare (Noponen et al. 2012).

Concerning **foodmiles**, PGI Doi Chaang roasted coffee bean supply chain was compared to the conventional roasted coffee beans produced in Doi Phahee in Chiang Rai province. Over the entire supply chain, from coffee cherry producers to distribution units (U3-D1), PGI coffee performs slightly better (−2%) than conventional coffee regarding the distances traveled and much better (−62%) as regards the emissions released at the transport stage. PGI coffee travels slightly shorter distances (1700 t.km *vs* 1730 t.km) and releases much less emissions (180 kg CO2 eq *vs* 500 kg CO2 eq) than the reference product. The larger emissions embedded in the conventional product can be explained by the larger emissions released per tonnes of product on the domestic market since the conventional chain uses a more carbon intensive transport mode, light goods vehicles, while the FQS chain uses heavy goods vehicles. The logistics of the domestic market impacts the whole retail level since there is no export. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated for transport along the value chain (i.e. more than 88%). Regarding foodmiles indicators, we can conclude that the PGI Doi Chaang coffee is more sustainable than its reference in terms of distance traveled (−2%), as well as in terms of emissions released (−62%) at the transport stage.

Concerning the **water footprint** the main conclusion is that FQS shows a higher overall footprint than the REF product, and this conclusion holds for every specific fraction (green, grey, blue) of the indicator. The exception is the processing phase, for which FQS has a better performance than REF, although, as said, this fraction has a negligible share of the indicator.

To compute the indicator we used specific information for yield, nutrient, irrigation but same values were used for FQS and REF concerning meteorological data, crop parameters, soil features. Some of this information was provided by the case study conductor some was collected from already compiled default data set (e.g. CLIMWAT for wind speed, Allen et al. 1998 for some crop parameters). Due to this data set the main causes that explain the difference in water footprint are yield and final product ratio. The REF production shows a greater yield than the FQS (2.5 and 1.8 respectively) and this increases the latter's water footprint. However the final product ratio shows that FQS is a more efficient production as it produces 0.136 tons of coffee from 1 ton of cherries (0.128 for REF). This difference does not compensate completely the effect that the different yield has over the indicator, which remains higher for FQS. Coffee that is grown in the region is not irrigated, thus both FQS and REF have WF_blue = 0 in the agricultural phase. Thus the WF_blue consists only in what deduced from the LCA procedure and concerns the overheads. This fraction concerns water that is consumed to produce and distribute pesticides, to produce and spread fertilizers. The REF production performs better in this respect as it shows no pesticide application and, accordingly, the production and distribution of these substances affects only the water footprint (blue fraction) of the FQS. The grey water footprint, which quantifies water request to dilute pollutants, still is higher for FQS. This outcome is explained by the higher amount of mineral fertilizers that are applied to the FQS product. There's no impact linked to tap water production and distribution because manufacturers uses water taken directly from mountain springs.

Conclusion

To summarize the possible drivers of the sustainability performance of the QS, the crucial factors for the sustainability of QS based on the analysis carried out in PGI Doi Chaang case include the code of practice, the production system, the territory (environment), local actors, and the marketing efficiency.

The code of practice can be beneficial for all actors along supply chain as guidelines in performing production activities. This may lead to standardization of process. Educating the code of practice along the stakeholders is necessary for the sustainability of QS.

The role of the production system can be a guideline for those who want to create a product with similar quality scheme. The yield production of Kafae Doi Chaang could been improved with more efficient farm management. Moreover, the well management of fruit trees can be additional income of coffee growers.

For the territory (environment), as an entity that sources its main raw material from natural resources, environment plays a significant role in sustainability of quality. Thus, the stability and sustainability of natural resources must be maintained well. Hence, all of activities perform along the chain should consider the environmental effect generated from those activities. This is important as Kafae Doi Chaang has high dependency on environment. There are some areas in the chain that need more attention when it comes to carbon footprint reduction. Particularly, coffee cultivation performed by coffee grower and transportation activities performed by the company is identified to release high and medium carbon emissions, respectively. These activities need to be priority to reduce carbon footprint emission.

As executor, local actors play a role to run the operations from upstream to downstream. Therefore, trained local actors are one of the important things to support the sustainability of the quality scheme. As the company and coffee growers has a strong relationship, the company assists coffee growers with knowledge and technological supports in order to get higher yields and quality of coffee cherries. The company also has a good relationship with franchises and exporter level, as well as share similar visions and long term objective, which is developing the local economy and strengthening Kafae Doi Chaang's positioning in market. However, the relationship between manufacturer-retailer and manufacturer-individual coffee shop need to be improved to make the Kafae Doi Chaang chain becomes more sustain.

For the role of the marketing efficiency, as a unique quality product, Kafae Doi Chaang has good potential in both domestic and international markets. Understanding what it is that consumers need is necessary since this allows the company to focus on ways to create value. As the coffee consumption continue increases, multi-channels would provide consumers more convenient to access the products such as increasing the number of coffee shop location, providing an online shop, and providing delivery. In addition, one important marketing strategy is to encourage to educate domestic consumers more about PGI and fair trade or other certifications.

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Part IV
Meat Sector

PGI Dalmatian Ham in Croatia

Marina Tomić Maksan and Ružica Brečić

Characteristics of the PGI Dalmatian Prosciutto

History of Dalmatian Prosciutto

The first written evidence of trade in "Dalmatian prosciutto" dates back to 1557, and states that prosciutto and cheese were exported to Venetians through Zadar. It is reported that the export went from "Bosnia", and at that time Bosnia covered the whole area west of the Drina River under the Ottoman dynasty. Since the Turkish Empire in the sixteenth century reached the city walls of Zadar, it is very likely that it was a prosciutto from the immediate Zadar hinterland. Travelers recognized the specialty of "Dalmatian prosciutto" and it is mentioned in numerous travel books as dalmatinischer Rohschinken.

Until the Second World War, "Dalmatian prosciutto" was produced only on family farms, and limited production permitted the consumption of prosciutto only in more prosperous rural households.

"Dalmatian prosciutto" started to be produced on a larger scale after World War II, when there was a significant development of existing and new cooperatives. "Dalmatian prosciutto" is one of the few autochthonous products that has been offered in the past six decades as a cold appetizer in many restaurants throughout Croatia.

With the development of tourism in the mid-1990s and the increasing demand for local products, "Dalmatian prosciutto" became a recognizable specialty from Dalmatia and an economically significant traditional food product in Croatia. It

M. T. Maksan (✉)
University of Zagreb, Faculty of Agriculture, Zagreb, Croatia
e-mail: matomic@agr.hr

R. Brečić
University of Zagreb, Faculty of Economics & Business, Zagreb, Croatia

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Table 1 Summary of the technical specifications

Territory	
Geographical area	Dalmatia (see map Fig. 1)
Varieties/ breeds	No constraint for pork. For wood smoke, only hornbeam, oak and beech are allowed.
Arable farming practices	
Fertilization	No constraint
Plant health	No constraint
Field operations	No constraint
Animal management	
Minimum weight	The minimum weight of a trimmed leg is 11 kg.
Meat quality	pH between 5.5 and 6.1 Moisture content between 40% and 55% Water activity (aw) below 0.93 Salt (NaCl) content between 4.5% and 7.5%
Fat coverage	At least 15 mm
Process	
Meat temperature	When a leg is delivered to the production site, its internal temperature is between 1 °C and 4 °C. During storage and transport, fresh legs are kept at a temperature of between 1 °C and 4 °C. The legs may not be frozen. The leg must be salted between 24 and 96 hours after the pig is slaughtered.
Minimum weight	6.5 kg
Ripening time	At least 12 months
Salting	Using sea salt
Processing steps	See Table 2
Conditionning	Whole or in pieces. Must bear the 'Dalmatinski pršut' name and symbol.

obtained the Protected Geographical Indication status in 2016. The registered technical specifications are summarized in Table 1.

Description of the First Stage Product (Fresh Pork Ham with Bone)

"Dalmatian prosciutto" is a preserved dry-cured meat product made of a pig's leg, with the bone, skin and subcutaneous fat. "Dalmatian prosciutto" does not contain any additives (nitrites, nitrates, potassium sorbate, ascorbic or propanoic acids), except sea salt. It is smoked using cold smoke obtained by burning hornbeam (Carpinus sp.), oak (Quercus sp.) or beech (Fagus sp.) hardwood or shavings. It undergoes drying and maturation processes that last for at least 1 year.

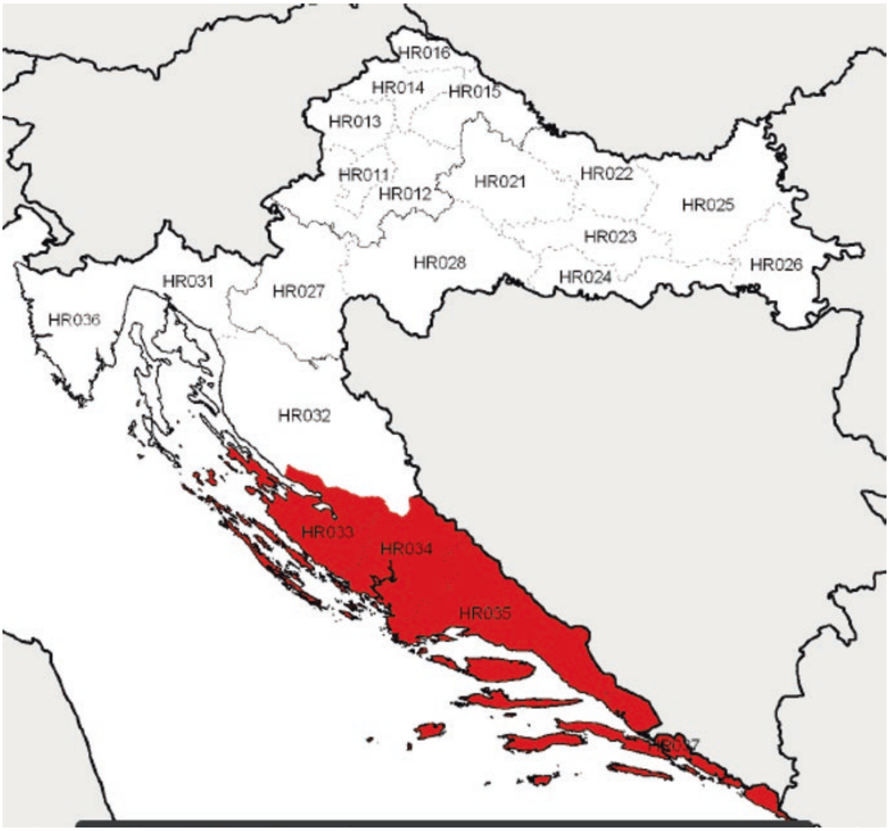

Fig. 1 Geographical area of PGI "Dalmatian prosciutto" production. (Source: Ministry of Agriculture 2017, 2018)

"Dalmatian prosciutto" is produced from fresh pork legs, on the bone, obtained from pigs from commercial meat breeds, cross-breeds or breeding lines, or cross-breeds of any combination thereof. It is important to emphasize that the fresh ham for Dalmatian prosciutto production is imported mostly from Hungary and Austria.

Ham must be separated from the half swine between the last vertebrae (v. lumbales) and the first cross vertebrae (v. sacrales). There must be no pelvic bones in the ham, or lateral bone (os ilium), sore bone (os ishii), perforated bone (os pubis), or cross bone (os sacrum), and tailed vertebrae (v. caudales) must be removed. Ham must be separated from the articulus coxae that connects the head of the thigh bone (caput femoris) and pectoral cup (acetabulum) on the horn. There must remain only part of the sitting bones with cartilage (tuber ishii). Soft muzzles must be properly rounded so that the proximal edge of the processed ham is approximately 8–10 cm

Table 2 Steps in technical process of "Dalmatian prosciutto" production

Salting	The most critical phase in the technological process of prosciutto production. The salting is carried out at a temperature of 2–6 °C and a relative air humidity of more than 80%. "Dalmatian prosciutto" can only be salted with sea salt. After 7–10 days (depending on the weight of the hams), the hams are re-salted with sea salt and they are left for the next 7–10 days with the median side facing down.
Pressing hams	The main objective of this phase of prosciutto production is to properly mold prosciutto. The pressing phase lasts 7–10 days, then producers washed the hams with clean water and tear them, after which they are ready for smoking, drying and smoothing. The temperature of the pressing stage must be 2–6 ° C and the relative humidity of the air must be higher than 80%.
Smoking and drying	Properly salted hams, washed and drain, are bound with a rope or hung on a stainless steel handle over the tubes (calcanei) and transfer to another, clean room (chamber) to equalize the temperature before smoking. Smoking is done using cold smoke obtained by burning hornbeam (Carpinus sp.), oak (Quercus sp.) or beech (Fagus sp.) hardwood or shavings. If smoking is performed in the traditional manner with an open fire, it is necessary to take special care of the temperature of the room for smoking which must not exceed 22 °C. Smoking and drying of prosciutto takes up to 45 days.
Ripening	The prosciutto is moved to a room (chamber) with stable microclimate which has air exchange (windows) for the proper running of the technological process. It is desirable that the temperature of the ripening room does not exceed 20 °C and the relative humidity of the air is below 90%. The ripening phase takes place in dark areas with slight change of air. After 1 year from the beginning of the salting, the prosciutto is ready for consumption.
Packaging and marketing	A product with a geographical indication "Dalmatian prosciutto" may only be placed on the market after the end of the last stage of production and after the certification body has determined the conformity of the product with the specification. The product may be placed on the market as whole prosciutto or in pieces.

(four fingers) away from the head of the femur (caput femoris). Leg is separated in the articulus tarsi by removing the proximal row of bones. In the case of tibia and fibula only tuber calcanei should remain, and hams are bound and hung for drying. On medial and lateral sides, ham have skin and subcutaneous fatty tissue.

A fresh leg must display no discernible signs of trauma. The meat is reddish-pink, firm in texture and free of surface wateriness (RFN). Pale, soft and exudative meat (PSE), dark, firm and dry meat (DFD), meat that has desirable colour but is soft and exudative (RSE) and meat that is firm and non-exudative but pale (PFN) may not be used. At the time of its delivery to the production site, the pH of a pork leg, as measured in the area of the semimembranosus muscle, is between 5.5 and 6.1.

The minimum thickness of the subcutaneous fat, with the skin, on the outer part of a trimmed leg, measured vertically below the femur head, is 15 mm and it is desirable that the thickness of the bacon with the skin is 20–25 mm. The fat covering along the whole of the rounded edge of the leg is sufficient to prevent the skin from separating from the underlying muscle.

Description of PGI Dalmatian Prosciutto

"Dalmatian prosciutto" has the following organoleptic properties:

- external appearance: free of any cracks, cuts or loosely hanging muscle tissue or rind, and without prominent wrinkling of the skin
- cross-section: the subcutaneous fat is white to pinkish-white, while the muscle meat is evenly red to light red
- aroma: aroma of fermented, salted, dried and smoked pigmeat, without any extraneous smells (of tar, oil, raw meat, wet or dry grass); the aroma of the smoke is mild
- taste: slightly salty to salty
- texture: soft.

"Dalmatian prosciutto" has the following chemical properties:

- moisture content between 40% and 55%
- water activity (aw) below 0.93
- salt (NaCl) content between 4.5% and 7.5%

When is placed on the market, "Dalmatian prosciutto" has a minimum weight of 6.5 kg and has matured for at least 12 months counted from the start of processing.

Geographical Area of PGI Dalmatian Prosciutto Production

The production of "Dalmatian prosciutto" takes place in Dalmatia. The northern boundary of the production area runs through the town of Novalja, the municipality of Kolan, the town of Pag, the municipalities of Starigrad and Jasenice, the town of Obrovac, the municipality of Ervenik and the town of Knin. To the east, the boundary traces the state borders with Bosnia and Herzegovina, and Montenegro. To the south and west, the area is demarcated by the maritime state border with the Italian Republic.

The link between "Dalmatian prosciutto" and the geographical area where it is produced is based on the product's characteristics that stem from the traditional production method, and also on the reputation which this regional product has attained nationwide.

Technical Process of "Dalmatian Prosciutto" Production

Prosciutto-makers in Dalmatia select quality hams that weigh at least 11 kg and have a fat and rind cover of at least 15 mm. Before salting they massage the leftover blood out of the ham, particularly from the femoral artery, to prevent spoiling during the drying and maturation stage.

Fig. 2 “Dalmatian prosciutto” symbol

The process of “Dalmatian prosciutto” production begins with the control of the quality of raw materials, i.e. the selection of only fresh hams whose physico-chemical and sensory properties meet the conditions stated above. Table 2 describes the key steps in technical process of “Dalmatian prosciutto” production.

“Dalmatian Prosciutto” Symbol

The “Dalmatian prosciutto” symbol is oval shape with inside three lion heads, and on the upper rim ‘Dalmatinski pršut’ “*Dalmatian prosciutto*” (Fig. 2).

After the end of the maturing stage, the hams are hot-branded with a brand mark comprising the common symbol of ‘Dalmatinski pršut’ and the producer code, which is the same as the veterinary inspection number.

When placed on the market, the product must bear the name ‘Dalmatinski pršut’ and the symbol. The name ‘Dalmatinski pršut’ must be clearly legible and indelible, and must be sufficiently large and highlighted through type and colour to stand out more clearly than any other wording. All users of the designation of origin who place the product on the market in accordance with its specification have the right to use the common symbol, under the same conditions.

Dalmatian Prosciutto Value Chain (Fig. 3)

Level U1-P1

It is important to emphasize that most of the Dalmatian prosciutto producers (90%) import fresh hams for prosciutto production from Hungary (75%) and Austria (25%) (Croatiastočar 2016). Producers do not have information about animal feed producers and breeders in importing countries, but most visit slaughterhouse before ham purchase to check quality of meat. Transport of fresh ham from importing countries is mostly organized by Austrian or Hungarian slaughterhouses, and sometimes prosciutto producers organize transport by domestic, Croatian companies.

P2. Prosciutto producers

According to the data of the Ministry of Agriculture, in 2016 (the year when Dalmatian prosciutto was protected as PGI), seven producers produced Dalmatian prosciutto with a geographical indication. In 2016 total production of prosciutto in

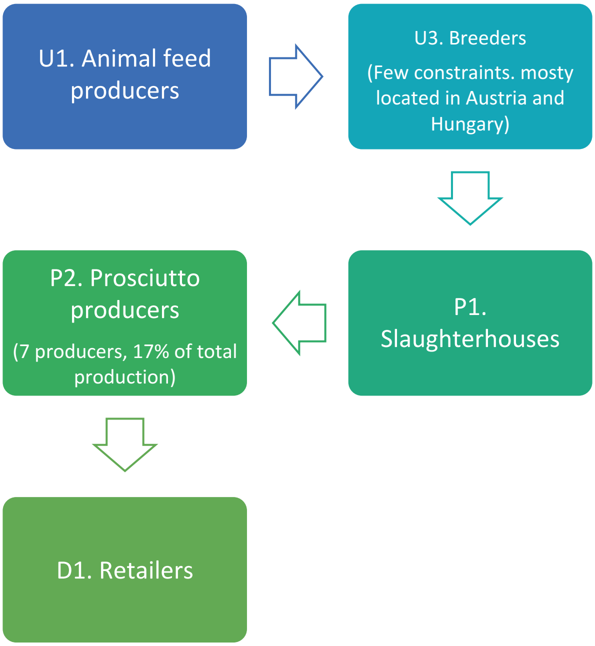

Fig. 3 PGI Dalmatian prosciutto value chain

Croatia was 350,000 pieces, while total production of PGI Dalmatian prosciutto was 59,730 pieces, which is around 17% of the total prosciutto production. As well as Dalmatian prosciutto, there are two other PGI prosciutto in Croatia ("Krk prosciutto" and "Drniš prosciutto") with three producers in total. There is also "Istra prosciutto", which has protected designation of origin (PDO) – Ministry of Agriculture.

The biggest producer of Dalmatian prosciutto is the company Pivac, which produces about 35% of total output of Dalmatian prosciutto, and second biggest producer is Voštane (25% of total Dalmatian prosciutto output). There are five more producers (Smjeli, Opskrba Trade, Delicije Marović, Mijukić prom and Dalmatino) which produce Dalmatian prosciutto with a geographical indication. Rising demand for PGI Dalmatian prosciutto underpins significant investments in production capacities.

Prosciutto producers do not have any type of contracts (short-term, long-term) with breeders and with retailers. However, prosciutto producers are member of Association "Dalmatian prosciutto", which followed the application procedure for the geographical indication. The Association hold promotional events in different Croation cities every year.

Half of Dalmatian producers sell only on the domestic market, while half of them export, mostly to European countries (Slovenia and Germany).

D1. Retailers

Dalmatian prosciutto is sold through four different channels: supermarkets, HoReCa (hotels and restaurants), specialized stores and others. Interviews with Dalmatian prosciutto producers reveal that most of the PGI prosciutto is sold through supermarkets (50.3%) and HoReCa (25%), while other channels (17%) and specialized stores (7.7%) are less important.

Prices of Dalmatian prosciutto differ in these channels. The highest price is for HoReCa channel (about 12 €/kg), while the lowest is for supermarkets (about 10.2 €/kg).

Governance of the PGI Dalmatian Prosciutto

Members of the Dalmatian prosciutto association, a group of prosciutto lovers, started the procedure for the protection of Dalmatian prosciutto. They run communication and marketing activities together. As noted above, they organize annual publicity events round Croatia.

Members of Dalmatian prosciutto association decided to start with the procedure for Protected Geographical Indication in 2012, and they obtained the Protected Geographical Indication status at European level in 2016. Although the procedure was complicated and lengthy, producers are aware that protected products like Dalmatian prosciutto have an added value. Consumers (especially tourists) perceive protected products as high-quality products and they have higher level of trust in protected products. Traceability was one of the major reasons for producers to start with the procedure. The PGI provided the conditions for removing "fake dalmatian prosciutto" from the market: technical specifications and strong control by producers.

In Croatia Ministry of Agriculture is responsible for the protection of products with the designation of origin (PDO) and PGI (Fig. 4). Figure 4 shows the national process of protection of the name of a geographical indication.

Biotechnicon Entrepreneurial Center d.o.o. is responsible for control over the production and processing of the Dalmatian prosciutto.

Sustainability Diagram Based on Strength2Food Indicators

The sustainability diagram is based on comparison of economic, environment and social indicators for the PGI product, Dalmatian prosciutto and the reference product, which is conventional prosciutto produced by one company, the biggest producer in non-PGI or PDO prosciutto production in Croatia. The assessment follows the Strength2Food method (Bellassen et al. 2016).

There is no price premium for PGI prosciutto at farm level, whereas it benefits from a price premium about 45% at processing level. This high price premium is

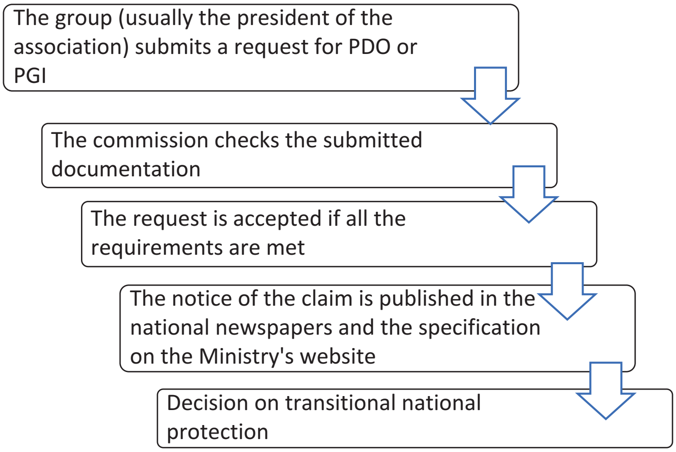

Fig. 4 Procedure for PDO or PGI validation in Croatia. (Source: http://www.mps.hr/datastore/filestore/81/NAC_POSTUPAK_SHEMA.pdf)

explained by the technical specifications: the PGI prosciutto requires more intense drying compared to reference product. Moreover, PGI producers use a traditional production process. Only the PGI product is exported. Exports (mostly to Europe) account for 5% of the volume and 18.7% of the value. This gap in percentages reflects a high valuation of PGI prosciutto within or outside Europe.

The local area assumed for the **local multiplier calculation** is the area of origin for the product, i.e. Dalmatia region. Unfortunately, the non-PGI producers did not supply answers to questions about the location of suppliers, and the local multiplier could therefore only be estimated for the PGI. The local multiplier indicator for Dalmatian Prosciutto is 1.75; in other words, €1 received by the ham processor activates additional global expenditure in the local area of €0.75. Assuming all the suppliers, and in particular pig herders, are located in the local area, the local multiplier would largely increase to 2.72; while assuming all the suppliers are located outside the local area the local multiplier would fall to 1.09. The component of the actual local multiplier of Dalmatian Prosciutto is the share of turnover devoted to other direct costs, of which 62% remains within the local area. Without this local economic component, local multiplier would be lower by 33%.

The **carbon footprint** (excluding transport) of PGI prosciutto is 23% higher than its reference product, although the footprint of the fresh meat used for PGI prosciutto is only 5% higher. This is largely due to the technical specifications which require a more intense drying for the PGI. An accounting unit like tCO2e kcal-1 may yield results similar to those of fresh meat. The lower footprint of fresh meat is mostly due to manure management: Hungarian pig farms – from which most of the PGI fresh meat comes from – use more solid manure systems than their Croatian counterparts. These small differences may not be accurate as there is wider use of average national values in PGI estimates than in the reference. Our estimates for fresh meat – 2.04 and 2.24 tCO2e t of liveweight-1 for PGI and reference respectively – are at the lower end of the literature, which ranges from 2.1 to 11.9 tCO2e ton^{-1} pork meat (Clune et al. 2017; Meier et al. 2015).

In terms of **food miles**, the PGI supply chain was compared to the conventional prosciutto chain in Croatia. Over the entire supply chain, from fresh ham to prosciutto (U3-D1), there is a substantial difference between the PGI and its reference product. PGI Dalmatian prosciutto travels much longer distances (4000 km instead of 1000 km) and releases much more emissions (400 kg CO2 eq instead of 100 kg CO2 eq) than the reference. The ratio is 1 to 4 in favor of the conventional product. The longer distance embedded in the PGI Dalmatian prosciutto can be explained by the longer distance traveled by fresh ham from slaughterhouses located in other countries (Hungary and Austria) to processing units in Croatia. Similarly, the higher emissions embedded in the FQS can be explained by the emissions resulting from the import of raw products. Indeed, conventional prosciutto is produced and processed locally, while fresh ham for PGI prosciutto is imported. Nonetheless, the level of per kilometer emissions is relatively high for the FQS. This may be explained by the fact that imports rely on road transport. The processing level (U3-P2) concentrates most of the kilometers embedded in the product and most of the emissions generated along the value chain (i.e. around 80%) for the conventional product, while the distances and emissions are more equally distributed among the processing level (U3-P2) and the distribution level (P2-D1) (35% and 65% respectively) for the FQS. So in terms of food miles, we can conclude that the PGI Dalmatian prosciutto is less sustainable than its reference product both in terms of distance traveled (+270%) and in terms of emissions released (+270%) (Table 3).

The green water footprint accounts for the greatest share of the indicator (Fig. 5). The reference ham displays a slightly lower value for this indicator. This outcome can be explained as follows. Different meteorological conditions in PGI and reference production areas makes the green water footprint of crops used for REF production higher than that of FQS production. However, this result is inverted when the fraction of different crops that compose the diet of the animals used in the two products is considered. The amount of wheat, barley and maize in the diets of the animals is different and this difference increases the green water footprint of the FQS production. Among the crops, soy cultivation has the higher water footprint (more than twice than the others), and is thus the strongest driver of the water footprint values. The higher water footprint of the PGI is caused by the higher share of soy cake in the diet (26.6% for the PGI versus 16.9% of the reference ham). No difference in green water footprint can be associated with crop parameters as we used similar default data for both productions.

Table 3 Water footprint of Dalmatian ham (FQS) and its reference (REF)

	FQS (m^3/kg)	REF (m^3/kg)
Green	74.23	68.57
Blue	2.89	2.74
Grey	14.43	12.97
Overall WFP	**91.14**	**84.00**

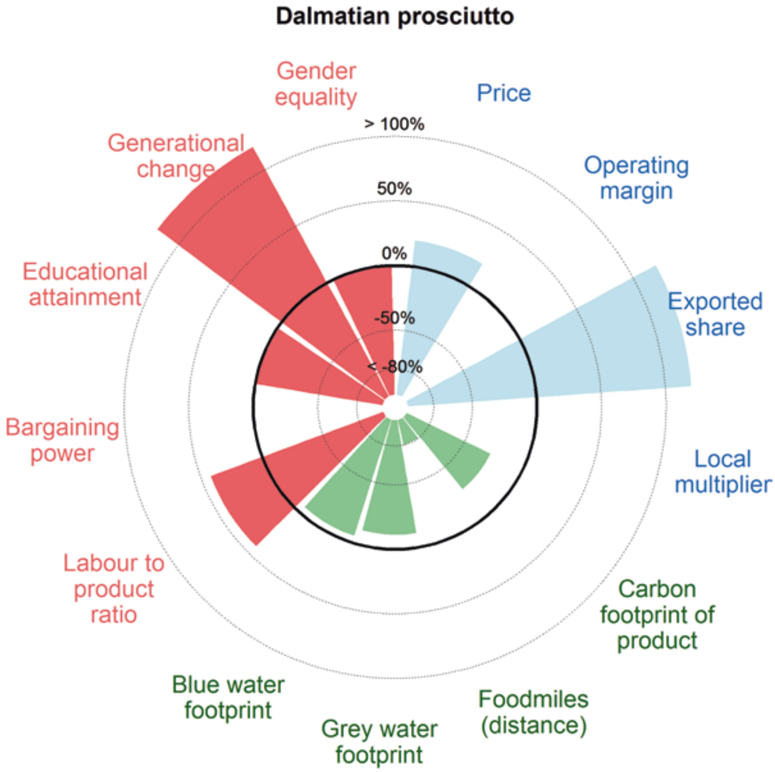

Fig. 5 Sustainability performance of PGI Dalmatian prosciutto (supply chain averages). (Each indicator is expressed as the difference between PGI Dalmatian prosciutto and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

The blue water footprint is very small for both products. It has a small share of the overall water footprint (3% in both PGI and reference productions); in the agricultural phase, water consumption is associated only with LCA, in other words, water is consumed by all the activities supporting production (e.g. water to produce fuel, fertilizers and so forth). There is no direct blue water consumption because none of the crops are irrigated.

The PGI product has a slightly higher grey water footprint because crops used to feed the animals use more nitrogen as fertilizer. In particular, the amount of nitrogen fertilizer used to grow barley in PGI production is twice that used in the reference production. As in the case of the carbon footprint, these small differences are perhaps not completely accurate because of average national values in PGI and reference product estimates.

The **employment indicator** (**labour use ratio indicator**), calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is higher for Dalmatian prosciutto than for its non-PGI reference. It takes 25.6 hours of work to produce 1 tonne of Dalmatian prosciutto, where the reference product requires 18 hours. The difference (42%) indicates that the PGI product generates more jobs than the reference system. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 7% higher in PGI than in non-PGI sector. These differences reflect the very different production technologies. FQS producers use a traditional production procedure based on long smoking and drying (up to 45 days) as requested in the technical specifications of the PGI product. The production of the reference product is more automated.

The **bargaining power** values for both the PGI and the reference are high (>0.5). This indicates that their position can be described as strong, which implies that they are likely to be less impacted by changes occurring at the supply-chain level. This strong position can be explained by the low number of actors for both supply-chains, which means coordination is simple, and by the fact they use highly specific resources. This is particularly the case for the PGI because of its high concentration level: the market share of the largest producer is 35%, and of the second largest is 25%.

Both Putnam (2000) and Halpern (1999) identify education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator**, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The level of education is approximately the same in both PGI and non-PGI sectors, with approximately 80% of staff having a secondary school certificate.

Regarding **generational change and gender equality**, the meat processing stage of the supply chain of the Dalmatian Prosciutto PGI is more sustainable than the same stage in the reference product in terms of the generational change indicator. The meat processing stage of the PGI product employs many more young people than older ones. Looking at the Gender Inequality index, production of both PGI and non-PGI Prosciutto appears largely unsustainable in the high levels of the indicator. However, the reference prosciutto appears slightly more sustainable in terms of gender equality than the PGI prosciutto. The absence of female entrepreneurship in meat processing and the consistently different gender opportunities in secondary education and overall employment levels drive the value of the indicator, which suggests that gender inequality is higher for the PGI than the counterpart product.

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Organic Pork in Germany

Michael Böhm, Lisa Gauvrit, and Burkhard Schaer

Market Development of Organic Pork in Germany

Consumption of organic food grows constantly in Germany. In 2016, the turnover of the organic food sector is around 9.5 billion euros, which is an increase of about 10% compared to 2015 (Fig. 1). Despite this rapid growth, the market share of organic food only amounts to 5% of the total private expenses for food. Regarding organic meat in general (e.g., pork, beef, poultry), the share is even lower, with 1.8% (BÖLW 2017).

The market for organic pork is rather small (less than 1% of market share) and demand for organic pork grows at slow pace, but continuously. In 2016, the total production volume of organic pork is around 20,000 tons of meat (which corresponds to approx. 23,000 t carcass weight). About 1500 farmers hold organic pigs in Germany in 2016 with around 19,000 breeding sows and places for 105,000 fattened pigs. This means that approximately in Germany 230,000 to 250,000 reared pigs have been delivered to the slaughterhouses in 2016 (AMI 2017b; Destatis 2017; Wucherpfennig 2017b).

Nearly 75% of the German production of organic pork is situated in the following five Länder: Mecklenburg-Western Pomerania, Bavaria, North Rhine-Westphalia, Baden-Wuerttemberg, Lower Saxony. Nevertheless, the geographical distribution of organically fattened pigs is more balanced than the conventional one (Fig. 2). Organic Production has its core areas in the northern part as well as in the southern part of Germany, whereas conventional production is much more concentrated in the western part of Germany.

M. Böhm (✉)
Ecozept, Freising, Germany
e-mail: boehm@ecozept.com

L. Gauvrit · B. Schaer
Ecozept, Montpellier, France
e-mail: gauvrit@ecozept.com; schaer@ecozept.com

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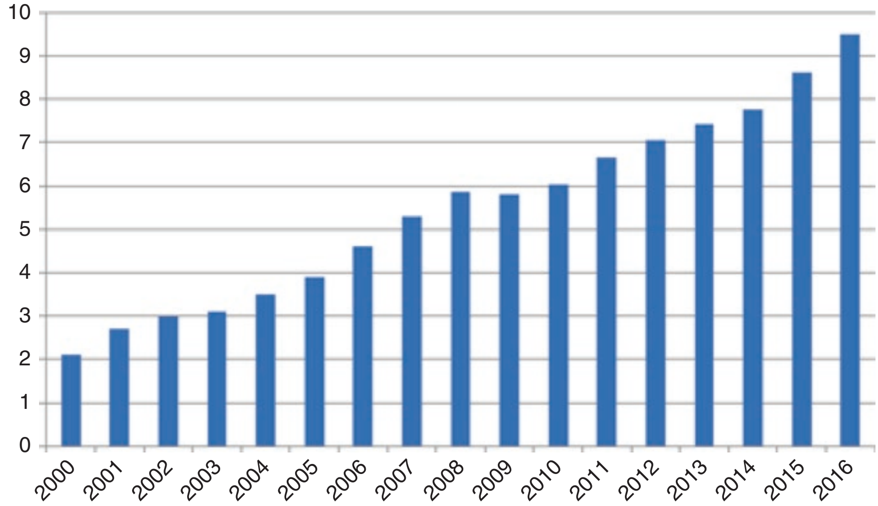

Fig. 1 Evolution of the organic food turnover at retail level in Germany (in billion €). (Source: Graphic of Ecozept based on Statista 2017)

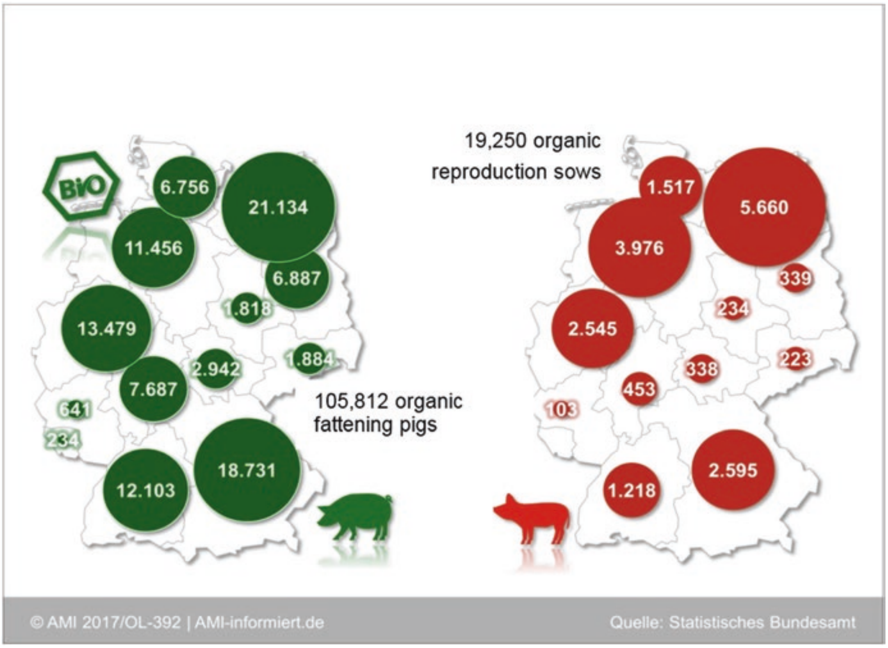

Fig. 2 Production of fattened pork (left side and reproduction sows (right side) in Germany (average number (fattening places or places for sows) per Land, 2016). (Source: AMI 2017a (OL-392), modified)

The German self-sufficiency degree in organic pork is around 70%: Germany's import rate accounted for 32% of domestic consumption for the campaign 2015/2016 and 26% in 2015. The Netherlands as well as Denmark are the main supplier countries (AMI 2017b). In the last years, the main reasons for limited inland production were restricted availability of piglets born and reared under organic production rules (lack of breeders) as well as high costs in conversion and in production in general. In the past, farmers often hesitated to convert their farming and rearing system into organic because of high investment costs for buildings, especially for piglet production. Due to strict rules for animal well-being, organic pork hast to be provided with much more living space in the pig lots, leading to larger buildings. As well, organic pigs have to have access to a free-range area, which renders complex and more expensive the building structures. Another cost factor is organically produced feed, which is substantially higher than conventional one.

Other problems are related to economic aspects of processing and sales: there was, during a long time, less demand for the valuable sections of the organic pig than for its less valuable sections. In the last years, consumers requested mainly fresh meat of lower categories (like goulash or minced meat) as well as sausages. This was partly related to the creation of new organic product lines in conventional retail (discount as well as supermarkets). As this strong demand was not covered, the noble pieces of organic pork went also into lower categories. However, this situation has changed since 2015/2016 and valorization of the carcasses is much more balanced and efficient now due to the strong demand in all meat parts.

Because of this strong demand, prices for organic piglets rose from around 110 € in 2015 to 137 € in April 2017 (28 kg piglet, delivered, source AMI 2017a).

This strong and stable rising demand is also responsible for higher sales prices of organic pork at production level: with 3.70 €/kg of carcass weight (February 2017), they are currently more than twice higher than conventional pork (1.70 €/kg carcass, end of 2016, without VAT, farm level, source AMI 2017a, b). Another important difference to the conventional sector is that since several years, prices for organic pigs are not connected to conventional market prices and therefore are much more stable than the conventional ones, which are highly fluctuating.

All in all, the organic market seems to be well balanced at the end of 2016 although some experts interviewed for this chapter fear that prices might go down in the near future, because of a rising supply in other EU-countries, especially The Netherlands and Denmark.

Quality Attributes of Organic Pork

Consumer motivations for the purchase of organic food are various. Appropriate animal keeping, less additives and the regional origin are the most important purchase reasons for German consumers of organic products (BMEL 2017).

Research on comparison between organic and conventional products shows differences in quality with measurable factors such as first cut, appearance, tenderness, Omega-3-content, water binding capacity, sensory qualities like smell and taste as well as presence of not desired elements like antibiotics (Stiftung Warentest 2003; FIBL 2015; EU Parliament 2016; British Journal of Nutrition 2016).

Often, these intrinsic attributes are examined only insufficiently in scientific studies and the results are controverted. But there are significant differences in water and fat content, as well as in contamination with antibiotics: in general, organic pigs seem to have a higher fat content which affects positively the sensory quality and organic meat has a lower water content, which gives more meat at the end of cooking (Stiftung Warentest 2003). Since the preventive use of antibiotics is forbidden in organic husbandry and the curative use is heavily restricted (with double waiting period), there is a lower risk of having antibiotics in the final product or of development of antibiotic resistance.[1]

However, organic production is a quality system based on special production and processing methods, rather than on final product specifications. There are no thresholds for physicochemical and organoleptic characteristics or nutritional values. Therefore, many advantages of organic meat are more or less directly related to the special requirements of organic animal husbandry. Important aspects concerning the way in which animals are kept, fed, transported and slaughtered under organic conditions are summarized in Table 1.

Description of the Value Chain

The typical value chain for organic pork meat in Germany is quite similar to the conventional one (Fig. 3). It is important to stress that not all of the final products must obligatory follow this scheme. For example, important volumes of organic pork meat are sold by companies at levels U4, P1, P2 and D1. Slaughtering is either done in-house or externalized to service providers. Furthermore, organic farmers in general do more direct selling than their conventional colleagues so that U3, P2 and D2 may be in the responsibility of one operator (the farmer). Another difference to the conventional value chain is the higher percentage of farmers covering the whole production cycle: piglet production as well as fattening on the same farm.[2]

Inputs in the value chain from other areas which are not presented in the figure above are e.g. agrarian technology, stable equipment, animal health: e.g. veterinary (in general, there is less medication in organic animal husbandry, since medication frequency is limited by organic regulations). A major difference between conventional and organic pork meat production is the origin of feedstuff: in general, organic farms produce their feed themselves or in cooperation with neighbored

[1] See: Smith-Spangler et al. (2012).

[2] There are no statistics on the number of such farmers, there must be at least 250 farmers in Germany, rearing both: piglets and fattening pigs (source: Destatis 2017, p. 43).

Table 1 Rearing conditions and quality attributes of organic pig production in Germany

Influence factors	Requirements in organic production/quality attributes
Feed	Only organic feed is allowed, with exception of max. 5% of conventional potato stark (derogation running until the end of 2017). Among other requirements, genetically modified organisms (GMO) as well as synthetic fertilizers and pesticides are forbidden in the production of feed crops. A certain minimum of roughage (coarse, fibrous fodder) is mandatory for fattened pork and breeding pigs. Concerning the origin of feed, it has be out of own farm production or the same region at least for 20% in volume for farms working on basis of EU-organic regulation. Farms having been certified according to higher private standards (see section "Market Development of Organic Pork in Germany") must provide 50% of feed from the own farm or from neighbours, based on a written cooperation (exchange with manure)
Health and treatments/ keeping	Growth supporting ingredients in the feed and preventative treatments with antibiotics are forbidden in organic husbandry. Farmers must adopt management practices which minimize disease risk (e.g. appropriate keeping conditions and feeding, herbal and homeopathic medicaments). Regarding piglet production, the lactation period is longer – a mandatory minimum of 40 days. Breeds used in organic production are similar to the ones in conventional production, but genetics are selected with focus on motherliness and resistance to illnesses and stress[a] Due to strict rules for animal well-being, organic pork hast to be provided with much more living space in the pig lots, leading to larger buildings. As well, organic pigs have to have access to a free-range area, which renders complex and more expensive the building structures.
Taste and ingredients	No specific requirement. Yet, regarding fat content and marbling, organic meat achieves better results (Stiftung Warentest 2003). Because fat is an important taste enhancer, this advantage can positively affect the flavor.
Environmental and resource protection	In order not to spread too much manure on agricultural land and therefore reduce nitrogen pressure, there is a limit of max. 14 fattened pigs/ha land allowed (or 6.5 sows/ha). If there is not enough space on the farm, it is possible to cooperate on a contractual basis with other organic farmers in the neighborhood (the farmer with few animals provides feed and receives in return organic manure as a fertilizer).
Transport	EU regulation on organic production does not limit transports in a special way. But most of the private certification organizations (see Chap. 1) limit the transports to the slaughterhouse to 4 hours or 200 km, in order to limit animal stress. It is not allowed to give tranquilizers to organic animals. Straw is required during the transport and in some areas of the slaughterhouse. Sometimes there are restrictions on maximum animal number in the vehicle or the space over the heads of the animals.
Processing	Production of organic meat products (e.g. boiled sausages) and cold cuts differ from conventional methods: e.g. pickling salts (nitrite brine) or phosphates may be forbidden depending on the certification organization. Forbidden are furthermore glutamate and artificial aromas. Other ingredients, e.g. spices and vegetables, must come from organic farming.

Source: Realisation Ecozept on basis of Stiftung Warentest (2003), EU-Parliament (2016), EU-regulations 834/2007 and 889/2008 as well as guidelines of private certification standards (Naturland, Bioland, Biokreis, etc.), FIBL (2015), British Journal of Nutrition (2016)

[a]Most commonly used breeds are "Deutsche Landrasse", "Deutsches Edelschwein" crossbred with Duroc or stress resistant Piétrain. Genetics used are the "Triesdorf-line" as well as breeding sows from Switzerland, where piglet production on straw has a long tradition (Herrle 2017). Another actor is BESH, the "Bäuerliche Erzeugergemeinschaft Schwäbisch Hall" is a regional producers' association in the south of Germany with currently about 1400 farmers. Since 1988, the production of pork meat is under PGI (protected geographical indication) with a special traditional breed called Schwäbisch Hällisches Landschwein

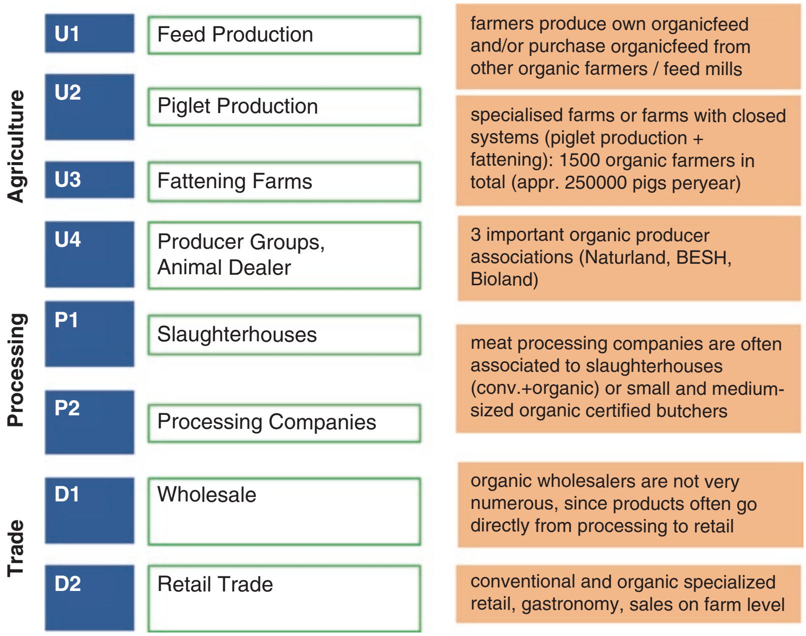

Fig. 3 The different steps of value chain for organic pork meat in Germany and types of companies involved in. (Source: realisation Ecozept)

farms. External feed is bought in to much a lower extent than in conventional pig fattening.

Piglet Production and Fattening Farms (U2, U3 and U4)

In March 2016, there were 1517 farmers in Germany rearing organic pigs (piglets, sows or fattening pigs) (Destatis 2017[3]), of which 1379 were rearing fattening pigs. But according to experts' opinion, more than half of them have no market relevance, as they rear only a few fattening pigs in the order to diversify their production systems. Indeed, more than 1100 farmers rearing pigs or piglets had less than 50 animals on their farm (Destatis 2017, p. 48).

In order to be in line with EU organic regulation, pork meat producers (especially those who rear piglets) face higher production costs than those in conventional production. The feed costs represent thereby with 66% the biggest position of the variable costs (LfL 2012). As in conventional value chain, organic piglets are

[3] Farms with less than 50 pig places and which are under the thresholds for the other production branches are not taken into consideration by Destatis.

sold to fatteners (farmers who fatten the piglets) when they reach the weight of 25–30 kg (approx. 80 days).

Most of the organic production is realized by "organized value chains" with long term supply contracts between the piglet producers, fattening farms and organic producer groups. These producer groups bundle up supply and thereby improve bargaining power of farmers. They are important connectors in the value chain: thanks to their contacts with trade operators, they know the consumer expectations and transmit information about necessary meat qualities directly to farmers. Partially also the transport is carried out with the vehicle park of the producer group.

Organic pig fatteners can buy the piglets directly to piglet producers or they can buy them through a producer group like Bioland or Naturland. The management of the piglet sales is a critical phase in the supply chain: animals experience high stress when they change location (transport to a new farm, separation from their mother and change of diet). At this time, it is particularly important to properly manage feed ration, feeding intervals, hygiene and water availability.

In general, fattening of organic pigs is quite different from conventional farming: an organic pig is fattened more than 125 days in order to reach a slaughter weight (carcass) of approx. 95–98 kg. Depending on breed, feeding diet, hygiene and keeping conditions, the average organic pig weight gain lies between 650 and 850 gr per day whereas 750–950 gr are achieved in the conventional sector. Feed to liveweight in organic production varies between 1:3.2 and 1:3.5 (Ökolandbau 2015; KTBL 2015; Naturland 2017), whereas in the conventional sector, this ratio is slightly better (1:2.9).

Nevertheless, these higher production costs are largely covered by higher sales prices. The average selling price of fattened pork is about 350 € apiece. Subtracting feed costs, costs for piglets and variable costs, up to 70 € per pig remain, an average cross margin is about 50 €/fattened pig (25 € per fattened pig is the minimum cross margin in conventional sector; Vollmer 2012; Ökolandbau 2015; KÖN 2017; experts interviews).

According to official statistics, there were 543 farmers rearing reproduction sows in 2016 (Destatis 2017). Approximately half of them are also doing fattening on their farm. After years of under-valorization, the market for old organic reproduction sows is now nearly completely disconnected from the conventional one and experts estimate that more than 80% of the old (reform) sows are sold within the organic value chain, mainly going into salami production.

Slaughter and Processing (P1–P2)

Regarding the slaughtering of organic pigs, there are three main cases. The most frequent is a farmer's association which organizes, on the farmers' behalf processing and selling (e.g. BESH, Naturland Marktgesellschaft GmbH, VGS Bioland, or others). It pays the farmers a price that is fixed contractually in advance for 2 or 3 years and controls and coordinates the entire supply chain, including slaughtering.

Concerning slaughtering, it may be executed by mixed operators (conventional and organic). If this is the case, slaughtering of organic pigs only is generally done on 1 or 2 days a week in order to guarantee adequate separation from conventional pork.

In 2016, around 250,000 organic pigs have been slaughtered in Germany. Generally, the animals are butchered (cutting) either in the slaughterhouse or in a special processing company mostly nearby. The 15 biggest slaughterhouses in Germany slaughter at least two thirds of the organic animals (Wucherpfenning 2015). These slaughterhouses are the same than those for conventional pork, slaughtering organic animals on special days. There are not many 100% organic certified slaughterhouses. One example is “Tagwerk Bio-Metzgerei” near Munich (see Fig. 4).

Among the most important German companies involved in the organic pig supply chain (trade, slaughtering, processing and sales), are the three farmer’s associations Naturland Marktgesellschaft, Bioland Markt GmbH and the Bäuerliche Erzeugergemeinschaft Schwäbisch Hall (BESH), as well as the private companies Tönnies Lebensmittel GmbH & Co. KG, Biopark Markt GmbH, Friland J. Hansen, some regional farmers associations of Bioland (e.g. Rebio – Regionale Bioland Erzeugergemeinschaft or Bioland Markt GmbH & Co. KG in Berlin), as well as the Naturverbund Niederrhein/Thönes e.K., LFW Ludwigsluster Fleisch- und Wurstspezialitäten GmbH & Co. KG, Biofleisch NRW e.G., etc.

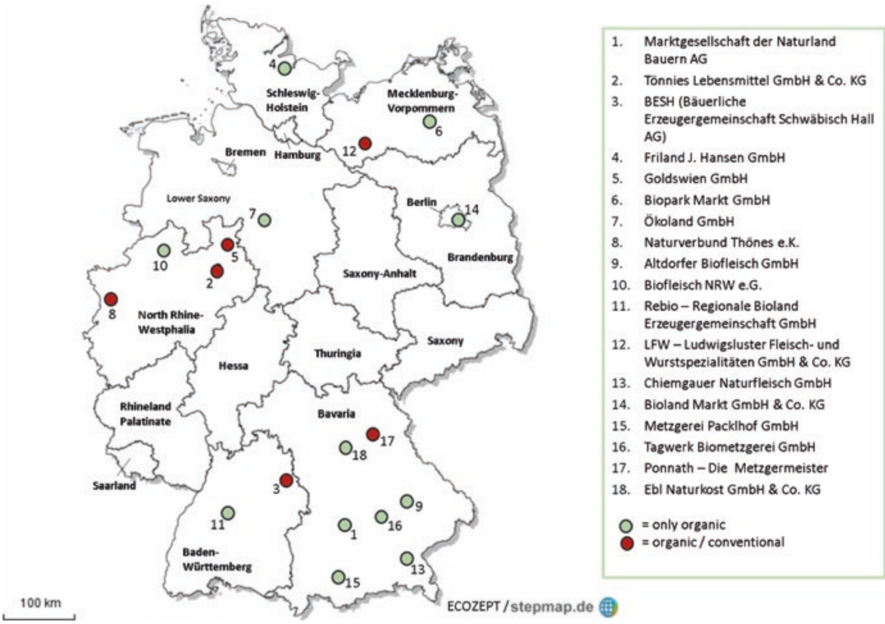

Fig. 4 Location of the main companies buying and/or processing organic pork meat in Germany. (Source: Ecozept on basis of various expert interviews; homepages of indicated enterprises)

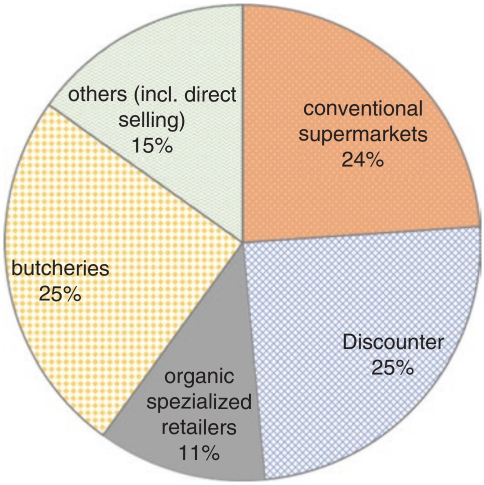

Fig. 5 Main distribution channels of organic pork meat in Germany (year 2016, market share in volumes, organic fresh meat as well as meat products). (Source: Estimation Ecozept on basis of AMI 2017a, b; Wucherpfennig 2015 as well as expert interviews)

It is important to underline that most of these companies (also see Fig. 6) buy from German organic pork meat producers, but some of them also import organic certified carcasses of organic pork meat from other European countries.

Wholesale and Retail of Organic Pork Meat

Organic pork is offered to consumers through these four main channels:

– Conventional retailers including supermarkets (Rewe, Edeka, etc.) and discounters (Aldi, Lidl, etc.),
– Organic specialized retailers: organic supermarkets and organic stores
– Organic specialized butchers
– Direct sale from organic farm to consumers.

Regarding conventional retailers and discounters, they represent half of the organic pork meat market at consumer level, whereas organic specialized retailers and butcheries hardly reach 40% (see Fig. 5). Most of the organic meat is distributed as fresh meat, whereas turnover in conventional channels is mainly triggered by processed meat products like sausages, hash, etc. It is important to underline, that these figures are estimations.[4] Wholesale is not very important in the organic pork meat chain and is limited mostly to organic specialized retail (the most important ones are Dennree and Weiling).

Success in the marketing of organic pork meat depends above all on stable relationships within the value chain. In the past years, these kinds of stable relationships have been established. The continuously rising demand for organic pork meat is due

[4] A survey by AMI is ongoing in 2017/2018 on butcheries as well as on direct selling farmers in order to get more solid information on these two channels.

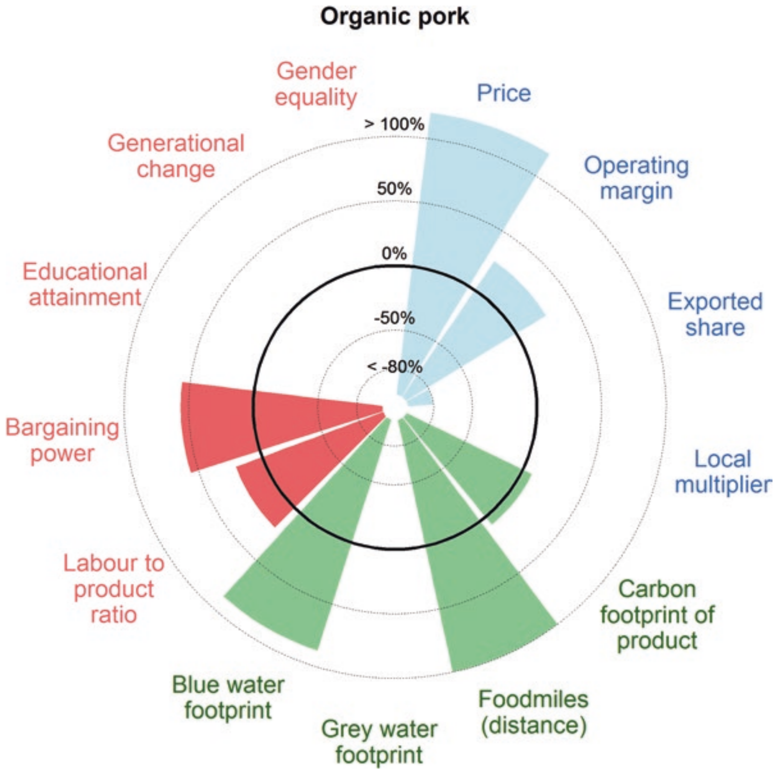

Fig. 6 Sustainability performance of organic pork (supply chain averages). (Each indicator is expressed as the difference between organic pork and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

to the increasing number of organic supermarkets with their own deli or service counters (Ökolandbau 2015), but also, more recently, to range extensions and product launches in the conventional distribution channels (discounters and conventional supermarkets). Since these latter channels mainly offer processed meat products (sausages, hash, salami, etc.), there is also a need of less value added sections of the carcass, contributing to a balanced use of the carcass.

Governance of the FQS

In this chapter the value chain is described regarding the bargaining power of the different market actors. The characterization is based on Porter's five forces model: in general, the value chain of organic pork is not dominated by industry rivalry, even if there is strong competition between the two main distribution channels "conventional retail" (supermarkets and discounters) and "organic specialized retail" (organic food stores and organic supermarkets, butcheries). German farmers rearing organic pigs can choose between a wide panoply of potential clients buying the animals. In the conventional value chain, market concentration gets more and more important: 65% of total processing and sales of pork meat is done by five main important actors are (Tönnies, Vion, Westfleisch, Danish Crown and Müller. Source: ISN 2017). Contracts are generally made on a long-term basis (more than 2 years). Therefore, the farmer's bargaining power can be considered as high in the organic sector. The threat of new entrants exists through actors in other countries (note: the German self-sufficiency degree in organic pork is around 70% and pork meat from Netherlands and Denmark is cheaper). Up to now, the threat of substitute products and services is not very important, since other labelling schemes do not have a big market importance (see next paragraph).

On production level, the insufficient piglet availability, related to the former absence of price premium on reform sow meat, has been for a long time the limiting factor in the development of the organic pork offer in Germany. But by the growing interest in organic pig farming, offer and demand tend to be balanced since the end of 2016. The main economic actors achieve a good coordination of the value chain, which results in stable sales prices on a high level. The sales prices for organic pork meat are decoupled from the price development in the conventional sector. There is a small threat of substitute products because of an increasing offer of non-organic certified meat, labelled "environmentally friendly", "out of appropriate keeping" or "from regional origin". The most important labelling schemes in Germany are the voluntary initiatives like "Das Regionalfenster", "Neuland", "BESH-quality meat", the "Tierschutzlabel" (an initiative of the German association for animal protection "Deutscher Tierschutzbund") as well as the "Initiative Tierwohl", which is a consortium of the main German conventional retailers, but which still does not cover up to now pork meat.

The only association specialized in organic pork meat in Germany is the "alliance of organic pig keepers in Germany" (ABD: "Aktionsbündnis der Bioschweinehalter Deutschlands e.V."), that was founded in 2008 in the Kassel region. Presently, the alliance has more than 80 members (farmers with less than 1000 pigs), covering more than 1/3 of the total production volume in Germany (Wucherpfennig 2017). The aims of this lobbying organization are exchange of information among the farmers and bundling up of the interests of the organic pig holders towards the market partners in trade and processing. ABD recently undertakes actions in order to establish its own farmers association being able to buy and resell organic pork meat (become a market player).

In Germany, two organic markets exist in parallel: the "market for organic products, certified according to EU organic regulation" and the so called "market for Verbandsware", which covers products having been certified according to one of the private organic standards.[5] In principle, these markets can be considered as not connected, since products certified Verbandsware do not allow EU-organic raw materials. Furthermore, they are operating with different prices (at least for raw materials, but not always for final products), distribution channels (some organic specialized retailers only allow Verbandsware, but they are getting fewer…) and special labelling. But in reality, they are not completely separated any more: often (and on a basis of exceptions), EU-certified raw materials (feed, piglets) may enter into Verbandsware. One of the major problems for organic farmers certified by higher private standards is that they have to face higher production costs (due to higher production standards), but cannot always sell at higher prices at farm gate. The reason, why these farmers choose nevertheless to get certified by one of these private certifiers is that private standard certification generally gives more security concerning sales: the contracts offered are generally more stable, reliable in time.

Furthermore, there are many associations and institutions in Germany that support and develop the production and the marketing of organic food products in general, but not specifically the pork meat market. The most important ones are BÖLW ("Bund Ökologische Lebensmittel-Wirtschaft e.V.") – the umbrella organization of the producers, manufacturers and traders, founded in 2002 as well as AÖL (organic processors organization) and BNN (association of organic wholesalers and retailers). Moreover, on the level of the federal states, some lobbying and umbrella organizations exist: competence centers (like the KÖN in Niedersachsen) or regional associations for organic farming.

Other Important Issues

In earlier times, numerous organic farmers worked also with regional butchers who slaughtered independently. However, as this was the case in conventional sector as well, the number of independent butchers has sunk importantly during the last years because of strict EU-hygiene requirements, which forced many small butchers and municipal slaughterhouses to stop their activity. Therefore, the organic value chain is also concerned by national transports of pigs (Münchhausen et al. 2015).

Animal welfare is a big issue in Germany these days and brings double dynamics into organic value chain. On the one hand, there is a stronger demand and higher

[5] A private certification organization is a union of organically producing farmers and manufacturers – with the purpose to support the common marketing and control of the products. The first organization was "Demeter" founded in 1924 and their requirements are higher than those laid down in the EU regulation on organic farming. The most important organic certification organizations in Germany for pork meat are Bioland, Naturland, Demeter, Biokreis, Biopark and Gäa. These certifiers have their own standards ("EU+") which are checked by the yearly mandatory controls of German control bodies. Approximately 60% of organic pigs in Germany are certified by Naturland. Some of these farmer's associations have created "market actors" in different value chains and with different organization forms. These stakeholders then buy and sell pork meat. Exampels are the "Vermarktungsgesellschaft Bio-Bauern mbH (Bioland)" or the "Marktgesellschaft der Naturland Bauern AG".

marketing opportunities for organic meat. On the other hand, there are more and more requests for even stricter and animal-friendlier production rules, also in organic production systems.

Sustainability Assessment Based on Strength2Food Indicators

Sustainability assessment of organic pork meat in Germany was implemented through the specific methodology of Strength2Food (Bellassen et al. 2016). The key indicators of the performances are depicted in Fig. 6.

Some of the indicators were elaborated by using values coming from the whole German organic sector when sectorial (pork meat production) values were not available.

Economic Indicators

There is a significant price premium between organic and conventional pork at all level of the supply chain. The study also shows that the operating margin at farm level is 27% higher in the organic sector than in the conventional sector, but this result should be nuanced as it only takes into account costs of wages of employed workers and not the cost of all workers. To that respect, FADN data show a better productivity of work by animal in the conventional sector than in the organic.

Social Indicators

As we just said, the organic system is more intensive in work per animal. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is higher for organic pork than for its non-organic reference (conventional pig farms in Germany). At the farm level, it takes 39 hours of work to produce a ton of organic pig carcass when the reference product requires only 32 hours. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per annual work unit is 131% higher in organic pig systems than in conventional ones. This difference is mainly due to the difference in price between organic and conventional pork.

The indicators on educational attainment, generational change and gender equality are not available for this case study. Indeed, specific statistics on work in the organic pork farms are not available in Germany. Furthermore, experts were not confident enough to provide a written expert judgment on these topics. A sample of companies in the processing industry (P1 and P2 levels) was contacted, but they were not able to provide estimations on the differences between the organic and the conventional sector, the two being handled by the same operators in many cases.

The assessment indicates that bargaining power is evenly distributed among levels for both organic pork and its reference, even though one can witness a small advantage of the organic chain over the conventional one. This small advantage is mostly due to the fact that the organic supply chain is better organized, benefitting from the existence of a professional union at the farm level. However, both supply chains are characterized by an advantage of processors over farmers. This difference is essentially due to the fact that the leading processor companies concentrate a significant share in the market, in both organic and conventional chains.

Environmental Indicators

The carbon footprint (excluding transport) of organic pork is 8% higher than its conventional reference (3.7 vs 4 tCO2e ton^{-1} pork meat). These values are in the lower range of the literature which ranges from 2.1 to 11.9 tCO2e ton^{-1} pork meat (Clune et al. 2017; Meier et al. 2015). The small net difference between organic and conventional pork results from two balancing differences. On the one hand, the carbon footprint of organic feed is twice lower per ton of dry matter, thanks for the absence of mineral fertilizer and the use of waste fishmeal. On the other hand, total intake is 40% higher, and emissions from enteric fermentation and manure management are also substantially higher, because organic fattening pigs live longer and are more active, and because of the lower pigs/sows ratio. A similar tradeoff is also reported by Kool et al. (2009) and by Basset-Mens and van der Werf (2009): both studies report a lower carbon footprint per ton of feed for the organic chain although the carbon footprint of feed as a category is almost the same between organic and conventional as organic pigs require more feed per ton of final product. The difference in performance between organic and conventional is within the literature range of −11% to 73% (Kool et al. 2009; Meier et al. 2015). It is lower than the 35% found by Kool et al. (2009) for Germany, despite many similarities in input data for three main reasons: 31% of the diet of organic pigs comes from straw and fishmeal which are assumed to be waste and have no carbon footprint. If instead we assume that fishmeal is fished for the sole purpose of feeding pigs, then the carbon footprint of organic pork becomes 20% higher than its reference. The second reason is that Kool et al. (2009) uses the IPCC Tier 1 approach to estimate N2O emissions from fertilizer use which results on average in 30% higher estimates (Carlson et al. 2016). Finally, Kool et al. (2009) uses lower pigs/sows ratio of 6.6 (organic) to 7.3 (conventional) which increases the weight of sows emissions per ton of meat and consequently increases the feed/meat ratio.

The water footprints of the organic and conventional pork chains at farm level were also investigated: the data situation does not allow, as for today, to conclude firmly neither on green water foot print nor on grey water foot print.

The green water footprint might be higher in organic, as organic feed crops yield less, per hectare, and consequently more rain water is absorbed by these bigger surfaces.

As for grey water footprint, especially the pollution of ground water bodies by nitrates, literature does not provide clear evidence. But considering that organic farming has much lower animal density, and an obligatory link to surfaces for cropping feedstuff on farm level, the amount of nitrates per hectare should be significantly lower in organic than in conventional.

The blue water footprint is higher for conventional pork. Water used to grow crops is indeed higher on not locally grown items, such as sugarcane molasses, soy cake and soy oil.

Concerning food miles, we only have available data regarding exports. There is a substantial difference between organic pork and its reference. Indeed, exports of organic pork meat are negligible since supply is much lower than domestic demand, while 52% of the German conventional pork meat production is exported. On average, the FQS travels 0 km while its reference travels 6500 km for exports, and 3500 km at the distribution level, assuming 0 km distance for products distributed nationally. The FQS releases much less emissions (0 kg CO2 eq instead of 110 kg CO2 eq) than the reference. The higher emissions embedded in the reference can be explained by the emissions resulting from exports.

Conclusion

The production of organic pork meets ecological, ethical and social requirements on a high level. Better quality attributes are achieved through the stricter regulations along the whole value chain, than in conventional systems. This concerns different factors, e.g. feed, treatments and rearing conditions as well as low-input processing with a very limited list of ingredients and processing auxiliaries. Concerning transport, there might be no substantial difference between the conventional and the organic sector, even if some private organic standards limit transportation of live pigs.

Success in the marketing of organic pigs depends above all on stable relations along the supply chain. This seems to be the case in the German organic pork meat value chain: numerous organic producers associations as well as industrial slaughterhouses bundle up the offer and propose interesting long-term contracts, improving therefore the market position of organic farmers. The rising demand for conversions into organic farming make evident that this value chain is not only of ecological interest but also economically viable.

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PGI Gyulai Sausage in Hungary

Péter Csillag and Áron Török

Introduction

Hungary's most popular meat product is the 'kolbász' (sausage) not only as a component of sandwiches but as the ingredient of many traditional dishes. 33,826 tons of dry sausages are sold yearly in retail outlets in Hungary. The 'Gyulai kolbász' PGI represents 15.45% of the domestic production. The market leader producer is the Gyulahús Kft.

Traditional Hungarian sausage has been present since the eighteenth century when the production and use of its most important ingredient, the spice paprika and its grounded form (see Kalocsai and Szegedi paprika PDOs), became popular in the area of the Great Hungarian Plain (Hungarian: Alföld). The ground paprika was significantly cheaper than pepper that was used before, so hot paprika became the substitute of black pepper. Sausages might be preserved by salt, drying on cold air and smoking.

The area of 'Gyulai kolbász' PGI (Fig. 1) is limited to the municipalities of Gyula (30,007 inhabitants) and Békéscsaba (59,732 inhabitants).

The 'Gyulai kolbász' appellation of origin has been registered by the Hungarian Intellectual Property Office on the 30th November 1998, and even earlier by the World Intellectual Property Organization (WIPO) under No. 601 (HU) on 3rd April 1975.[1]

[1] Appellation of Origin (Lisbon) N° 10: 09/1975, Source: gi.gov.hu

P. Csillag (✉)
ECO-SENSUS Research and Communication Non-profit Ltd., Szekszárd, Hungary
e-mail: csillag.peter@ecosensus.hu

Á. Török
Eco-Sensus Nonprofit Kft., Szekszárd, Hungary

Department of Agricultural Economics and Rural Development, Corvinus University of Budapest, Budapest, Hungary

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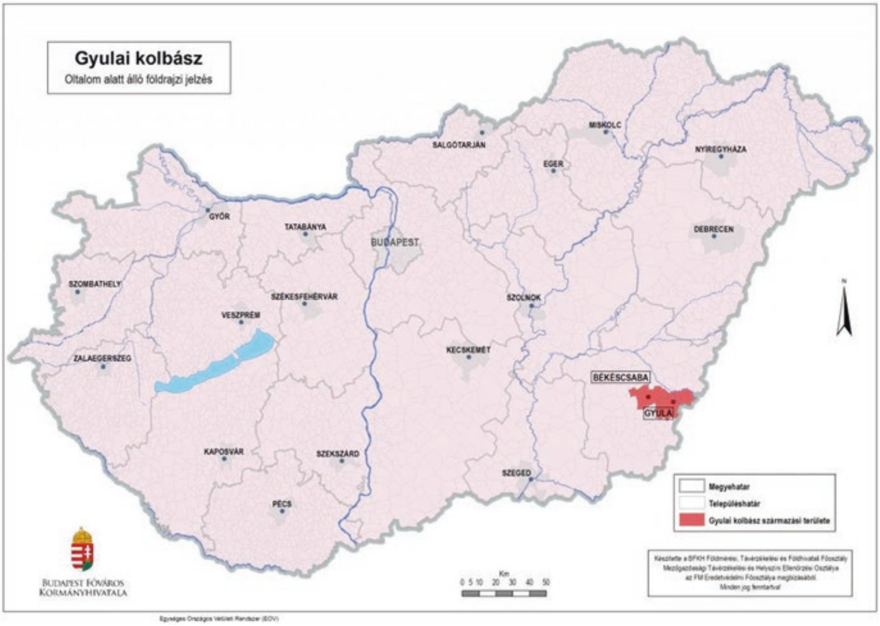

Fig. 1 Production area of the 'Gyulai kolbász' PGI. (Source: gi.gov.hu)

The European Commission accepted and registered the appellation 'Gyulai kolbász/ Gyulai pároskolbász' (PGI) to the List of products with PDO/PGI/TSG classifications under dossier number HU-PDO-0005-0394,[2] with a description of its attributes. In addition, the Codex Alimentarius Hungaricus (MÉ 1-3/13-1)[3] provides key principles for processed meat products and specifically for smoked and cured sausages.

The two PGI municipalities used to be stops on the road towards livestock markets. Herders watered their stock at the rivers and kept them at rest along the forests. There was an opportunity to slaughter the injured animals in the towns. From the end of the 1800's, proper slaughtering infrastructure was built. The ingenious slaughter men and butchers settled there, thereby kickstarting the meat industry of the municipalities.

The Gyulai sausage became world famous when local meat producer József Balog won golden medal in 1910 at the Brussels World Exposition. Industrialized manufacturing of the Gyulai sausage was developed also during the 1910's by András Stréberl, a former co-worker in Balog's manufacture. Also, he took his products to Brussels to the World Exhibition of Food in 1935 where the 'kis páros Gyulai kolbász' (Gyulai small pairs) was awarded a gold diploma. Stréberl bought a firm in the centre of the town and he established the industrial manufacturing of

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010R0530&from=HU

[3] https://elelmiszerlanc.kormany.hu/i-kotet-eloirasok

the Gyulai and other cured sausages. After some years, he was exporting the processed meat from Gyula to several continents. He set up a modern firm with a smoker, a cold store and storages, employing 80 people in the 1930–1940s. The firm became one of the biggest meat processing plants of the region. He also employed skilled workers from the surrounding settlements.

Beside thin and thick sausage, ‘téliszalámi’ (winter salami), double sausage, ‘szalonna’ (firm lard), ham wares, different meat and ham products and tinned food left the storages of the plant. This last section was prepared for the Hungarian Royal Army. The liabilities of the state became huge during World War II and were never fully paid to the firm. Then in 1948, the firm was nationalized with the upcoming communist era. András Stréberl never entered his plant again. During the nationalization, the Stréberl-plant was combined with the communal slaughterhouses and the manufacture of Gyulai sausage continued, fortunately by keeping the age-long tradition, technology and technique along with continuous development.

The nationalized firm continued the processing after its privatisation but then it entered into a crisis and in 2013, with the intervention of the local government, a reorganization commenced. The Gyulahús Ltd. was founded and is still the biggest producer of the ‘Gyulai kolbász’ PGI. The Gyulai sausage was selected to the Collection of Hungaricums[4] in 2013. In 2015, the ‘Gyulai kolbász’ gained two golden stars on a test by the International Taste & Quality Institute in Brussels. A year later, the ‘Gyulai szalámi’ and in 2017 the ‘Pokol szalámi’ (Hell salami) acquired the ‘two golden stars’ qualification. Their products were acknowledged by several Excellence Hungarian Quality Product Awards and Hungarian Brands Awards. The market leading ‘Gyulai kolbász’ and ‘Gyulai májas’ (liver paste) product line won the award of the most important brand evaluating system, Superbrands and Business Superbrands Award in the customer and business categories.

Attributes of ‘Gyulai kolbász’

Raw Material

For the production of the Gyulai kolbász PGI ground pork, firm lard, mild and hot ground paprika, garlic, black pepper, ground caraway, antioxidant and pickle salt containing potassium nitrite can be used. ‘Gyulai kolbász’ or ‘Gyulai pároskolbász’ PGI is produced from the chopped meat and firm lard of cross-breeds of Hungarian Large White meat-type pigs, long-haired ‘Mangalica’ and Hungarian lowland pig

[4] ‘Hungaricum’ is a collective term indicating a value worthy of distinction and highlighting within a unified system of qualification, classification, and registry and which represents the high performance of Hungarian people thanks to its typically Hungarian attribute, uniqueness, specialty and quality.’ http://www.hungarikum.hu/en/content/what-hungarikum

varieties, and Hampshire, Duroc and Pietrain varieties and their hybrids,[5] fattened to the weight of at least 135 kg.

The raw material designated for production need to meet defined quality criteria values (GÖFO reflexion coefficient min. 70, pH 1-value min. 5.7, intramuscular fat marbling min. 4%).[6] The PGI regulation does not mention that the pork to be processed can originate solely from Hungary so the processors purchase most of the meat raw material – in chopped and prepared form – from abroad. Neither in the case of the ancillary material – spices, intestines – is there any area restriction so producers also use the most competitive products mostly from foreign suppliers as well.[7]

Production Area

The production of the Gyulai sausage may take place within the administrative boundaries of two south-eastern towns: Gyula and Békéscsaba. The region is a typical landscape of the Great Hungarian Plain that has a temperate continental type of climate, many rivers (Körös) and forests. These geographical specificities define the particular nature of the products: the climate conditions have a significant effect on the quality of the end-product.

Due to the restriction in processing area, there are only eight companies, authorized to produce the 'Gyulai kolbász' PGI. And only two of them, the Gyulahús Ltd and the Slovak-owned Kaiser Food Ltd use the PGI label on a regular basis.

In the GI area, several dozens of other small producers are active, who sell their wares on their own at the local marketplace or at their homes. The regulation only protects the two words 'Gyulai kolbász' used together, but it does not prohibit the use of 'Gyulai' for other products even when they are produced elsewhere. Thus, it is not rare to find products with deceptive names such as 'PIKO Gyulai vékonykolbász' (PIKO Gyulai thin sausage) or 'TESCO Gyulai kolbászka' (TESCO Gyulai little sausage).

Trademark applications are examined by the National Food Chain Safety Office. The authority examines the traceability, the compliance of the standards laid down in the PGI regulation, and the producer can start using the label only if the product meets all the criteria.

[5] Source: Hungarian Purebred Pig Breeders' Association. URL: http://www.mfse.eu/hu/fajtaismertetes

[6] http://eredetvedelem.gov.hu/wp-content/uploads/2017/12/Gyulai-kolb%C3%A1sz-vagy-gyulai-p%C3%A1roskolb%C3%A1sz_term%C3%A9kle%C3%ADr%C3%A1s_2018_01_15.pdf

[7] Interview.

Quality Attributes

Considering the raw materials and the technology, the Gyulai sausage and the Gyulai small pairs have centuries-old tradition: the product is made from pork and firm lard, with a specific flavouring, filled into casings of pig's small intestine, – if produced for slicing then filled into vapour-permeable artificial casings - in pairs, smoked and dried; the climate of the region has a significant contribution to its characteristics in the curing process.

The adequate quality of the pig meat to be processed is ensured by manual boning in which the sinews are also removed. To adjust the flavour, salt, mild and hot ground paprika, garlic, black pepper, ground caraway and nitrite salt may be used. In adjusting the colour, paprika and nitrite salt have a great role, the latter is also responsible for preservation. In case of paprika, it is very important to use the highest quality so that the end product would not become bitter and it would keep its dark red colour.

When using spices, the preservation of the volatile substance content has to be secured with proper storage, and the microbiological contamination has to be decreased to minimal level (<105 CFU/g), the nitrite content of the pickle-salt cannot exceed the 0.5% (EU standard) using a permitted variation. Other chemical attributes are controlled (Table 1).

The 'Gyulai kolbász' has a diameter of 26–40 mm and comes in 18–26 cm pairs or in sliced form (Fig. 2). It is filled into casing, or when produced for slicing than into vapour-permeable artificial casing. The casing needs to be clean and free of damage. The sausage has a compact substance, it is flexible, cohesive and easy to slice. Its surface is reddish-brown, and it reveals evenly the meat and lard particles. It has a pleasantly smoky and spicy fragrance and owes its harmonious flavour and aroma to the blend of spices used.

The end product is sold in pairs, with a label around one of the sausages. In vacuum or modified-atmosphere packaging 'Gyulai kolbász' or 'Gyulai pároskolbász' is printed on the packaging. 'Gyulai kolbász' or 'Gyulai pároskolbász' produced specifically to be sold in slices is longer and is not manufactured in pairs; the casing is removed, and after slicing it is sold in vacuum-packed units of various sizes.

In order to reach the quality of the original Gyulai sausage, it is not enough to respect the rules above. The production technology of the original Gyulai sausage is

Table 1 Chemical characteristics of Gyulai kolbász PGI

Water activity	Maximum 0.91
Water/protein ratio	Maximum 1.5
Fat/protein ratio	Maximum 2.7
Meat-protein content without connective tissues	Maximum 15%
Sodium-chloride content	Maximum 5.0%

Fig. 2 Curing room of Gyulai kolbász (left) and typical “Gyulai’ (right). (Source: Gyulahús Ltd)

also essential (Table 2). After post-maturing, during which the moisture content of the packaged product evens out, the cut surface becomes consistent and the substance crumblier, also the colour stabilises as a result of the antioxidant effect of the natural spices. These properties, combined with a full-rounded flavour, completely set ‘Gyulai kolbász’ or ‘Gyulai pároskolbász’ apart from the flavour and substance of other, instantly marketed products.[8]

Manufacturing and Processing Data

The retail consumption of dried sausage in Hungary is 33,826 tons (3.45 kg/capita/year), not including the volume of sausage made by small producers (no data available, estimated data 9500 tons/year), as the small producers sell their products at the place of productions or at different local markets.

The producers using the Gyulai PGI label produce approximately 5225 tons of sausages per year, 95% of it is sold through the wholesale system and only the 5% through direct sales.

In 2017, the imported volume of sausages, winter salami and other salamis was 17,881 tons and 107,636 thousand euros. The imported dry sausage data can only be estimated for there is no available statistics about it.[9]

In 2017, the Hungarian export of dry sausage takes reached 12,040 tons (the main export markets being Germany, Austria, Slovakia, Romania, Czech Republic, Poland, Great Britain, and Hong Kong). These exports were worth 75,822 thousand

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[8] http://elelmiszerlanc.kormany.hu/download/9/4f/20000/Gyulai%20kolbasz_termekleiras_2008_12_02.pdf

[9] https://elir.aki.gov.hu/cikk/a-huskeszitmenyek-kulkereskedelmenek-alakulasa

Table 2 Main characteristics of the Gyulai sausage PGI, listed in the Code of Practice

Territory	
Geographical area	Municipalities of Gyula and Békéscsaba (Fig. 1).
Varieties/ breeds	Crossbreeds of Hungarian Large White meat-type pigs, long-haired 'Mangalica' and Hungarian lowland pig varieties, and Hampshire, Duroc and Pietrain varieties and their hybrids.
Arable farming practices	
–	There is no restriction on arable farming practices.
Animal management	
–	Pigs must be fattened to at least 135 kg.
Processing	
First stage	Parts used: leg, shoulder joint, knuckle, belly, loins, shoulder and collar steak of the half carcasses (without head and feet) and the firm lard (free of glands). The meat parts (frozen to −2 to 4 °C or pre-cooled to 0 to +7 °C) and the lard (0 to −7 °C) are minced by machine into 4–6 mm particles, then the spices and the nitrite salt are added. The resulting paste (that has a temperature of 0 to minus 4 °C) is filled by machine into casings of pigs' small intestines or vapour-permeable artificial casings in pairs (if not for slicing) and the sausages are then clipped at the end.
Second stage	The filled sausages are subsequently smoked over slow-burning hardwood (primarily beech) logs for 2–3 days at 20 °C in a space with a relative humidity of 90–70%.
Third stage	After smoking, the sausages are cured and dried. In an effort to prevent quality defects (the formation of a crust), the dry-curing parameters are set in a way that the difference between the equilibrium relative humidity (ERH) of the sausages and the ambient relative humidity (RH) of the room should not exceed 4–5%. The typical ambient temperature is 16–18 °C; the initial RH of 90–92% is gradually reduced to 65 to 70%. The drying is continued until the water activity in the sausages reaches 0.91, a process that takes about 14–16 days.
Fourth stage	The dry curing is followed by post-maturing, a phase in which the moisture content of the packaged product evens out, the cut surface becomes consistent and the substance more crumbly, and the colour stabilises as a result of the antioxidant effect of the natural spices.
Other	All the four steps of the processing is required in order to gain the full-rounded flavour, which completely sets 'Gyulai kolbász' or 'Gyulai pároskolbász' apart from the flavour and substance of other, instantly marketed products.

euros. The export-import ratio is therefore balanced.[10] Because of the Russian embargo in 2014, the volume of export decreased by 15–20%.

The total annual income of Gyulahús Ltd in 2017 was 18.5 million euros.[11] The other company that actively uses the PGI label, the Kaiser Food Ltd reached an annual income of 16 million euros.[12] Compared with the previous year, the Gyulahús Ltd increased its income by 8%, and its production volume by 9%. Most of its

[10] Dried sausage market data based on Eco-Sensus own researches.

[11] http://www.ceginformacio.hu/cr9319891307

[12] http://www.ceginformacio.hu/cr9316406193

income (80%) comes from domestic markets, the income from export was 2.9 million euros, the company sold a significant volume of its products in the United Kingdom. For export, the most popular products are the sausages and salamis, so those of a higher value, produced with a more traditional technology.

‘Gyulai kolbász’ Value Chain

Feed Production

In case of the Gyulai sausage, there is not much specific information regarding this level because the companies process mostly imported raw materials. The following sections therefore describe pig rearing conditions in Hungary, typical of non-Gyulai value chains (Fig. 3).

The most considerable cost of pig breeding is the animal feed. Hungary’s agricultural structure that has been cereal-oriented for long time created a favourable condition for pig farming. Thus, the pig fattening is based mostly on domestic grains. In Hungary, the pig feeding shows significant differences between farms: there are

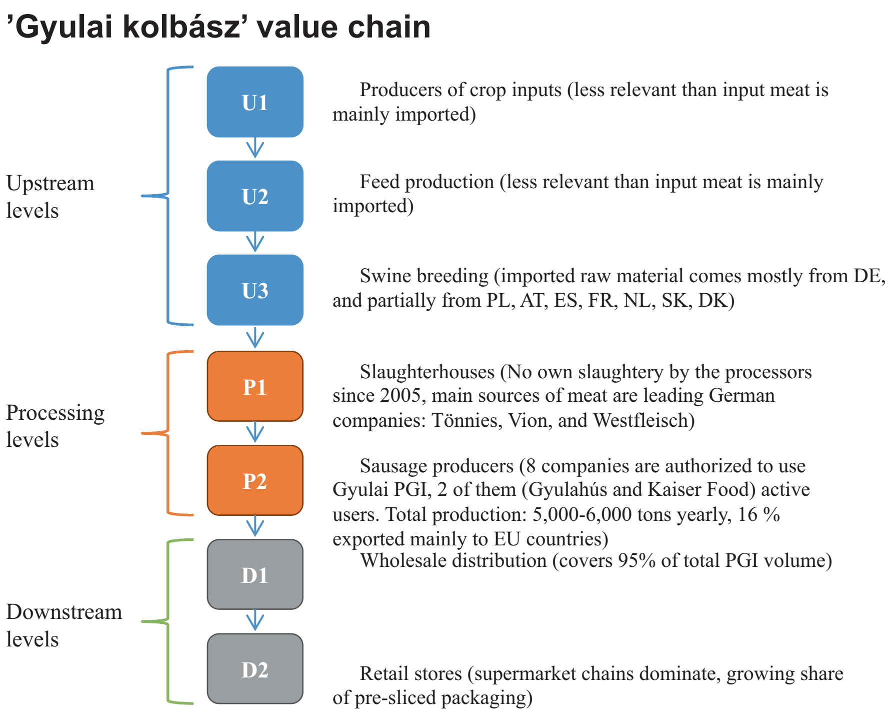

Fig. 3 Gyulai sausage value chain

farms with technological conditions suitable for more phase feeding. In their case, the pigs are fed with the same feed from reaching a body mass of 30–35 kg until slaughtering. In most of the farms, the feeding consists of nutritive mixes, based on a fodder-formula that depends on the conditions of the farm. A significant part of the fodder consists of grains, mainly of corn and barley, secondly of wheat and triticale, sometimes of oat or rye. Among protein carriers the most typically used the post-extraction soya meal with a raw protein content of 46%, less popular are the post-extraction sunflower seed and pellets of medicago. To adjust the raw fibre content of the fodder, wheat barn and pellets of medicago are used. That, the fodder would contain vitamins, micro- and macronutrients and synthetic amino acids, complete premixes, supplements and concentrates are added to the mixture.

Swine Breeding

The goal of pig breeding is the sale of pigs for fattening. The more pigs for fattening are sold per breeding sow in a year the more profitable the farming is. Throughout Hungary's history, pig breeding has had a significant economical role, supplying the population with basic animal protein and fat. By export, it connected the country to the European international trade.

In the last years, the Hungarian government has first decreased the VAT of the half carcass then later also that of the pork offcuts (from 27 to 5%) in order to increase the consumption and to reduce the proportion of the grey economy in the sector. The current number of sows is about 210 thousand, and the total number of pigs is over three million. The presence of the African swine fever induces immense challenges in the sector.

Concerning the dimensions of the domestic pig breeding: there are 72 farms with over a thousand sows, of which are 22 with foreign ownership.[13] 800–900 thousand pigs are bred as "backyard breeding" by about 150 thousand small farms.

Several competitive disadvantages arise from the present situation of domestic pig farming (Hungarian pig is, on average, 10% more expensive than the average price in the EU): the sector is very fragmented and there is a huge variation by quality in the management patterns of small farms; the degree of vertical integrations is low. The technical background of pig breeding is substantially outdated; lack of capital is a chronic problem. But the best farms are still competitive even compared to the most advanced pig rearing countries.[14]

The Hungarian conditions and potential are suitable for developing pig breeding. Moreover, the development of domestic tourism creates additional demand which is internal export.[15]

[13] https://www.tankonyvtar.hu/hu/tartalom/tamop425/00-59_sertestenyesztes/ch01.html

[14] Horn (2000).

[15] Horn (2000).

There are no data available regarding the share of each breed in imports, but the PGI specifications allow the most typical breeds in Europe so it likely poses no limitation in sourcing the meat input for PGI sausage production.

The imported raw material comes mostly from the areas of Germany, Poland, Austria, Spain, France, Netherlands, Slovakia and Denmark. In some countries, it is legal to inject water into the half-carcasses or into the chopped meat parts to decrease weight loss during transportation, to minimize the waste. The water injection is an actual procedure even in case of frozen meat parts. During defrosting, the meat parts release the injected water that causes direct and significant wastage for the manufacturer plant. The processing of non-castrated pigs or pigs with Cryptorchidism causes some problems. Purchasing meat parts poses an extra risk since, there is no technology to filter these.

For producing dry products, sow meat or breeding pig meat is the most suitable, since the technology for producing dry ware is curing, when dehydration takes place and the water content of the sow meat is lower than shoat or barrow meat, so they are more economically curable, and the end-product will have a higher quality.

Ad hoc transactions are typical of the meat raw material because of the fluctuation of the prices. It is not usual that suppliers would sign up a contract for a whole year.

Slaughterhouses

Pig slaughter stopped at Gyulahús Ltd. in 2005; since then ready for use meat parts have been purchased, mostly from import. The major portion of imports comes from Germany (from the three market leader slaughterhouses: Tönnies, Vion, and Westfleisch), Poland and Austria; where the equipment and hygiene conditions of these slaughterhouses are worthy of market leader companies.

According to Hungarian statistics there were 4.676 million pigs slaughtered altogether in Hungarian slaughterhouses in 2017. The monthly average slaughter in terms of live weight was more than 44 thousand tons. About 40% of pigs that arrive at the Hungarian slaughterhouses come from abroad, typically from Slovakia, Germany, and the Netherlands.[16]

Presently, there are 190 slaughterhouses and slaughter points in Hungary. Every animal is examined by a veterinarian and traceability has to be guaranteed also by slaughterhouses.[17] The protection of animals takes place according to 1099/2009/EC. In order to improve animal welfare, the regulation requires the personnel performing slaughter and related operations to have the proper expertise and certificate of qualification (articles 7. and 21.).

[16] http://nak.hu/en/agazati-hirek/elelmiszeripar/151-hus-baromfiipar/93418-nott-a-feldolgozott-hus-mennyisege

[17] NÉBIH.

Sausage Producers

'Gyulai kolbász PGI' products are mainly produced by two companies – Gyulahús Ltd from Gyula and Kaiser Food Ltd from Békéscsaba, however, eight companies are authorized to produce Gyulai sausage within the area boundaries defined by the GI regulations. Within the PGI area about 5000–6000 tons of sausages are produced. The main reason why the other authorized companies do not use the PGI label is that they do not have the appropriate technological background. Gyulahús Ltd – as the largest PGI producer – also operates with a 30–40 years old technological background. There are numerous other factors that influence the uniqueness of the final product that are insufficient to reproduce the formula.

Cured sausage (dry sausage) production is not a highly profitable activity since it is based on dehydration technology where weight loss cannot be totally recognized in the wholesale price of the final product. This feature can only be partially mitigated by using fast acting starter cultures to accelerate fermentation and to decrease losses, but the PGI standard does not allow the application of such methods. Furthermore, the PGI label does not currently create a substantial added value that customers would be willing to pay for. Gyulahús Ltd wishes to change that; the PGI label is part of the brand building and their marketing activity is closely connected to town marketing (the town of Gyula is also famous for its thermal bath). In the factory they receive groups and present the complete history of the Gyulai sausage through detailed presentations. Moreover, there is a museum called the "Gyulai Kolbász Múzeum" (Gyulai Sausage Museum). The majority of the employees of the museum used to work for the company.[18]

Wholesale Distribution

The largest Gyulai sausage PGI producer sells 95% of the PGI production on the wholesale level. The export in value is about 16%, of which only 0.44% is outside the EU. The export target countries are: Great Britain, Czech Republic, Germany, Slovakia and Romania, and in the extra EU markets Hong Kong and Georgia.

The Russian embargo activated in 2014 affected the 20% of the export market. 'Magnit' grocery store network in Moscow and retailers of the Krasnodar region used to procure from Gyulai different sausages and other dry goods. If the embargo is lifted, the return to the Russian market will likely not be as high as it used to be since the Russian have created their own production capacities and even though they cannot reproduce the Gyulai sausage, they are able to cover their market with similarly flavoured products.

The specifically more expensive products are exported; products made of less expensive ingredients and less expensive technology are typically not exported. This

[18] Interview.

translates into the average export price which is significantly higher than the average wholesale prices on the domestic market. The presentation of PGI products for export market are different, they are exported in bars, sliced, and packaged as well.

PGI suitable sausages are supplied to several pizza franchises in Great Britain. The PGI label is not pictured on the packaging of these sausages since these are used as ingredients for restaurants where customers do not encounter the packaged product. The tradition of Gyulai sausage fits the traditional recipes and 40-year history of pizza franchises perfectly and British partners value in trademarks.

Retail Stores

Gyulahús Ltd owns two stores in the towns of Gyula and Békéscsaba, but Gyulai sausage with the PGI label is mostly sold through large grocery store franchises as well as discount store networks such as Auchan, Metro, Tesco, Aldi, Lidl. The other PGI producer, Kaiser Food Ltd of Békéscsaba also operates one brand store called Csabahús in Békéscsaba.

Price composition of the retail market shows significant differences. Even though an acceptable markup for the product would be 30–40%, the application of a 200% spread is also frequent; however, retailers that apply such large margins can only sell smaller quantities. The average retail price of sausages without a PGI label is 10.55 euros/kg, the average retail price of Gyulai sausage with PGI label is 18.83 euros/kg.

There is a noticeable increase on the demand side for sliced and pre-packaged products. It is more convenient for customers, it means less labour for retail partners and the amount of wasted sausage is lower. According to the manufacturer, this packaging is driven by the fact that 85% of their customers are women, living in a constant time pressure and valuing time-savings resulting from pre-sliced and pre-packaged products. In order to meet demand requirements Gyulahús changed the initially used 120 g packaging to a 70 g packaging (even though this change increase costs as well as plastic-related pollution).

Sustainability Assessment of Gyulai kolbász PGI

In order to assess the sustainability of this Hungarian PGI sausage, the specific methodology of the Strength2Food project was applied (Bellassen et al. 2016). For benchmarking, we used generic (not GI) sausage as reference product, except for local multiplier calculations where small sausage processors (within the GI territory but producing no GI sausage) were considered.

Due to the quite limited amount of official data of the sausage value chain, the majority of the inputs for computing the indicators are collected via personal interviews (butchers, sausage processors, representative of the Hungarian Meat Industry Federation, the management of the biggest GI processor company and other industry experts). On the other hand, all the available data are included, mainly gained from the databases of the Hungarian Central Statistical Office and the Hungarian FADN, while for trade flows we used the dataset of the World Bank.

Price, Profit and Exports

At farm level, there is no significant difference for pig production, and economic indicators are the same. At processing level, the price premium is high, but profitability of PGI is lower than its reference (Fig. 4). Indeed, both intermediate consumption and wages are higher for PGI (due to the traditional processing method, mainly the smoking and ripening process). The result is that the profit margin on Gyulai PGI is considerably lower than on the non-PGI products. Nonetheless Gyulahús Ltd. considers it as an emblematic product, an important brand, so they continue to manufacture it even with a smaller profit margin. At distribution level, price premium is higher, and at this level PGI appears to be more profitable, considering costs are almost the same for distribution.

Concerning export, a large share of conventional sausages are exported, Gyulai sausages being more destinated to local and national markets. However, Gyulai sausage benefits form a higher price at export level, as the difference between share of volume and share of value is higher for PGI than for reference.

Local Multiplier

The local area assumed for the local multiplier calculation is the Gyula and Békéscsaba municipalities; the same applies for the reference product. The local multiplier effect of Gyulai sausage is 53.5% higher: each euro of turnover for Gyulai sausage triggers 0.43 € of respending in the same region versus 0.28 € for the reference. The main driver of this difference is the processor's payroll: in the case of Gyulai sausage 12.6% of the processor's costs are devoted to local wages, while for the non PGI-product, just 8%. Indeed, without local spending of payroll, the local multiplier would reduce of −12% for the PGI product and −9% for non-PGI sausage. In both cases, the supply chain seems to be relied on external resources (just 5% of the slaughterhouses is local). This shows that the direct local economic spillover is small. For the PGI, just 22% of the initial budget remains within the local area at round 2 (expenditure addressed to local first tier suppliers), and 20% of the initial budget is kept within the local area at round 3 (expenditure addressed to second tier suppliers). For the reference product, 15% of the total budget remains at local level in the second round and 13% in third round.

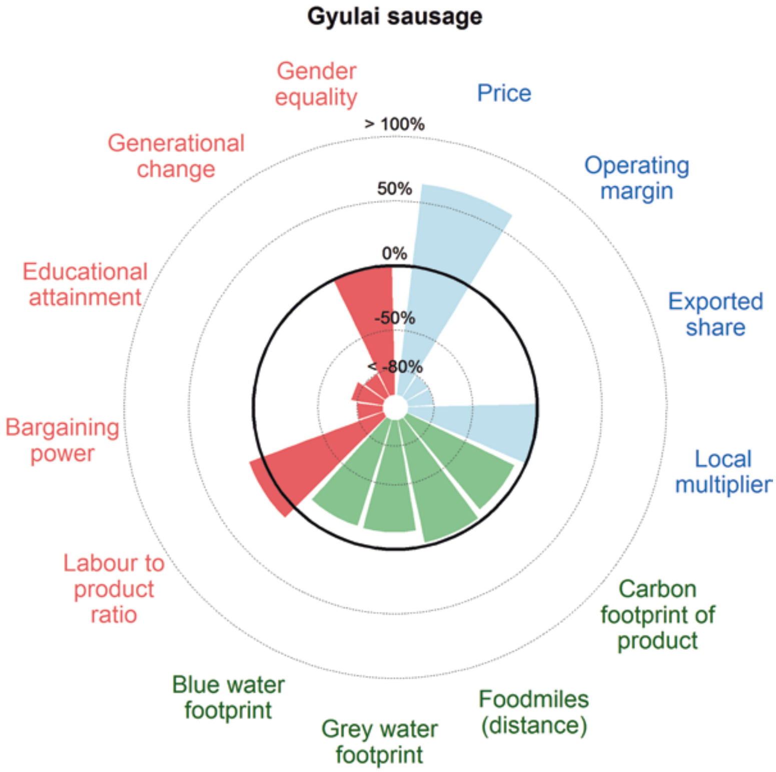

Fig. 4 Sustainability performance of PGI Gyulai sausage (supply chain averages). (Each indicator is expressed as the difference between PGI Gyulai sausage and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

Carbon Footprint

The carbon footprint (tCO2e t^{-1}) of PGI sausage is 11% higher than its reference, despite a similar footprint of the fresh meat used for PGI ham. This is largely due to the technical specifications which require a more intense drying for the PGI. Therefore, an accounting unit like tCO2e $kcal^{-1}$ may yield results similar to those of fresh meat. Our estimate for fresh meat – 2.7 tCO2e t of fresh $meat^{-1}$ for both PGI and reference – is at the lower end of the literature which ranges from 2 to 11.9 tCO2e ton^{-1} pork meat (Clune et al. 2017; Lesschen et al. 2011; Meier et al. 2015).

Foodmiles

Over the entire supply chain, from farms to distribution (U3-D1), there is a slight difference between the PGI and its reference. The former travels slightly longer distances (4500 vs 4400 t.km) and releases slightly more emissions (445 vs 415 kg CO2 eq) than the latter. The longer distance embedded in the PGI Gyulai sausage can be explained by the difference in transformation product ratios (0.58 for PGI vs 0.66 for its reference) at the second level of the processing stage, from slaughterhouses to processors. Indeed, more meat parts are needed to produce PGI sausage, leading to longer embedded distances travelled by imported meat parts, which concerns most of the production (95%) and involves long distances. Shorter distances travelled at retail level due to a smaller share of exports for PGI (12% vs 35% for its reference) are totally offset by the longer distances travelled at processing level by imported meat parts. Similarly, the larger emissions embedded in the PGI can be explained by the larger emissions resulting from the imports of meat parts. Distances (and emissions) related to imports of meat parts outweigh distances (and emissions) related to exports due to the lower transformation ratio at processing level that leads to more embedded distances (and emissions).

The processing level, and especially the second level of processing, from slaughterhouses to processors (P1-P2), concentrates most of the kilometres embedded in the product and more than 70% of the emissions generated along the value chain. Regarding foodmiles indicators, we can conclude that the PGI Gyulai sausage is less sustainable than its reference both in terms of distance travelled (+1.5%) and in terms of emissions released at the transport stage (+7%).

Water Footprint

Since slaughtered meat is imported, impacts of the agricultural phase are not located in Hungary. Data from the three main meat exporters to Hungary were used in the calculation: Germany, Austria and Poland. PGI and reference production systems have the same upstream level and, therefore, the same waterfootprints related to agriculture, diet and breeding.

Most part of the water footprint is due to the agricultural phase which takes place in these countries. PGI production is slightly more water demanding than the reference product due to its lower final product ratio which of 0.332 (t sausage/t liveweight) versus 0.376 (t sausage/t liveweight) for the reference (Fig. 5).

Irrigation was considered to be zero on all feed crops. Slaughtering takes place in exporter countries, while sausage production takes place in Hungary. Because of the lack of specific data, a unique processing phase was considered, taking into account the final product ratios of both slaughtering and production. Data for processing include only energy consumption. Electricity consumption impact was estimated by using the Hungarian electric mix. Blue water footprint of processing is

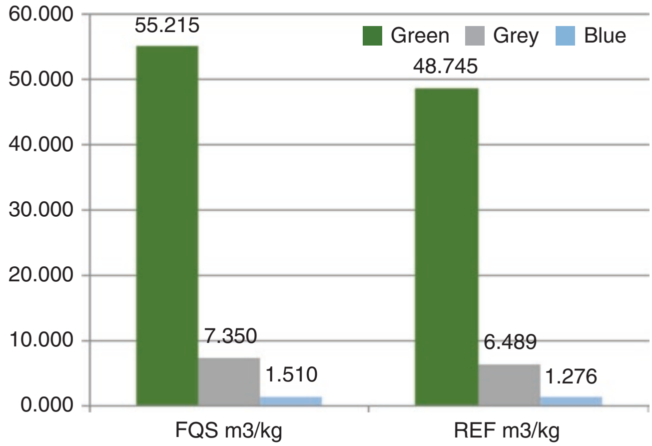

Fig. 5 Water footprint (FQS = PGI, REF = reference product; green = rainwater use, blue = surface and ground water use, grey = water pollution by nitrates)

0.028 m^3/kg of sausage for both products. This amount is negligible in comparison with the total water footprint of Gyulai sausage.

Employment and Educational Attainment

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is slightly higher for Gyulai sausage than for its non-PGI reference: it takes 104 hours of work to produce a ton of sausage when the reference product requires 94 hours. The difference (−9.6%) indicates that the PGI product generates somewhat more jobs than the reference.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator,** which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The level of education is very low compared to what is observed for the reference sectors. The large majority of employees in the sector (80%) have only a primary education level compared to a minority in the reference sector (20%). The low level of education (having only primary or secondary degree) is a general phenomena in the Hungarian meat industry as the core process allows to have less educated employees.

Bargaining Power Distribution

Bargaining power is rather unevenly vertically distributed along the PGI supply chain (bargaining power distribution indicator of 0.42). This is mainly due to the low bargaining power score obtained at the U3 level (0.14), which is due to the fact that processors mostly source raw materials at the international level (Germany, Poland, Austria, Spain), mainly meat and firm lard is needed for producing sausage through a market logic. By way of contrast, the dominant position held by processors P1 of the PGI is due to two factors. First, they are very few in number, with, in particular, a very strong market leader. Second, this level enjoys a strong advantage over the upstream level in terms of “transaction costs”: they master the specific resources needed for producing sausage. The P1 level is indeed key for the distinctiveness of the product.

Generational Change and Gender Equality

The generational change and gender inequality indicators were calculated only for the meat processing stages because both pig rearing and slaughtering takes place abroad. The reference sausage is ten times more performant than the Gyulai Sausage PGI regarding generational change. This may be because the PGI is produced in a very small area by very few firms. The meat industry in the PGI area currently faces a considerable labour shortage and aging, the renewal of personnel is getting harder. This suggests that there may be troubles ahead for continuing to produce the PGI Sausage, due to the very limited involvement of young workers in the processing stage, compared to older ones.

Likewise, both the production of the PGI and the reference product appear hampered by the inequality in opportunities between males and females at the processing stage of the supply chains. In fact, firm ownership accrues completely to males, determining the high values of the indicator. Regarding gender inequality, the reference sausage is marginally more sustainable than the PGI thanks to the higher educational attainment of women.

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PGI Ternasco de Aragón Lamb in Spain

Hugo Ferrer-Pérez and José Maria Gil

Characteristics of the PGI Ternasco de Aragón

Introduction

Sheep farming is very important in Aragón due to its economic, social and environmental impact. It is present all over Aragón, in both non-irrigated and irrigated areas, and in plains, plateau and mountainous areas, and is a key factor for society in tough areas.

Numerous sheep breeds, most of them native, can be found in Aragón, including, *Rasa aragonesa, Ojinegra de Teruel, Roya Bilbilitana* and *Ansotana*. See, for instance, Sierra (2002, 2011).

Sheep farms basically follow the extensive grazing model recommended by the Common Agricultural Policy (CAP), and comprise a truly sustainable livestock farming system. They use resources that otherwise would be unused, together with stubble fields, post-harvest wastes and agricultural sub-products. This kind of farming favours a positive impact on the environment. Sheep farming in Aragón is linked to grazing and complementary food like maize, alfalfa, etc.

It is important to note that Aragón is probably the region of Spain with the best cooperative structures for buying and selling lamb, which is an advantage for the farmer (Sierra 2016). However, CAP subsidies play a key role and most farms would not be economically viable without them.

H. Ferrer-Pérez · J. M. Gil (✉)
CREDA-UPC-IRTA, Barcelona, Spain
e-mail: chema.gil@upc.edu

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Spanish Lamb Sector

Germany, Spain, France and the UK have the largest numbers of livestock of all Member States (MS) of the European Union (EU). Although the sheep and goat sector is small compared to the beef and poultry sectors, it is nonetheless important in almost all MS, especially in the UK and Spain (16.4%) which together account for 56.1% of all EU-28 sheep and goats (39.7% and 16.4%, respectively). Sheep and goats can be important in the maintenance of rural economies and populations, and their production contributes towards the maintenance of agricultural landscapes. (Rodriguez et al. 2016; Eurostat 2016).

According to Marin (2016), the Spanish lamb sector can be divided into different groups:

- Productive orientation: dairy sheep farms and meat sheep farms.
- Land tenure: individual, communal ownership or rent.
- Structural system: familiar, small, medium and big farms, considering the size of the farm, the size of the herd, and the work force employed.
- Productive system: Extensive, semi-extensive and intensive.
- Grazing system: shepherding and transhumance.

The Spanish sheep farm is based on an extensive productive system with autochthonous breeds, best adapted to the local terrain, oriented to milk, meat-milk or meat production, mainly to lamb meat (Fig. 1), from a zero-grazing to a very extensive pastoralism system (Marin 2016).

Aragon Meat Sector

Aragón is one of the 5 major lamb meat producer regions in Spain. The relative importance of livestock sectors in Aragon is similar to the Spanish average (Fig. 2), except in the case of poultry. In Aragon, sheep and goat meat accounts for 2.3% of the total meat production which is well above the Spanish average (1.93%).

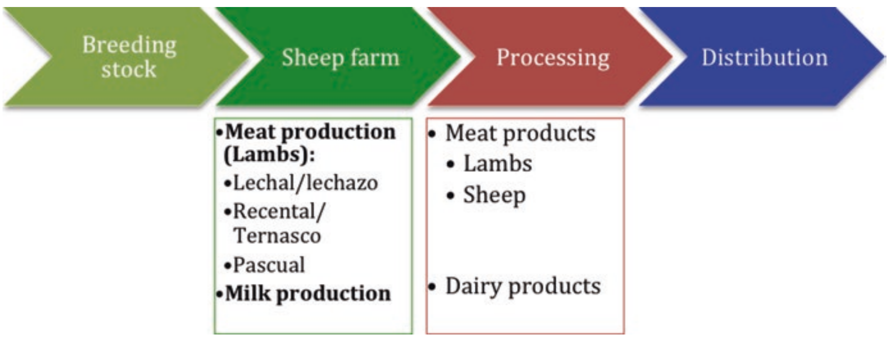

Fig. 1 Spanish ovine production system. (Source: Own elaboration based on (MAPAMA 2013))

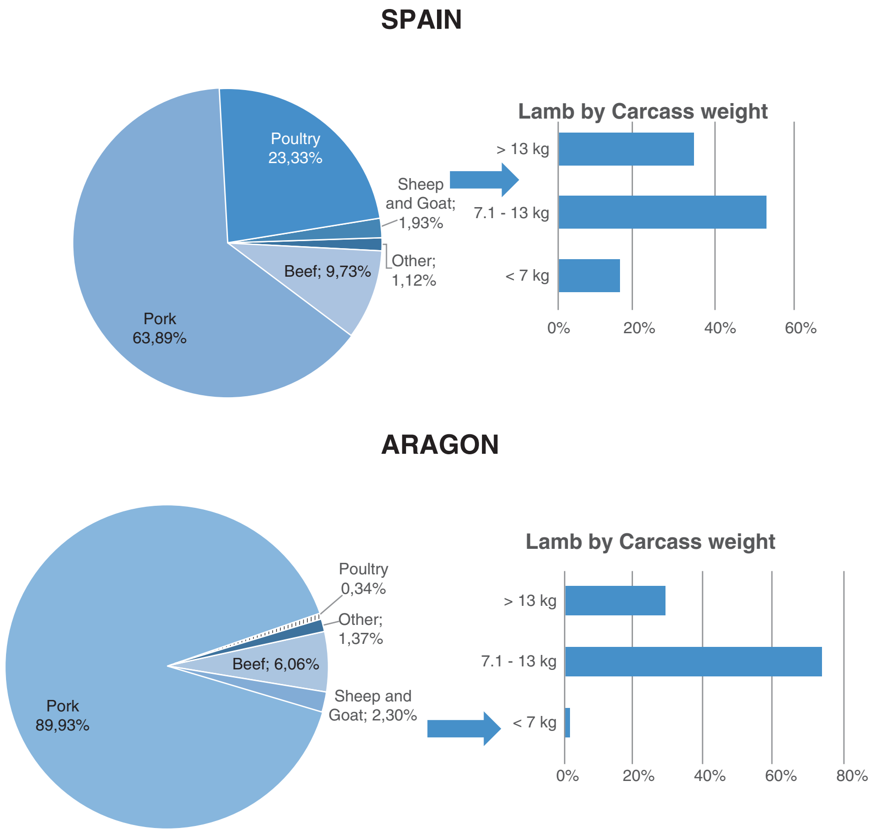

Fig. 2 Composition of the meat sector in Spain and Aragon. (Source: Own elaboration based on (MAPAMA 2017a)

Moreover, most of the lamb meat (71%) comes from animals with a carcass weight between 7.1 and 13 kg (ternasco or recental), while across the whole of Spain, this type of lamb meat only accounts for 51%. However, the percentage of meat coming from lighter animals is lower than the national Spanish average.

In recent decades, the contribution of the sheep and goat sector to Final Livestock Production has declined drastically (Table 1), due to the effects of new agricultural and lisvestock trends, particularly farm intensification. The Spanish sheep farm mainly corresponds to an extensive system, characterized by the rustic nature of soil, the feeding system and sheep breeds.

Table 1 Participation of the ovine sector in the Spanish Final Agricultural Production (Thousands of Euro)

Year	Sheep and Goat Final Production	Livestock Final Production	Agriculutral Final Production
2000	234,920	1,170,650 (20.07%)	2,735,230 (8.59%)
2005	128,814	1,461,683 (8.81%)	2,239,058 (5.75%)
2012	82,671	2,097,207 (3.94%)	3,436,587 (2.41%)
2014	91,379	2,159,701 (4.23%)	3,522,671 (2.59%)

Source: Sierra (2016)

Table 2 Classification and main characteristics of Spanish lambs

Classification	Weaning age	Age at slaughter	Live weight at slaughter	Carcass weight
Lechal	30 days	30–32 days	10–14 kg	5–8 kg
Recental Ternasco	50 days	70–100 days	14–26 kg	8–12.5 kg
Pascual	50–55 days	4–12 months	26–32 kg	13–16 kg

Source: Delfa et al. (1991)

Lamb Meat

The production of lamb meat in Span meets social and cultural demand. Lamb is one of the most popular meats, despite its downward trend in consumption, and in 2014 stood at 1.7 kg per capita (MAPAMA 2016a, b).

Lambs in Spain are classified into 3 groups (Table 2): "Lechal" (suckling lamb), which are mainly young male dairy sheep; "ternasco" (recental lamb), which are of autochthonous breeds, with meat characterized by a pink color, tenderness and an optimal level of fat, the most consumed lamb in Spain; and thirdly "pascual" which after weaning has been fed with concentrate, with red meat, a stronger flavor and a greater amount of fat (Delfa et al. 1991).

Description of the PGI Ternasco de Aragón

Breeds Included in the PGI

The climatic characteristics of Aragón territory have favoured the development of a sheep subsector. There are several breeds of sheep with particular characteristics which differentiate them from the other sheep commonly slaughtered in Spain.

The traditional lamb breeding system is characterized by a grazing phase and a stabling phase. Grazing takes place in mountainous areas, which gives the meat its particular taste (CRTA 2016; Sierra 2016).

Table 3 Summary of the characteristics of the breeds included in the PGI Ternasco de Aragón

	Rasa aragonesa	Ojinegra de Teruel	Maellana	Ansotana	Roya bilbilitana
Geographical distribution of the breed	Ebro Valley (Aragón) Castilla y León, Castilla-La Mancha, Navarra, La Rioja and Cataluña	Teruel (Aragón) Tarragona (Cataluña) and Castellón (Valencia)	Aragón	Aragón Navarra	Aragón Castilla-La Mancha, Castilla y León, La Rioja.
Age on slaughter (average, months)	3	3	3	No data	2.5
Type of production	Semi-extensive	Semi-extensive	Semi-extensive	No data	Extensive or semi-extensive
Average daily gain (gr./day)	201	210	226	No data	233
Carcass weight	11	8	11	No data	8.5
Yield carcass (%)	48	48	46	No data	48.5
Fleece colour	White	White	White	White	Brown

The Code of Practice of the PGI Ternasco de Aragón includes five sheep breeds, which are considered as native to Aragonese region: Rasa aragonesa, Ojinegra de Teruel, Maellana, Ansotana and Roya bilbilitana (Table 3).

The breeds included in the PGI Ternasco de Aragón (TA) have shown good adaptability to a harsh continental climate, with big oscillations in temperature, strong sunlight and scarce and widely-distributed rainfall (250–500 mm) on limestone soils located in valleys, plateaus or mountains. The TA breeds take advantage of the scarce grazing, stubble and residues of existing crops, and are also breeds which must return to the sheepfold every day (Sierra 1992; Pardos et al. 2008).

Technical Specifications of PGI Ternasco de Aragón

This section summarizes the information of the current Code of Practice of the PGI Ternasco de Aragón (Table 4).

Intrinsic Quality Attributes

Ternasco de Aragón is characterized by the composition of the carcass. According to studies carried out by Alfonso et al., (2001), the tissue composition of TA is: bone 20.41%, lean 63.22%, fat 14.49% and other tissues 1.88%. The consumer expects the 5 main lamb cuts to have a high percentage of muscle and be low in bones and fat (Fig. 3) (Mar-Campo et al. 2008).

Table 4 Technical specifications PGI Ternasco de Aragón

Product description	
Breeds	Rasa Aragonesa; Ojinegra de Teruel; Maellana; Ansotana; and Roya Bilbilitana
Lambs	Males (uncastrated) and females
Feeding	In stabling: Breast milk, Straw and Concentrates (authorized by the regulatory councl) It is forbidden the use of substances that may interfere with the normal rhythm of growth and development of the animal.
Meat characteristics	
Carcass weight	Between 8.0 and 12.5 kg.
Characteristics of the fat	External fat: white colour, consistency and firm Cavity fat: white colour and covering al least half of the kidney
Carcass conformation	Rectilinear profile with subconvex tendency; Harmonic proportions; Slightly rounded contours
Other characteristics	Colour: Pale pink Muscle: Tender; Beginning of fat infiltration at the intramuscular level; Great juiciness; Soft texture
Production and Process	
Farming	The lamb must come exclusively from the authorized breeds and from the registered farms, located in the production area.
Slaughtering	In authorized centres
Conditioning	The carcass reaches the ideal temperature for its conservation and transport. This temperature will be a maximum of 7 °C in all meat.

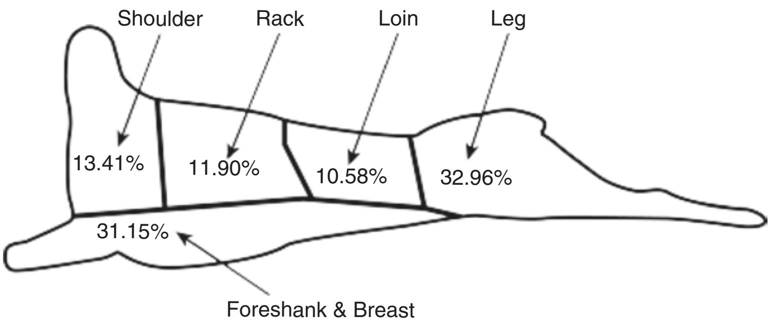

Fig. 3 Cut Proportions in Ternasco de Aragón. (Source: Da Silveira and Moreira 2006)

The nutritional composition of meat is a crucial aspect for human diet. The quality of the meat is determined by the carcass quality: carcass characteristics, pH and chemical composition as shown (Table 5).

Meat consumption is linked to two aspects, taste and nutritional contribution. Lamb meat has high levels of iron and zinc (Table 6), and is one of the best foods to ward off anaemia (Mar-Campo et al. 2008).

Table 5 Ternasco de Aragón carcass characteristics, pH and chemical composition

Carcass weight, kg	10.79	±0.64
External length of the carcass, cm	52.00	±1.35
Carcass compactness, kg/cm	0.21	±0.01
Tissue composition, %		
Muscle	62.65	±1.82
Subcutaneous fat	5.68	±1.74
Intramuscular fat	9.72	±1.34
Total fat	15.40	±1.88
Bone	21.96	±1.33
pH (48 h after slaughter)	5.59	±0.03
Chemical composition, %		
Humidity	75.65	±1.77
Protein	17.30	±0.66
Fat	3.62	±1.86
Ashes	1.04	±0.04

Source: Guerrero et al. (2016)

Table 6 Mineral and vitamin content of lamb meat. Concentration per 100 g of muscle

Minerals				Vitamins			
Calcium	14.0 mg	**Zinc**	4.8 mg	**A**	8.6 µg	**B6**	0.32 mg
Iron	2.3 mg	**Copper**	0.2 mg	**B1**	0.05 mg	**B12**	3.61 mg
Magnesium	25.0 mg	**Manganese**	0.04 mg	**B2**	0.11 mg	**D**	<5 µg
Phosphorus	224.0 mg	**Selenium**	10.1 µg	**B3**	6.5 mg	**E**	0.5 µg
Potassium	336.0 mg	**Iodo**	0.9 µg	**B5**	0.57 mg		
Sodium	64.0 mg						

Source: Mar-Campo et al. (2008)

Geographical Area of PGI Ternasco

The geographical area of the PGI Ternasco de Aragón comprises the 731 municipalities of the Region of Aragón in the northeast of Spain, grouped into the 3 provinces of Zaragoza, Huesca and Teruel. Aragón is bounded in the north by the Pyrenees and in the southwest by the Iberian System mountain chain. The River Ebro, which is one of the longest and most abundant rivers in Spain, flows through Zaragoza, the capital city of the region (Fig. 4).

Aragon's climate is Mediterranean continental; arid-temperate and windy in the lowlands, but cold and humid in the mountains. Average annual temperature is around 15 °C. The average annual rainfall is 200–400 mm, with oscillations between 800 mm in the Pyrenees, and 400–500 mm in the Catalayud-Teruel depression (CRTA 2016).

The watercourse network is distributed unequally among four large basins: the Ebro, which covers most of the territory (provinces of Huesca and Zaragoza, and two thirds of Teruel), and the Tajo-Guadalaviar-Turia and Mijares, which occupy the southern third of the province of Teruel (CRTA 2016).

Fig. 4 Geographical area of PGI "Ternasco de Aragón" production. (Source: Own elaboration from (IDEARAGON 2017)

There are two mains kinds of flora in the territory. In the meadows,there are: *Eriseteto-Polyugonion, Trisetum flavescens, Dactylis glomerata, Trifolim pratens, Festuca rubra,* and in the grassland*: Eremopyrum Cristatum, Platycapnos Echeandiae, Valerianella multidentata, Astragalus Alopecuroies, lappula Patula, Minimal Medicago, Scorpiurus Subuillosa, Astragalus Sesamens, Trifolum Scabrum, Melitotus Sulcatus* (CRTA 2016).

The environmental characteristics of the middle basin of the Ebro, especially in the central part, are typical of a semi-arid climate, with low rainfall. Together with a frequent wind and strong sunlight this means that natural resources are poor. For centuries, the most common domestic livestock in the region have been sheep. In mountain areas too, despite winter shortages and difficult conditions, sheep have persisted thanks to their adaptable nature, and there has been transhumance in winter and summer grazing (Sierra 2016).

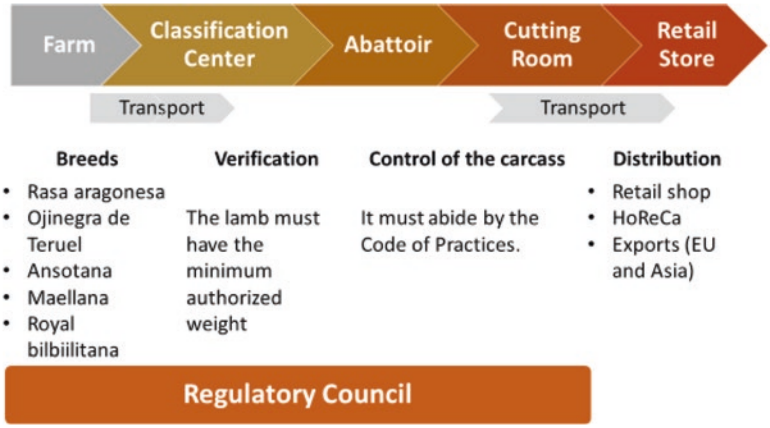

Fig. 5 Characteristics of the PGI Ternasco de Aragon supply chain and the role of the Regulatory Council

Technical Process of "Ternasco de Aragón" Production

Production

The production of TA involves: 2 main actors (farm and distributor), 3 service providers (Carrier, Classification Centre, and Slaughterhouse) and a Regulatory Agent (Regulatory Council). See Fig. 5.

Ternasco Value Chain

There are three levels in the Ternasco de Aragón chain. Upstream there are lamb producers. Downstream, at the first sub-level, there are wholesale distributors owning lamb-grading centres and, at the second sub-level, there are retail outlets. The processing level corresponds to abattoirs, which are public, and cutting rooms (Fig. 6).

In 2015, the PGI Ternasco de Aragón included 841 herds, 5 slaughterhouses and 2 cutting rooms, which processed more than 212,643 animals, representing more than 2153.45 tons of certificated meat and a turnover of €14.75 million (MAPAMA 2016b).

The Herds

The typical production system in Aragon and therefore in the Ternasco, is traditional extensive grazing. The system includes small farms with just one lamb born per year and little accommodation for sheep to larger farms with 3 births in 2 years

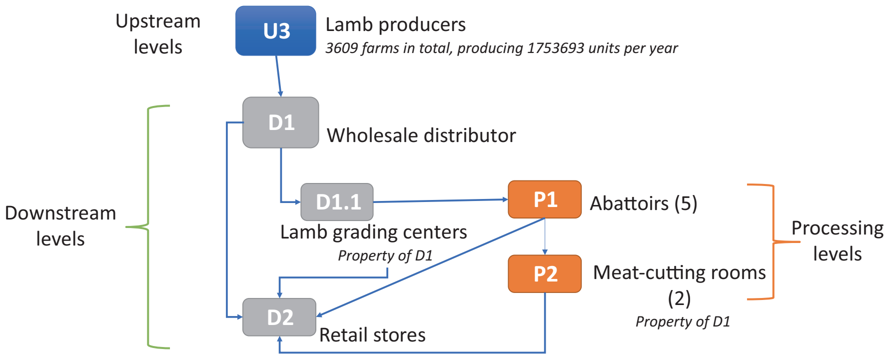

Fig. 6 PGI Ternasco de Aragón value chain

(Fau 2016; Sierra 2016). However, the farms of the Ternasco are moving towards intensification and increasing the number of heads per unit (Teixera et al. 2012).

Twenty-four per cent of Aragón sheep are concentrated in 21 of the municipalities (Fig. 7). Ministry of Agriculture and Livestock of Aragón figures show that the number of sheep farms per municipality, oscillated from 1 to 75 in 2013, with a total herd between 2 and 50,034 sheep.

Pardos et al. (2008) identify 4 typologies of the Ternasco of Aragón farms:

- Group 1 or Intensive farms: with flocks of between 500 and 600 sheep per unit, highly qualified farmers and a rate of 1.30 births per ewe per year. These farms are located in dry lands.
- Group 2: farms with an average of 747.4 ewes located in rainfed areas. These large agricultural farms rent extensive low-quality rainfed pastures, which form the basis of the livestock feeding system (1746 ha of winter cereal stubble, rough grazing, etc.).
- Group 3: farms with the largest flock size (1011.6 sheep) and the largest forage crop area (55.1 ha), located in irrigated areas, with significant differences with Groups 1, 2, and 4. They handle the largest number of sheep per worker and have large agricultural farms, also renting extensive areas of pasture, including irrigated stubble land.
- Group 4: farms characterised by the smallest flock (386.5 ewes) with exclusively family labour. They have 58.8 ha, basically rainfed land, and farmers have a low level of education. Reproduction rates are low, and they sell only 1.17 lambs per ewe per year, showing the highest mortality of lambs and breeding ewes.

As to the social characteristics of the PGI "Ternasco de Aragón" sector, farmers are on average 45 years old, with a partner and children (70.8%). Their main reasons for belonging to the PGI are that consumers trust it, it allows better quality meat, facilitates the sale of lambs and is more profitable (Sepúlveda et al. 2010).

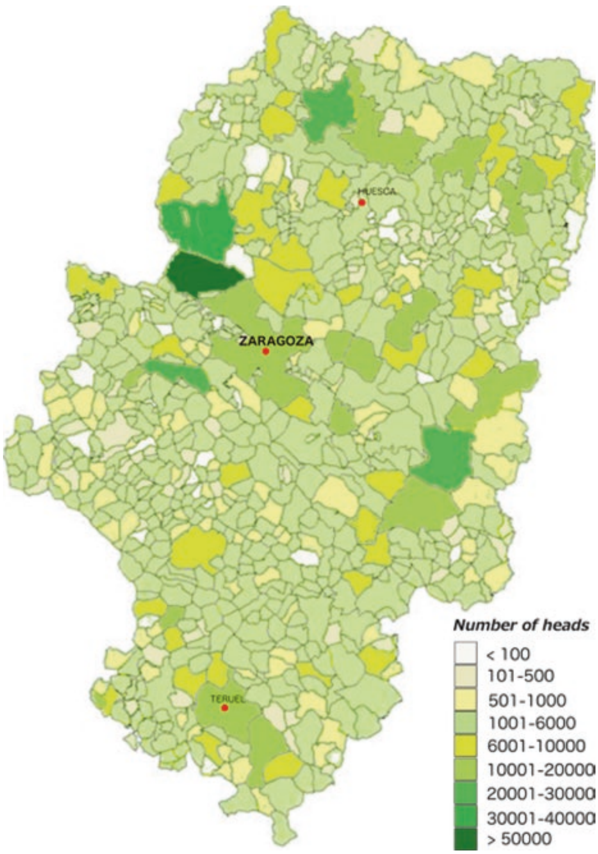

Fig. 7 Distribution of Final Ovine-Goat Production in Aragón. (Source: Own elaboration based on information from Gobierno de Aragón (2016))

Abattoirs

There are several commercial and productive reasons why Classification Centres (CC) are useful in the lamb meat production chain, including simplification of farm management, scarcity of specialized man power, and product standardization. Depending on their live weight at arrival, lambs may stay at the CC for several days or even weeks until they reach the appropriate slaughter weight (Miranda de la Lama et al. 2009).

The animals are slaughtered in EU-approved abattoirs and according to the Ternasco de Aragón Code of Practice. Of the 5 slaughterhouses, 3 are located in Aragón and 2 in the neighbouring regions, Navarra and Cataluña, near the major urban areas and with easy access for farmers to bring their lambs. Once lambs arrive at the slaughterhouse, they rest for at least 12 hours, in the pens, with water freely available. After this lairage, lambs are electrically stunned and dressed using standard commercial procedures (Miranda de la Lama et al. 2012).

The slaughterhouse is a public service provider in the TA supply chain and only charges a fee for each animal slaughtered. A certifying agent is present to supervise carcass compliance with PGI specifications (CRTA 2016).

The certificated meat can sold as a whole carcass, or sold in cuts. For cuts, the meat is taken to a cutting room to be prepared according to client requirements (CRTA 2016, 2017).

Cutting Rooms

The two cutting rooms are located in Mercazaragoza (Zaragoza), and process the lamb pieces in cuts to meet different consumer' needs. The cutting rooms respond to changes in requirements of clients, who may be HORECA or final consumers. The recent integration of companies has enabled the sheep sector to face the market with products and cuts which can better satisfy the different needs of Spanish household units (Gracia 2011).

The Regulatory Council permits the lamb carcass to be cut into pieces in order to meet the various market needs (Fig. 8). The sale of fresh chilled or frozen carcasses is now also permitted, and this makes it possible to offer new cuts and parts, facilitating their marketing and adding value to the product, especially for the least marketable cuts of lamb (Sierra 2016).

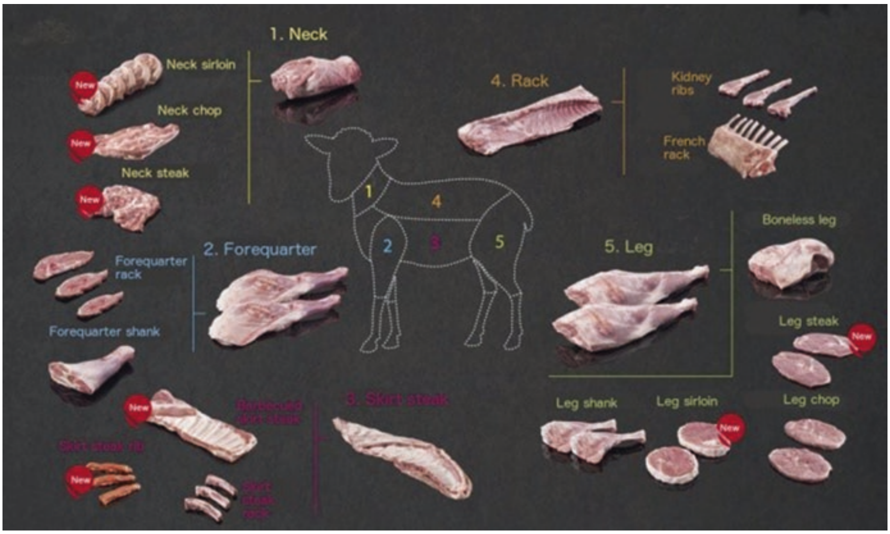

Fig. 8 Ternasco de Aragón cuts. (Source: www.ternascodearagon.es)

Table 7 Main distributors of PGI Ternasco de Aragón

	Gr. Coop. Pastores	Casa Ganaderos	Franco y Navarro S.A.
Employees (average)	70	12	7
Distribution channels (%)			
Retail	35.0	46	No data
Specialized	1.0	12	No data
Traditional stores	45.0	39.5	No data
Internet		0.5	No data
Buildings			
Slaughterhouses	5	No data	No data
Cutting rooms	1	No data	No data
Capacity of slaughter (number of sheep)	1000	No data	No data
Number of herds associated	7744	300	No data
Sales certificated as Ternasco de Aragón	65%	40%	

Distribution

Sales of T.A. are made under the traditional system, in either a contract or a cooperative model. In the contract model, which accounts for 5% of sales, each supply chain actor enters into contracts for the rearing, fattening or sale of the lambs. The majority of sales are made in a cooperative model which groups the majority of farms and distribution companies (Gracia 2011).

There are essentially three firms which distribute Ternasco de Aragón. Two of them (Gr. Coop. Pastores and Casa Ganaderos) work under the cooperative system, which means that take part in almost the whole chain. Pastores G.P. accounts for almost 75% of the meat sales and Casa Ganaderos and Franco y Navarro share the remainder, nearly 25% (Table 7).

The distribution of Ternasco is integrated by local companies, which are responsible for the distribution of the meat to more than 1500 points of sale including markets, supermarkets and butchers shops across Spain. The Aragón area itself consumes between 50 and 60% of Ternasco, and neighbouring areas buy between 25% and 35%. Exports account for less than 10% of output. The main importer countries are: France, UK, Belgium and United Arab Emirates (Sierra 2016).

Ternasco de Aragón is expected to have an increasing trend in the next few years. Figure 9 shows that the volume of certified meat has been stable in the last 9 years, although the number of farms is continuously decreasing (Antelo 2016).

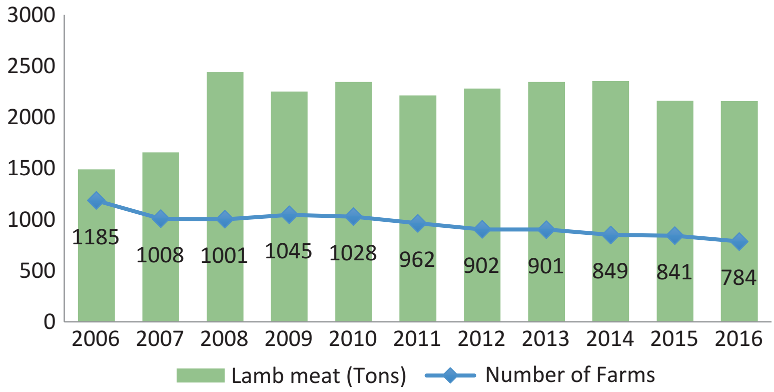

Fig. 9 Evolution of the PGI Ternasco de Aragón (2006–2016). (Source: Own elaboration from data of MAPAMA 2017b)

Governance of the PGI Ternasco

Ternasco de Aragón has a Regulatory Council (*Consejo Regulador*), which is the responsible for guaranteeing lamb quality. It also issues reports, supervises compliance with local, national and European regulations, and certifies each operator involved along the supply chain.

The fundamental requirements for the origin of the product to be certified are:

(a) The meat comes exclusively from the authorized breeds from registered farms, located in the production area. Lambs are identified on their birth farm by way of a numbered ear tag which shows the source of the livestock and the farm code. The ear tag identifies the lamb until slaughter.
(b) Vehicles used for transportation to the abattoir are inspected.
(c) The slaughter and/ or handling of the animals is supervised and checked.
(d) Meat hanging and conservation is carried out on registered and controlled premises.
(e) The final product is subject to tests to guarantee quality.
(f) Once the above procedures are completed the product is sold on the market with the guarantee of its origin, which can be a numbered label, sticker or seal.

This logo (Fig. 10) appears on the labels of Ternasco de Aragón:

In addition, each carcass is stamped with a red TA stamp and a CE stamp to enable consumers to distinguish the product in retail stores. So overall, the product bears numbered labels and seals ensuring traceability and guaranteeing its certification and origin.

Sierra (2016) notes that the Regulatory Council takes part in the Ternasco de Aragón production chain in the following actions:

- Farm - checks at points of interest: birth date of lamb, individual identification (tag), genetic registration and feeding.

Fig. 10 Logo PGI Ternasco de Aragón. (Source: CRTA (2017))

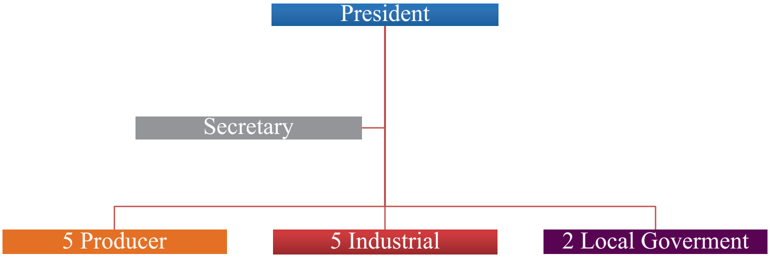

Fig. 11 Structure of the Regulatory Council of PGI Ternasco de Aragón

- Classification Centre - technical visits to monitor the entry date, number, feed and characteristics of the animals.
- Abattoirs - monitoring animal welfare, assessing carcasses as meeting standards ("Pass" or "Fail") and marking the carcass with labels and seals.
- Cutting room - regular inspection visits to supervise product traceability.
- Finally, presence during audits and visits by the Government of Aragón and the National Accreditation Entity (ENAC) to maintain the PGI.

The Regulatory Council is a representative body elected by members the PGI. Figure 11 shows its structure.

All the actors in the value chain of the Ternasco de Aragón are represented in its governing body, the Regulatory Council (CRTA 2017). The secretary is technical expert hired by the consortium, and there are two local government representatives appointed by the Regional Authority of Aragón. The 5 producers and the president are sheep farmers, and the 5 industrial representatives are from slaughterhouses and distribution.

Consumer Perception and Reputation of PGI Ternasco de Aragón

Ternasco de Aragon is a meat product which is identified by 98% of the population in the processing area. It is also widely recognized as nutritious meat and versatile in its preparation due to its softness, juiciness and fat quality (Gracia 2005; Ouhibi and Sayadi 2011).

Consumers perceive Ternasco as a meat with better quality controls, with restricted diet for the lamb, and as a product with identified geographical origins, which guarantees traceability and highlights the organoleptic characteristics of the product (Gracia 2004).

Segregating the consumer sector, it has been found that "habitual consumers" show a willingness to pay price premium between 15 and 20% for the product, while "occasional consumers" accept a premium of 13% compared to the average price of recental lamb (Ulloa and Gil 2007, 2008; Gracia and de Magistris 2013).

Other Actors Involved in PGI Promotion

With the aim of increasing the Ternasco market, the consortium has developed several commercial strategies.

The first is to promote consumption through its webpage. The webpage provides customers with easy access to their nearest distributor and suggests recipes based on Ternasco de Aragon. The Regulatory Council has developed an alliance with the overseas sector through the website, and promotes more than 60 restaurants where numerous Ternasco dishes can be tasted.

Sustainability Diagram Based on Strength2Food Indicators

In this section we present the results of the sustainability assessment of the PGI Ternasco de Aragón. It uses the approach proposed by Bellassen et al. (2016) based on economic, environmental and social indicators, which are reported in Fig. 12, and briefly discussed below.

Economic Indicators

Regarding economic indicators, the price premium is almost constant along the supply chain, with a value around 15%. Upstream and at processing level, the cost structures are similar for the FQS and reference product (lamb from the same region). Profitability (gross value added and gross operating margin) are similar for the two categories of product. A shortage of data means that it is not possible to calculate the net result at these levels of the chain; profitability at upstream level cannot be calculated. Only the reference product is exported, but export accounts for less than other distribution channels. FQS product exports, inside and outside Europe, are very low (0.2%). The reference product is exported mainly to Europe (about 36% by volume), but the value of exports (17%) is lower than other distribution channels.

Moreover, the local multiplier effect of Ternasco de Aragon PGI is 7% higher than its reference product: each euro of turnover for Ternasco de Aragon PGI triggers

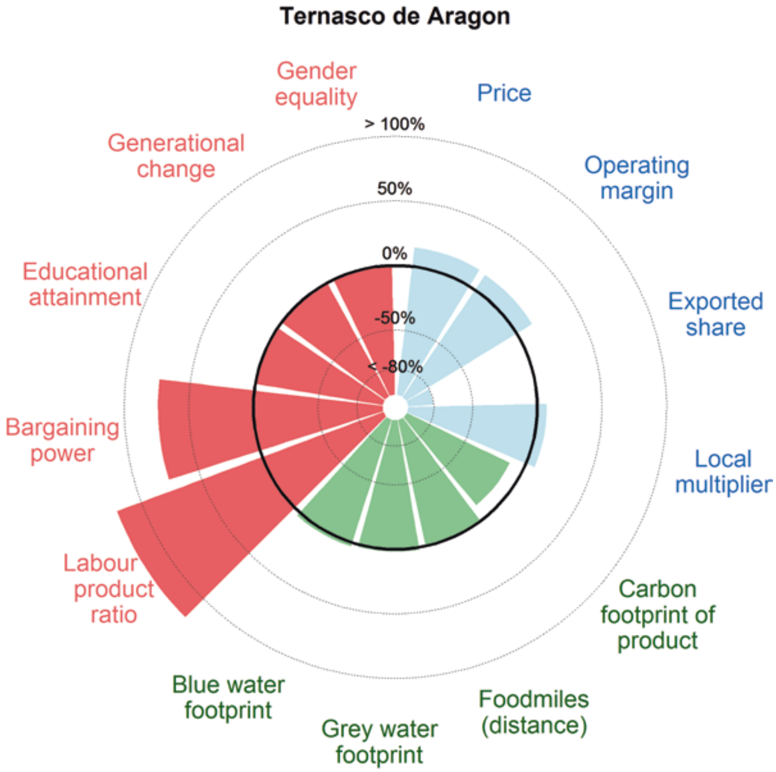

Fig. 12 Sustainability performance of Ternasco de Aragon PGI (supply chain averages). (Each indicator is expressed as the difference between Ternasco de Aragon PGI and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

€1.97 spending in the same region versus €1.77 for the reference product. The main driver of this difference is the location of second tier suppliers: in both cases, without farms located in the region, the local multiplier would be lower by 57%. Furthermore, under the hypothesis that all sheep farm inputs (excluding labor) were purchased outside the local area, the local multiplier reduction for the PGI product would be −13% and for the non-PGI one −11% compared to the current situation.

Environmental Indicaotrs

Turning to environmental indicators, the carbon footprint of Ternasco lamb is 59.3 tCO2e ton-1 of meat, that is 12% higher than its non-PGI reference from the same region. The difference in carbon footprint is mostly due to the lower weight at slaughter of reference lambs. Because lambs eat much less and live much shorter lives than ewes, the carbon footprint of the system is dominated by the "deadweight" of juvenile and reproductive ewes. As a result, a 12.5% lower amount of meat produced per ewe in the FQS translates directly into a higher carbon footprint per ton of meat. Both values are within the 38.9–56.7 tCO2e ton-1 of meat range reported by Ripoll-Bosh et al. (2011) for Spanish lamb.

Concerning food miles, the PGI supply chain was compared to the conventional lamb chain in Aragon, Spain. Over the entire supply chain, from farms to distribution (U3-D1), there is a significant difference between the FQS and its reference product. The FQS product travels half the distance (820 km instead of 1900 km) and releases half the emissions (80 kg CO2 eq instead of 180 kg CO2 eq) than the reference product. The shorter distance embedded in the PGI Aragon lamb can be explained by the much smaller share of PGI exports (0.3% vs 37% for conventional lamb), although export distances are longer for the FQS. Similarly, the lower emissions embedded in the FQS can be explained by the lower emissions resulting from exports. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated along the value chain (i.e. around 75%) for the conventional product, while the burden is more equally distributed among processing (55%) and distribution levels (45%) for the FQS. Regarding food miles indicators, PGI Aragon lamb is more sustainable than its reference product both in terms of distance traveled (−57%) and in terms of emissions released (−55%).

The PGI Ternasco de Aragón shows a higher water footprint for all the components of the indicator, although the differences are not particularly great. This is due to the fact that same data were used for FQS and REF in terms of crops used to feed the animals, crop yield, crop parameters, and amount of fertilizers. The same crop composition also occurs in the diet of the two production systems. The only difference concerns the different efficiency in converting fattening lamb into carcass weight; these values are 0.011 for FQS and 0.012 for REF. The blue water footprint is a sizeable part of the water footprint. Moreover, it is important to note that all the crops in lamb diet require irrigation and that outside farming, the contribution of the breeding and slaughtering phases to the overall water footprint is negligible.

Social Indicators

Finally, looking at social indicators, the labor use ratio indicator, calculated on the basis of output, reflects labor requirements for a unit of physical output. The allocation of labor to production is higher for Ternasco lamb than for its non-PGI reference. At farm level, it takes 409 hours of work to produce one ton of lamb meat, while the reference product requires only 127 hours. The difference (223%) clearly indicates that the PGI product generates more employment than the reference system. The relative difference is of the same order at process level; it takes 11 hours of work to prepare one ton of PGI-lamb meat against 3 hours for the non-PGI lamb meat. The turnover-to-labor ratio indicator provides an insight into labor productivity. The average turnover per employee is 66% lower on PGI farms than on non-PGI ones. Productivity levels are much higher at processing level, but the relative difference between the PGI-product and the non-PGI one is of the same order as at the farm level. These differences are mostly due to the technical specifications and strict controls on the PGI product.

Both Putnam (2000) and Halpern (1999) identify education as a key to the creation of social capital, and greater educational achievement as an important outcome. The education attainment indicator, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. Data from Casa de Ganaderos, a cooperative of approximately 270 sheep farmers, shows that there is no difference in education levels between producers of Ternasco lamb and producers for the conventional sector, given that most farmers raise both PGI and non-PGI lambs. The most frequent attainment level is primary (40%) or secondary (28%) education. At the process level, the educational attainment level indicator is higher: 47% employees have a secondary education or middle school diploma and 38% have degree or equivalent which entails 3 or 4 years study after high school.

The supply chain is very concentrated upstream (the leading cooperative's market share at U3 level is higher than 50%) as well as downstream (the leading firm's market share at P1 level is higher than 50%). This implies that the supply chain is dominated by two actors, one for each level, thus preventing any firm conclusion about the dominating level. There should however be fair distribution of bargaining power between the two levels. Furthermore, bargaining power upstream, which is the weakest level, remains strong (value 0.75). This implies that bargaining power distribution would be likely to evolve significantly to the benefit of U3 level if there were greater competition at P1 level, if, for example, a new competitor entered at that level.

It is noteworthy that the values of the indicators are the same for the two products for every stage of the supply chains. This may well be because breeders and processors work for both the FQS and reference products. Further findings relating to social indicators are as follows:

- At the farm stage, both types of Ternasco are largely unsustainable, according to the Generational Change indicator. There is very limited employment of young workers, compared to older ones
- Similar levels of social unsustainability appear at the farm stage of both supply chains in the calculation of the Gender Inequality indicator. The high level of the Gender Inequality indicator reflects the very low level of female participation in farm entrepreneurship and employment.
- Levels of social unsustainability for both supply chains for the processing stage are also higher than farm ones. This is due to a lower value of the Generational Change indicator and a higher one of the Gender Inequality. The further increase in the Gender Inequality indicator shows that entrepreneurship at the meat pro-

cessing stage is still dominated by men, but differences in gender-based employment levels are smaller than at the farm stage.

– As a whole, the supply chains for the FSQ and reference products both appear to be under threat in their prospects for social sustainability according to both indicators.

Conclusions

PGI Ternasco de Aragón is a quality product linked to a geographical origin. The PGI designation protects the historical and cultural value of lamb in the community of Aragón, and generates income directly for the actors involved in the chain, as well as indirectly, for operators in the tourism and restaurant sectors in particular.

Despite the downturn registered by the sheep sector in the number of farms and heads of sheep in Spain, certified production of lamb has been maintained. It is consumed and preferred by regular consumers, which guarantees the continuity of an agri-food system based on reputation of the product and its relative sustainability.

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PGI Mallorca Sausage in Spain

Hugo Ferrer-Pérez, O. Guadarrama, and José Maria Gil

Characteristics of the PGI Sobrasada

Introduction

The pig sector is one of the major production sectors in Spain. In 2015, the pig sector accounted for 35.6% of livestock production and 13% of agricultural final production (MAPAMA 2017a). Its importance is also linked to the national gastronomic heritage; pork has been a key element in the Spanish diet for centuries (Castro and Cort 2013; Mercasa 2016). Spain is the third largest pig exporter in the world, after China and USA, and in 2015, it became the top European Union exporter, ahead of Germany and Denmark (Food and Water Europe 2017).

The vertical integration and low production costs have allowed the Spanish pork industry to grow, but the panorama is currently undergoing change for two main reasons. The first is the number of pig farms is falling as the average number of heads in each farm rises. The second reason is that the current trend is to replace traditional breeds by the "industrial" breeds, or pigs with high levels of daily weight gain (Food and Water Europe 2017).

H. Ferrer-Pérez · O. Guadarrama · J. M. Gil (✉)
CREDA-UPC-IRTA, Barcelona, Spain
e-mail: chema.gil@upc.edu; hugo.ferrerperez@ceu.es

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The Porc Negre from Mallorca

The Porc Negre (PN) or 'black pig' breed played an important social and economic role until the 1960s, and then declined with the introduction of the intensive production systems and foreign breeds (Jaume and Alfonso 2000; Jaume 2007; Molina Alcalá 2009).

The Porc Negre is a native Mallorca breed which is rustic and adapted to Mediterranean climatic conditions (Jaume et al. 2006). It is difficult to trace the origin of the breed but pig livestock and pork consumption in Mallorca date from the period of the first settlers, approximately by 3500 BC (Fernandez Miranda 1985). The PN is the outcome of breeding carried out by various civilizations which have inhabited the island, except for Muslims, together with the adaptation of the breed to the territory subject to natural and human selection pressure (Gonzalez et al. 2013; Jaume and Alfonso 2000; Torrens 1947).

The distinctive aspect of the PN lies in its characteristics: black or dark grey skin; concave nose profile; tassels at the neck base; and large and pendulous ears (Fig. 1) (Anguera Sansó 2007; Jaume and Alfonso 2000).

As for the production system, the Porc Negre is managed in extensive or semi-extensive conditions (between 10 and 25 pigs/ha, in farms with more than 25 ha) often as a complementary activity on family farms - 83% of the farms can be classified as family farms. The feeding regime is based on rotational crops within the farm, mainly barley and legume seeds. Pigs also eat figs, almonds, acorns and Mediterranean shrubs present in the typical PN plots (Gonzalez et al. 2013; Jaume and Alfonso 2000; Jaume et al. 2008; Köhler-Rollefson 2001).

The low productive parameters of the PN are similar to other native breeds. They have 2.1 litters per sow per year, the average number of piglets weaned per sow per

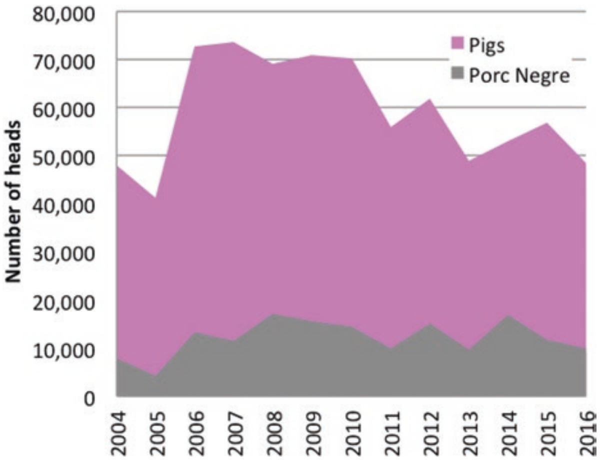

Fig. 1 Swine production in Mallorca. (Source: Authors' elaboration with data extracted from GOIB 2017; MAPAMA 2017b)

year is 12.0 and the lactation period lasts four weeks. They show an average daily gain between 400 and 550 gr/day and conversion rates between 5.0 and 8.0 during fattening. Despite its lower productive performance compared to conventional breeds, the PN has adapted to the environment throughout its history. The ability to take advantage of poor nutritious resources makes their productive parameters acceptable (Gonzalez et al. 2013; Jaume et al. 2012; Varela et al. 2017).

The production of the PN is at a clear disadvantage against overall pig production in Mallorca as can be seen in Fig. 1. This is mainly for economic reasons, as the cost-benefit ratio in the production of foreign pigs is more attractive to the farmer than that of the Porc Negre.

Despite this, in 1997, the national government and local authorities started a conservation program aiming to design strategies and breeding programs to minimize inbreeding effects and maintain the genetic variability and the most representative phenotypic traits. The program generated a slow recovery of the sector, and maintained constant the number of farms and animals certified for reproductive purposes and conservation of the breed, as indicated in the Porc Negre's Herd Book (Gonzalez et al. 2013; Jaume and Alfonso 2000; Temple et al. 2012).

Characterization of the Carcass of the Majorcan Porc Negre

The carcass of the PN is characterized by a high killing-out (dressing) rate (Table 1). The pH is between 5.39 and 5.78. Main cuts such as loin, tenderloin, shoulder and ham make up less than 20% (Fig. 2) of total carcass weight and fat makes up more than 43% of total carcass weight (Bouche et al. 2012; Frau 2012; Jaume et al. 2008).

Finally, the main meat product produced from Majorcan Porc Negre is piglet, "porcella", which is eaten roasted or as a confit on special occasions (CAIB 2015). The second most important product is the Sobrasada de Mallorca de Porc Negre, a spreadable dry cured sausage made using only meat (approximately 60%) and subcutaneous fat (approximately 40%) from purebred animals (Gonzalez et al. 2013).

Table 1 Characteristics of Majorcan Porc Negre

Concept	Value
Live weight	152.4 kg
Carcass weight	114.6 kg
Killing-out rate	80.1%
Flare fat	6.2 kg
Carcass length	81.8 cm

Source: Bouche et al. (2012)

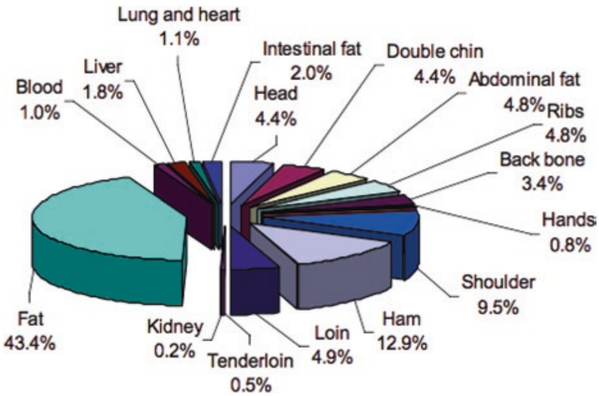

Fig. 2 Distribution of the carcass cuts in Porc Negre of Mallorca. (Source: Jaume et al. (2008))

Description of the PGI Sobrasada

In 1994, the government of Spain awarded the Protected Geographical Indication to Sobrasada de Mallorca, a by-product made exclusively in the Balearic archipelago. This denomination protects a product but also a food heritage link to pork production and traditional know-how.

Historical Background

Preserving meat by curing whole pieces of PN on the island was difficult because of the interaction of temperature and humidity. This is probably the main reason why raw cured sausage is made in Malorca rather than ham or chorizos as in mainland Spain (Bestard et al. 2003).

Some authors attribute the origin of the Sobrasada to the Romans, who introduced it to Mallorca during their occupation (CR-IGP-SM and Govern de les Illes Balears 2016). Production techniques and recipe were improved continuously over the centuries, and new ingredients that increased shelf life and flavour were added.

The sobrasada is a raw cured sausage made from chopped pork (lean meat and white fat), paprika, salt and spices, which is kneaded, embedded and cured. There are two types of sobrasada according to breed of pig: Sobrasada de Mallorca, which is made with pork from all breeds and Sobrasada de Mallorca de Porc Negre, which is made exclusively with Porc Negre, the autochthonous breed, bred and fattened in Mallorca (GOIB 2014; MAPA 1996).

During the last decade, several measures have been taken to promote the consumption of Sobrasada by enhancing its cultural identity in the perception of island inhabitants. One of the most effective actions was carried out jointly by local authorities, processing firms, schools and the Consortium, and involved the publication of information leaflets for schools trying to raise levels of identification with the main food products of Majorca. The leaflets explain the origin of the Sobrasada and how it is made. The idea is to create a cohort effect that will guarantee the consumption of sobrasada in the future (CR-IGP-SM and Govern de les Illes Balears 2016). Another initiative was a book of recipes, supported by the Government of the Balearic Islands, in which 6 quality products interact with 6 renowned chefs. The aim was to show the versatility of this type of food for cooking (Luisa and León 2007).

Finally, several studies have been undertaken to highlight the sustainable benefits of the Porc Negre breeding system. These include the positive environmental impact of the feeding system; the quality of the meat from the Porc Negre breed compared to other breeds in terms of fat acid content; and the market potential for both traditional and innovative food products generated from this breed (CAIB 2015; Gianelli et al. 2011, 2012; Jaume et al. 2012; Martínez et al. 2014; Roselloó et al. 1995; Seguí et al. 2008).

Physical and Chemical Characteristics of the Sobrasada de Mallorca

The interaction of the ingredients of the Sobrasada gives the unique physical and chemical characteristics of the final product as shown in Table 2.

Table 2 Physical and Chemical composition of Sobrasada and Sobrasada Porc Negre

Characteristics	Sobrasada de Mallorca	Sobrasada de Mallorca PN
Shape	Irregular cylindrical, determined by inner morphology	
External appearance	The surface has a dark red colour, smooth or slightly rough, with no whitish mould or mildew	
Pasta	White, inelastic, adherent, cohesive, unctuous not very fibrous and marbled red appearance.	
Humidity	35% max	30% max
Fat	85% max	80% max
Protein	8% min	13% min
Carbohydrates (glucose)	2.5% max	
pH	From 4.5 to 5.2	
Activity Water (AW)	Between 0.91 and 0.95	
Moisture	24.6 approx.	20.8 approx.
NaCl	4.9 approx.	4.8 approx.
Ash	6.7 approx.	6.3 approx.
Nitrate	12.6 approx.	13.5 approx.

Source: Gianelli et al. (2012); MAPA (1996); Seguí et al. (2008)

Geographical Area of PGI Sobrasada

The Balearic Islands (BI) are a Spanish archipelago located to the west of the Iberian Peninsula in the Mediterranean Sea (Fig. 3). They comprise four larger islands, Majorca, Menorca, Ibiza and Formentera, and there are also many other minor islands and islets, including Cabrera, Dragonera and S'Espalmador. This archipelago is one of the most popular tourist destinations in Europe and boasts a Mediterranean climate (Balears 2017; Castro and Cort 2013; Consejería de Trabajo Comercio e Industria 2016).

Agriculture and Livestock

The BI economy is based more on agricultural production than on livestock, except for Menorca, where livestock production plays an important role (Fig. 4), due to the different geographic features of each island, agricultural and pasture lands, water availability, and historical production systems (GOIB 2016).

In 2015, 45% of total BI land area was given over to agriculture, and 34% was given over to woody crops, mostly almond trees, carob trees, olive groves, and vineyards. In livestock production, the beef cattle sector is the most important (in both dairy and meat production) with 13,489 heads, followed by the ovine cattle (219,594 heads) and pig farming (14,584 heads), both oriented to meat production. Finally, the goat sector (10,203 heads) oriented to both dairy (cheese) and meat production (Fig. 5) (Castro and Cort 2013; GOIB 2016). The Spanish Ministry of Agriculture

Fig. 3 Geographical area of PGI "Sobrasada" production. (source: www.ine.es)

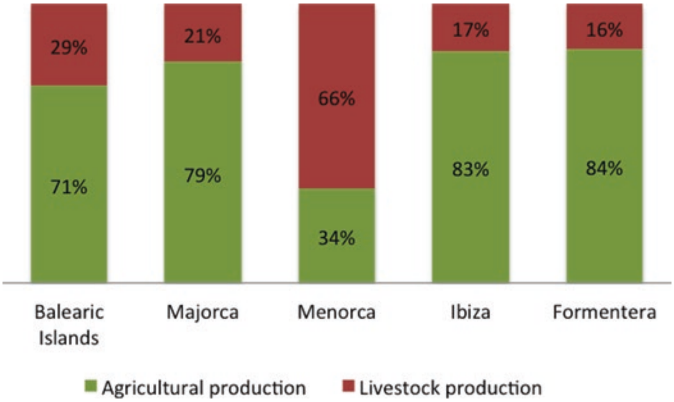

Fig. 4 Distribution of the production value by sector and island. (Source: GOIB (2016))

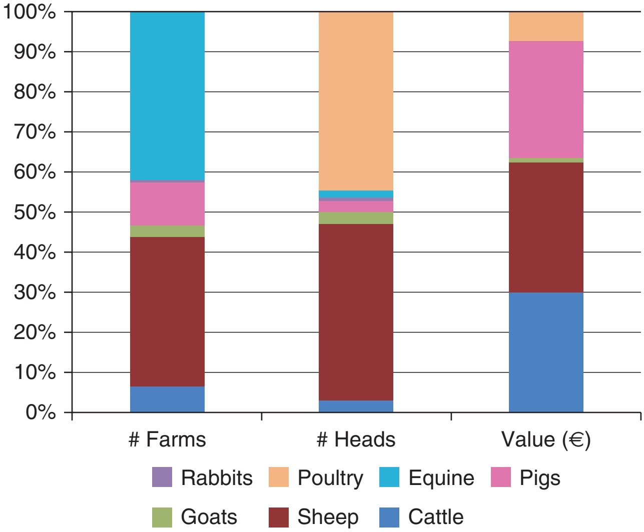

Fig. 5 Balearic Islands livestock sector. (Source: GOIB (2016))

reported in 2015 that the BI had 8756 farms, most of them with a mixed system production, with a total of 490,670 heads, and a total net farm income accounted for €28,215,861. The beef, sheep and pig sectors were the most productive (MAPAMA 2017a; Mercasa 2016; Quetglas Olivier 2016).

In the BI, livestock production is either for self-consumption (animals meet owners' needs) or for meat and by-products (mainly milk and eggs). In both cases, the livestock sector generates complementary revenues for Balearic farms (Castro and Cort 2013; Consejería de Trabajo Comercio e Industria 2016; Quetglas Olivier 2016).

Agricultural production is affected by the orography, or mountain features, of the island. Mallorca has two mountain chains; "Sierra of Tramontana" in the north, and "Sierra of Levante" in the south, and there is the plateau of "La Pla" in the middle of the island (Fig. 6). The plateau is used for crops and livestock production takes place in the mountain areas (Castro and Cort 2013; Consejería de Trabajo Comercio e Industria 2016).

Currently, sheeps, pigs and beef cattle account for more than 90% of the Majorcan farm income, although 80% of the farms are given over to sheep and horse production. Although beef cattle and sheep account for the largest numbers of heads and farms in Majorcan livestock production, the pig sector is the oldest traditional livestock system in the island, and the black pig (Porc Negre) plays a key role (Fig. 7).

The Majorcan pig industry is dominated by two types of production: piglets and pig meat sales (Fig. 8). This entails two different breeding systems. In the first system, females are more valuable in producing young, and piglets are sold 2–3 months after birth. In the second system, males are more valuable as they gin more weight useful for producing fresh meat and meat products (Food and Water Europe 2017; Jaume et al. 2008; Molina Alcalá 2009).

Technical Process of "Sobrasada" Production

According to the specification of the PGI Sobrasada de Mallorca (Table 3), four groups of ingredients are basic to production of Sobrasada (Table 4):

Fig. 6 Orography of Mallorca. (Source: www.ibestat.caib.es)

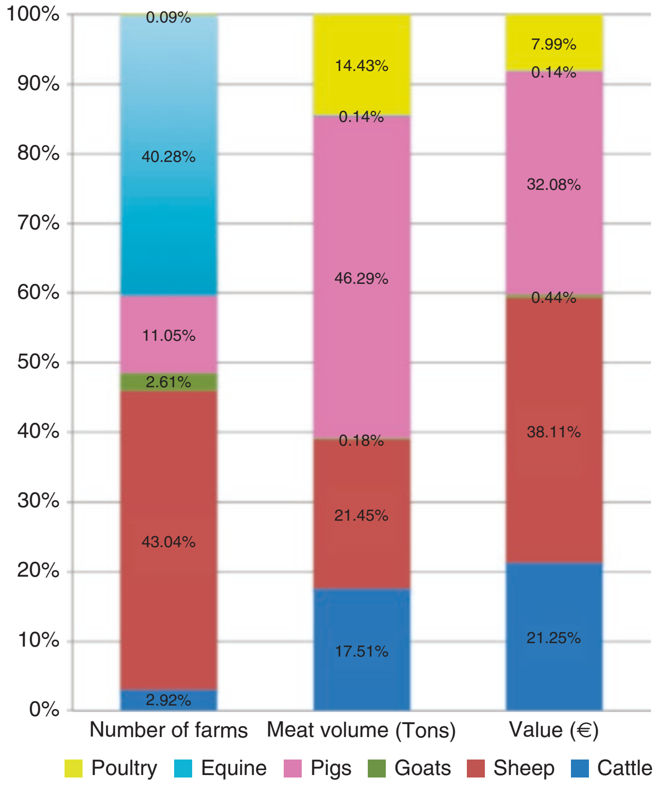

Fig. 7 Majorcan livestock production. (Source: GOIB (2016))

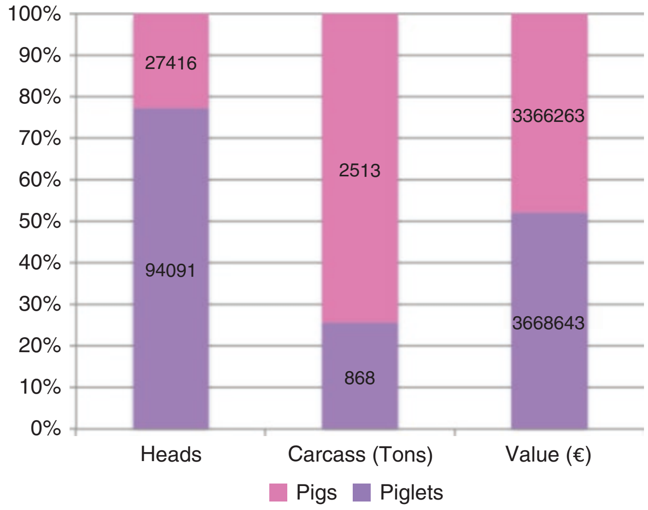

Fig. 8 The swine sector in Mallorca. (Source: GOIB (2016))

Table 3 Summary of the technical specifications

Territory	Spain
Geographical area	Balearic Islands (see map Figure?)
Varieties/breeds	Majorcan Porc Negre.
Animal management	Extensive or semi-extensive conditions

Table 4 Ingredients permitted in the Sobrasada de Mallorca PGI

Ingredients	Ratio
Pork meat	
Lean meat	30–70%
Bacon	40–75%
Paprika	4–7%
Salt	1.8–2.8%
Herbs and spices (Pepper, rosemary, thyme, oregano)	Free use

Source: MAPA (1996)

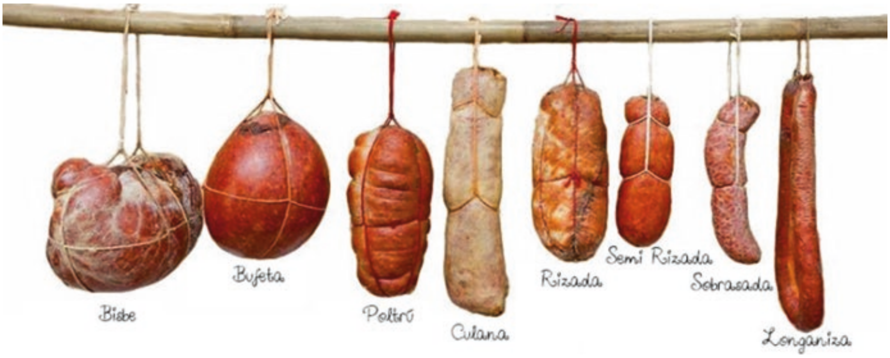

Fig. 9 Forms of the Sobrasada de Mallorca PGI. (Source: Revista +Mallorca, www.masmallorca.es)

The manufacturing process of the Sobrasada de Mallorca involves 3 stages:

- Grinding. Ingredients are ground until particles are less than 6 mm in diameter.
- Mixing. The ground meat is mixed with salt and herbs and spices to obtain a homogeneous paste.
- Stuffing and curing. The paste is stuffed into natural or artificial innards with different forms and names. These are dried to achieve the necessary AW level, and the curing process starts. During its dry-cure process, the Sobrasada of Mallorca develops different volatile compounds, with smell and taste identifiable by the final consumer as its unique sensory characteristics (Gianelli et al. 2012) (Fig. 9).

Since 2014, all shapes of sausage have been permitted for both Sobrasada de Mallorca and Sobrasada de Mallorca de Porc Negre (Fig. 10). The Sobrasada de Mallorca of Porc Negre traditionally appeared in a sobrasada form, but today can also appear in a terrine and in slices (CR-IGP-SM 2017).

Fig. 10 Official logos for Sobrasada de Mallorca. (Source: Official website of the Consortium of Sobrasada de Mallorca (www.sobrasadademallorca.es))

The PGI Certification of the Sobrasada of Mallorca

Only the firms registered in the PGI Sobrasada de Mallorca can produce both types of sobrasada, Sobrasada de Mallorca and Sobrasada de Mallorca de Porc Negre. In order to guarantee the traceability and origin of the sobrasada, it is compulsory that each sobrasada presents a label, which denotes Sobrasada de Mallorca, the number of the enterprise, and the logo of the Consortium.

The type of Sobrasada de Mallorca can be identified by a logo, as shown in Fig. 10. The left-hand side logo indicates the PGI Sobrasada de Mallorca, and the right-hand side logo indicates the PGI Sobrasada de Mallorca de Porc Negre.

Sobrasada Value Chain

The PGI Sobrasada de Mallorca de Porc Negre is the result of a process which integrates various actors at farm and processing levels in a circumscribed territory together with the historical, cultural and gastronomic identity of Majorcan society. The value chain of the PGI Sobrasada de Mallorca de Porc Negre is shown in Fig. 11.

Upstream Level

The upstream level comprises piglet production and pig fattening carried out on Majorcan farms. Piglet production takes place in those farms enrolled in the Herd Book (Genealogical register), created by the Associació de Ramaders de Porc Negre Mallorquí Selecte, under National Law 2129/2008, which protects the Porc Negre as a native breed in Mallorca (Baleares 2008; MAPA 1996). The piglets born on a farm or bought from a hatchery farm are fattened with crops grown on the same farm, mainly cereals and legumes, or with natural pasture, shrubbery or wild trees (Gonzalez et al. 2013; Jaume et al. 2008; MAPA 1996).

The number of farms farming this breed has grown (Table 5) over the past 20 years. The 1997 national and regional conservation plan, together with the above

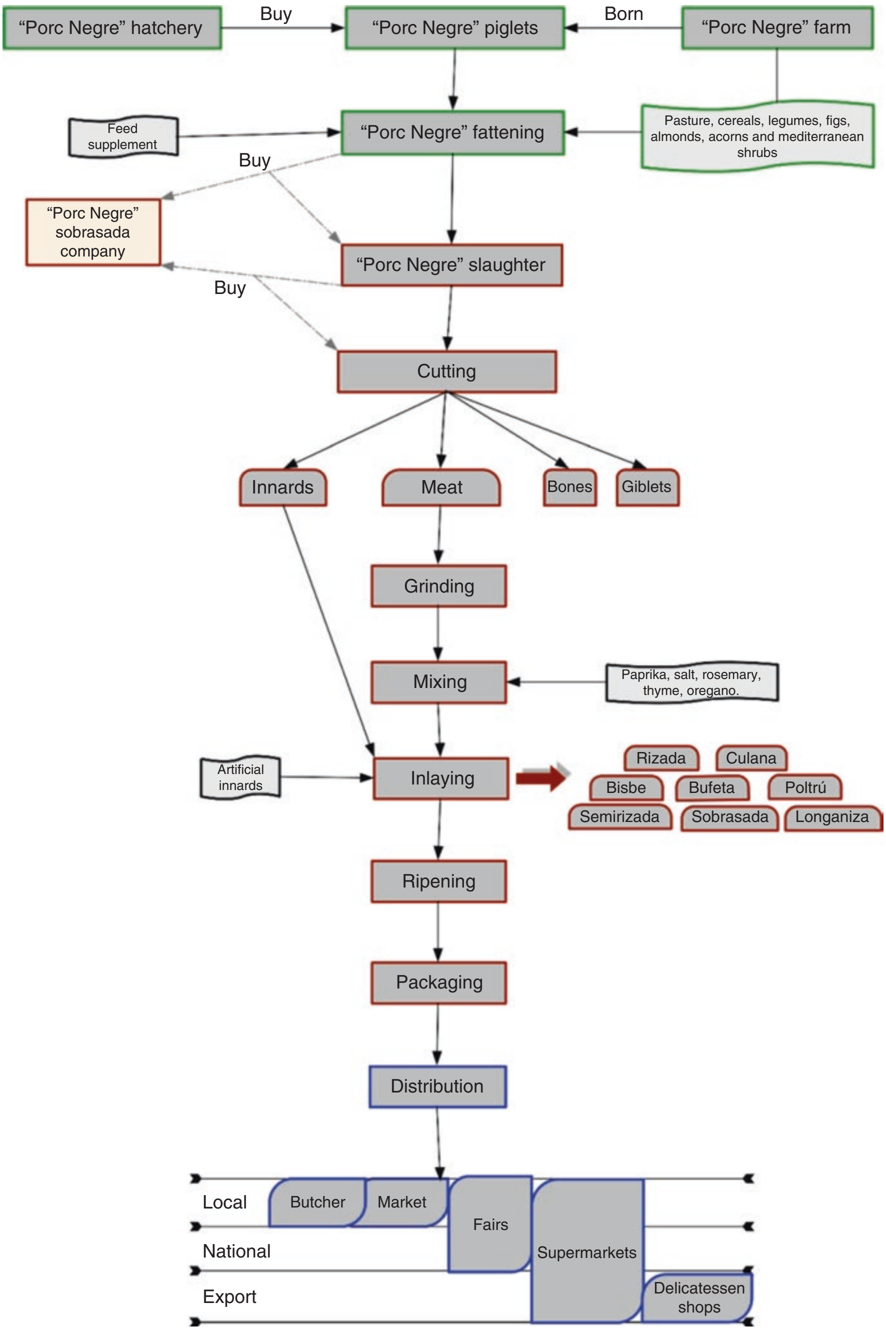

Fig. 11 Sobrasada value chain

Table 5 Evolution of the farms and Porc Negre production

	1998	2000	2002	2004	2006	2008	2009	2010	2011	2012	2013	2014	2015	2016
No. of farms	30	50	85	91	68	65	64	60	60	59	63	59	59	55
Total Porc Negre	447	730	908	1011	1432	1263	1925	1217	1208	1116	1312	1105	1134	1077
Male	38	74	91	113	100	91	233	83	82	73	75	68	79	54
Female	409	656	817	898	1332	1172	1692	1134	1126	1043	1237	1037	1055	1023

Source: (España 2015; GOIB 2017)

mentioned law, has strengthened the historical links of the Porc Negre with Mallorca and its gastronomic traditions, reflected with products such as the sobrasada and porcella (Bestard et al. 2003; Jaume et al. 2008). Moreover, the contractual scheme is based on long-term contracts and the rise of the Porc Negre has contributed to preserving the landscape as a complementary activity to agriculture (Gonzalez et al. 2013; Jaume et al. 2008; MAPA 1996) .

Processing Level

The processing level comprises both slaughterhouses and Sobrasada manufacturing companies. Once the fattened pig reaches a weight of about 150 kilograms, the production process starts. There are two production lines. The first one is where after slaughter the carcass is processed in the same processing factory. In the second, the sobrasada is produced by an independent manufacturer. In this case, there are two potential marketing channels. In the first one, the farmer sells the live animal to the sobrasada company, which slaughters the animal and produces sobrasada. In the second, there is another intermediary, as the farmer sells the animal to the slaughterhouse and then this company sells the carcass to the sobrasada company.

In Majorca there are three slaughterhouses, two owned by municipalities and one by a farmers' cooperative, which offers the service to cooperative members and also to other farmers on payment of a fee (Agrupats 2017; CR-IGP-SM 2017).

In 2016, there were 17 sobrasada processing firms in Mallorca. Nine of these, one cooperative and eight belonging to local butchers, are included in the PGI Sobrasada de Mallorca and produce Sobrasada de Porc Negre with a total production of 105.2 tons (Fig. 12). The sobrasada processing industries produce both Sobrasada de Majorca and Sobrasada de Porc Negre. Sobrasada de Porc Negre however is relatively less important as the stricter regulations make it economically less attractive. Figure 12 shows that the number of industries has decreased in the last years, but the percentage of industries producing Sobrasada de Porc Negre has remained constant during the last two decades. As noted above, contractualisation is mainly based on long-term contracts.

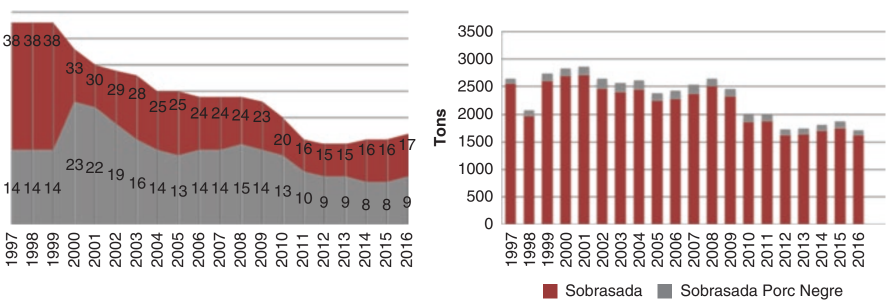

Fig. 12 Evolution of production and industries registered for the PGI Sobrasada de Mallorca

The production costs of Sobrasada de Mallorca and Sobrasada de Porc Negre are different. Costs for the PGI Sobrasada de Mallorca of Porc Negre are higher because the prices of raw materials are higher, because farming Porc Negre is much more expensive than farming other pig breeds.

Moreover, the PGI Sobrasada de Porc Negre is exclusively produced with Porc Negre pigs, and the entire carcass is used for this purpose. For the PGI Sobrasada de Mallorca, any other pig breed can be used, animals can be imported from other regions, and only the cheapest parts of the carcass are used. This is reflected in end prices; current prices are between €12–16 /kg for PGI Sobrasada de Mallorca of Porc Negre but only €4–8 /kg for PGI Sobrasada de Mallorca (Govern de les Illes Balears 2017).

Figure 13 summarizes the first two stages of the value chain, showing the distribution of Porc Negre farms, slaughterhouses and manufacturing companies in Mallorca.

The farms are located on the fertile plain and the mountain chain of Levante, covering the central and south area of Mallorca. The slaughterhouses are located in

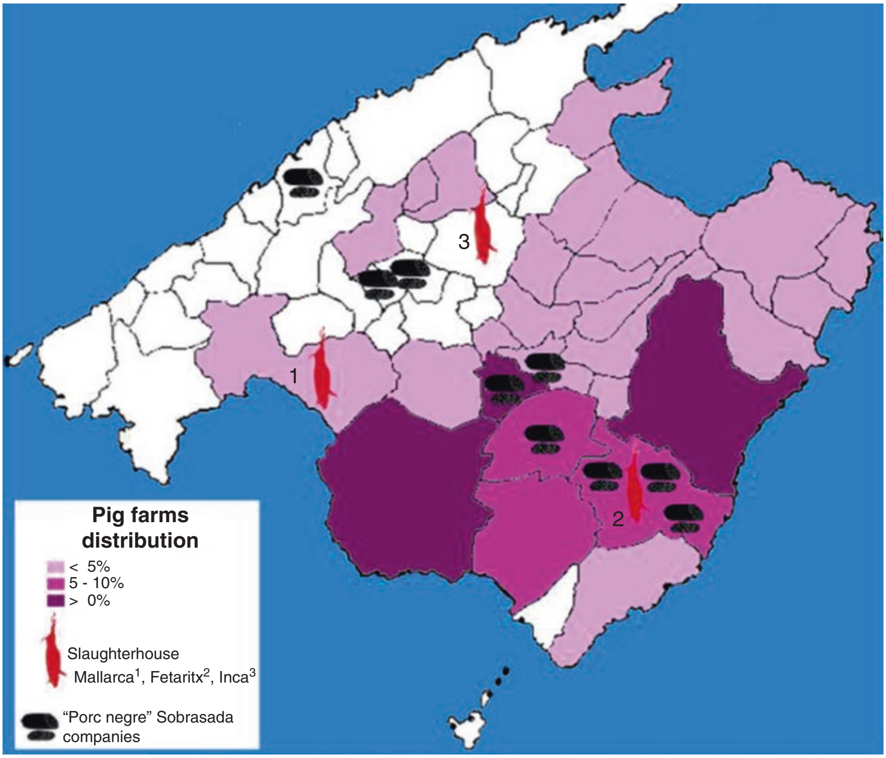

Fig. 13 Location of the farms, slaughterhouses and enterprises for Sobrasada Porc Negre. (Source: Authors' elaboration with data from (CR-IGP-SM 2017; GOIB 2016; Govern de les Illes Balears 2017))

Table 6 Firms producing Sobrasada de Mallorca de Porc Negre in 2016

Municipality	Company' name	Municipality	Company' name
Binissalem	Productos Cárnicos PROCAM, S.A.	Montuiri	Embotits Fiol
Consell	Crisol	Porreres	Embutidos Munar, S.L.
Felanitx	Can Manxa	Sant Joan	Embotits Sa Caldera, S.L.
	El Zagal Tradició		
	Ramaders Agrupats, S.A.T.	Soller	La Luna

Source: CR-IGP-SM (2017)

the three major municipalities, Palma de Mallorca, Felanitx and Inca. The manufacturing industries are concentrated in 7 municipalities as indicated in Source: CR-IGP-SM (2017) (Table 6).

Downstream Level

The Sobrasada de Mallorca de Porc Negre is basically a product of proximity, mostly commercialized in the Balearic Islands and Spain, which consumes almost 90% of the total production (Fig. 14).

In retailing, there are different marketing channels, but butchers' belonging to sobrasada processing firms are the most common. The second most important channel is selling directly from processing firms to national and international supermarket chains and the food service sector. Exports have risen in the last few years, which is a positive sign for the future viability of Sobrasada. The third marketing channel, and the least important, is through delicatessen or gourmet shops.

To sum up, the value chain of Sobrasada de Mallorca de Porc Negre consists of 3 levels: (1) hatchery and fattening farms; (2) slaughterhouses and Sobrasada processing companies; and (3) the retail and food service levels. In addition, there are also suppliers of feed to farmers and of other raw materials to processors (salt, spices, and packaging).

In terms of ownership, there are companies that operate independently at each level of the supply chains: breeding farms, fattening farms, breeding rooms, Sobrasada processing companies, etc. There are also however examples of vertical integration and horizontal concentration. There is horizontal concentration at farm level with a significant presence of cooperatives. Vertical integration exists mainly between farmers and processors and between processors and retail butchers.

The association of Farmers of Mallorca (Ramaders Agroupats) integrates the three levels. It is a cooperative formed by more of 50 farmers (not only in the Porc Negre sector), which has a slaughterhouse for use by all members and also provides services to non-members. The meat is transformed by a sobrasada company, which makes not only both types of Sobrasada (Sobrasada de Mallorca and Sobrasada de Mallorca de Porc Negre) but also different pork by-products as well as supplying fresh pork meat. The cooperative sells through its own butcheries all over the island, using a fleet of three trucks, and in Spain and Europe, thanks to an agreement with

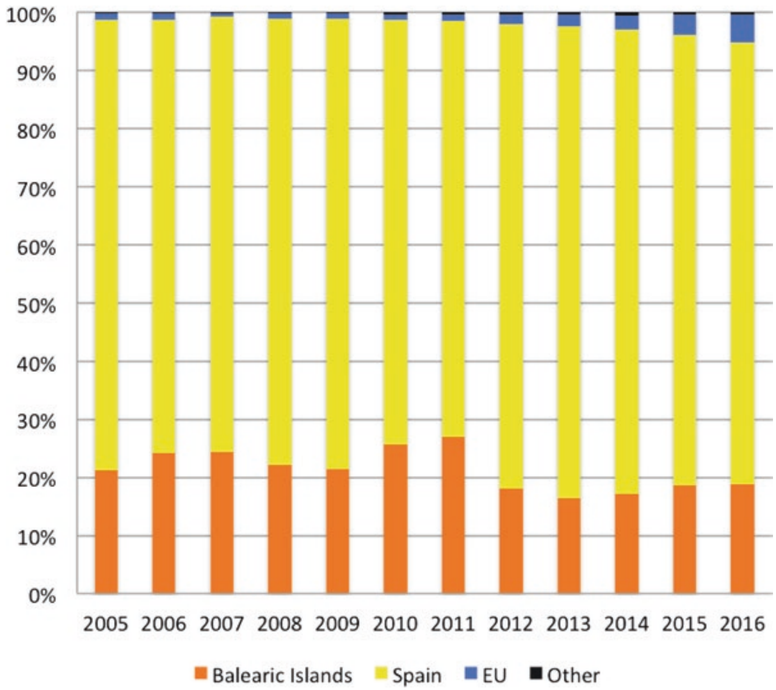

Fig. 14 Commercialization of Sobrasada de Mallorca. (Source: GOIB (2017); Govern de les Illes Balears (2017); Vera et al. (2010))

one of the largest supermarkets in Spain (Agrupats 2017). Finally, over the last few years, environmental farming has developed within the PGI and three organic farms and one processing company have been registered in the attempt to meet increasing demand for organic Sobrasada de Porc Negre (GOIB 2016, 2017).

Governance of the PGI Sobrasada

Governance takes place in two phases along the value chain. The first step is by the Porc Negre Producers Association, which manages the Herd Book, and the second is by the Consortium of Sobrasada de Mallorca.

Certification of the Porc Negre

Two supervisory measures were implemented under the Majorcan Porc Negre improvement program (Baleares 2008):

- A pig 'birth certificate', which certifies that the piglets' parents and grandparents were registered in the Herd Book, and reports the morphological characteristics of the breed. This document helps to preserve the purity of the breed.
- A code number. All pigs must wear a code number in a plastic ear tag, for the purposes of traceability.

Under Consortium regulations, only those pigs that come from breeding animals registered in the Genealogical register (Herd Book) can be used for Sobrasada de Mallorca de Porc Negre. These animals are identified with a tag that incorporates a microchip, and each development they undergo is recorded in the book. Male pigs intended for Sobrasada de Mallorca must be castrated before 120 days and slaughtered with 12 months, at a live weight between 120 and 160 kg (CR-IGP-SM 2017).

The Consortium of the Sobrasada de Mallorca

Different supervisory checks are made during the process of making and curing Sobrasada, mainly for purposes of traceability of inputs and national and European health and safety requirements. The Consortium approves the use of labels that guarantee the sanitary and organoleptic quality of the product following the PGI Specifications for sale. Each Sobrasada is given the company's label and the Consortium label showing the registration number of the company with the Consortium, and that the product is Sobrasada de Mallorca de Porc Negre. The consortium comprises a president, a vice president, 6 representatives of sobrasada producers and 2 technical assistants with a good knowledge of the meat industry. They are responsible for managing the PGI and its compliance with norms as well as national and European regulations (CR-IGP-SM 2017).

Sustainability Diagram Based on Strength2Food Indicators

The sustainability diagram in Fig. 15 is based on comparison of economic, environment and social indicators for a PGI product. PGI Sobrasada de Mallorca of Porc Negre (FQS product) is compared to the PGI Sobrasada de Mallorca (REF product).

Economic Issues

Looking at economic indicators, the **price premium** is 78% at the upstream level and 125% at processing level for the FQS product. At the both levels, the cost of intermediate consumption is very high compared with the turnover, giving both

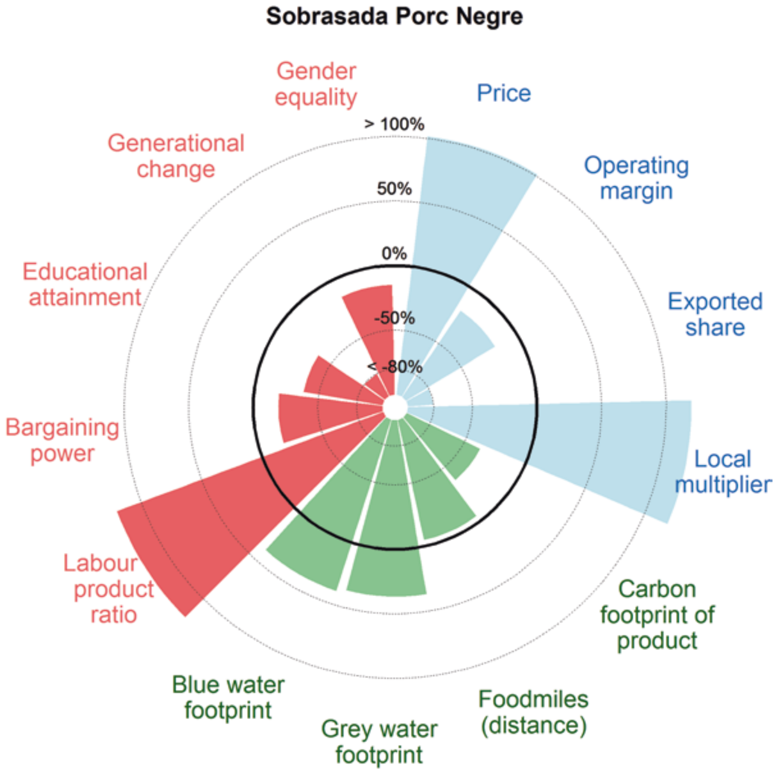

Fig. 15 Sustainability performance of PGI Sobrasada (supply chain averages). (Each indicator is expressed as the difference between PGI Sobrasada and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

products weak profitability. However, gross value added and gross operating margins are similar for the two categories of product. Overall, however, the FQS product is less profitable than the reference one. The main reason is the structure of smallholder farms, where as noted above, farmers tend to keep Porc Negre as a complementary activity with the main objective being to maintain the Porc Negre breed rather than making higher profits.

The **local multiplier** effect of Sobrasada de Mallorca PGI is more than double that of its reference product: each euro of turnover for Sobrasada de Mallorca PGI triggers 1.81 € of re-spending in the same region versus 1.28 € for the reference. The main driver of this difference is the location of the first and second tier suppliers. If the local supplier pattern were used for the reference product, the local multiplier would increase to 2.25. And if farms were not located in the region, the local multipier for the PGI product would fall by 28%. Furthermore, under the hypothesis that all the pig farm's inputs (excluding labour) are purchased outside the local area, the local multiplier reduction for the PGI product would be −31% and for the non-PGI one −4% compared to the current situation.

Environmental Issues

In environmental indicators, the **carbon footprint** (excluding transport) of PDO sausage is 44% higher than its reference. This is mostly due to the characteristics of the Porc Negre breed, where sows produce less than half the number of piglets that reference sows do and whose fattening pigs live around three times longer than reference pigs before slaughter. Despite the lower carbon intensity of fodder in the PDO, PDO pigs need about three times as much of it per ton of sausage. Similarly, as pigs spend most of their time outside, the manure management system emits less per ton of manure in the PDO, but longer lifetime and larger intake generate much more manure per ton of sausage. Our estimate for fresh meat – 4.4 and 3.1 tCO2e t of fresh meat-1 for the PDO and the reference respectively – is within the literature range of 2 to 11.9 tCO2e ton-1 pork meat (Clune et al. 2017; Lesschen et al. 2011; Meier et al. 2015).

For **food miles**, the PGI Sobrasada de Mallorca de Porc Negre supply chain was compared to the PGI Sobrasada de Mallorca chain, from U3 to D1, although no data were available for the reference product at processing levels. Over the entire supply chain, from farms raising pigs to distribution units (U3-D1), FQS sobrasada travels 5% longer distances (410 t.km vs 400 t.km) and releases 1% more emissions (71 vs 70 kg CO2 eq) than reference sobrasada. This difference is mainly driven by exports, and also by the transformation product ratio. In fact, a higher percentage of FQS sobrasada is exported than reference sobrasada (6.5% vs 5.4%), which drives distances and emissions up. On the other hand, fewer pigs are needed to produce a unit of FQS final product, which drives distances and emissions down. The exports effect is slightly stronger than the transformation ratio effect, leading to longer distances and more emissions for the FQS. So to sum up food mile indicators, PGI Sobrasada de Mallorca de Porc Negre is less sustainable than its reference in terms of distance traveled (+5%) and in terms of emissions released at the transportation stage (+1%).

Looking at the **water footprint** (WF), the two products are based on different diets. The FQS uses essentially grass, pea and barley, whereas REF uses maize and soybean. The difference in the green WF, which is higher for REF, reflects four different factors: type of crop, weather conditions, diet and transformation efficiency. Focusing on the fraction of the green WF made by crop production, REF shows a lower impact than FQS, even though it makes use of soy to feed the animals. Soy has the largest green WF as a crop, but it is used in the diet in a moderate amount, so that it does not strongly impact on the result, and REF production requires less green water. However, the scenario changes when we include the transformation procedure (fattening pig → carcass weight; carcass weight → meat). The REF system is less efficient than FQS and makes a larger green water footprint. This is so because efficiency of processing determines how much crop is transformed to obtain a unit final product, and this affects the green water footprint overall?? ~~as well as on the other fractions of the indicator~~.

The grey WF shows the amount of nitrogen-based fertilizers used in crop production. REF production makes a larger grey WF than FQS, revealing that REF production impacts on water quality less than FQS. This scenario is also reversed when focusing on how the grey WF is modified by processing efficiency, like the green WF.

The blue WF was computed for crop needs (e.g. irrigation) is more or less the same for the two products. However, considering processing efficiency, the REF system requires a greater amount of water per unit product. The Life Cycle Assessment component of the Blue WF for animal drinking is higher for REF than FQS. Drinking water accounts for only 0.3% of the whole WF both in REF and FQS. Diet is the largest use of blue water and accounts for about 99% of the whole WF in both production systems. FQS breeding has a slightly higher WF than REF (67.54 m3/t for FQS vs 54.13 m3/t for REF). Breeding accounts for <1% of the whole WF in both production systems.

Social Issues

Finally, among social indicators, the **labour use ratio** indicator, calculated on the basis of output, reflects labour requirements for one unit of physical output (Just and Pope 2001). The allocation of labour to production is higher for Sobrasada Porc Negre than for its non-PDO reference. At farm level, it takes 212 hours of work to produce a tonne of pigs while the reference product requires 31 hours. The difference (577%) indicates that the PDO product generates much more employment than the reference system. The relative difference is an advantage of Sobrasada Porc Negre at the process level (528%) since it takes 714 hours of work to prepare a tonne of product against 113 hours for the reference product. The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is 74% and 64% lower in the PDO sector than in non-PDO ones, at farm and process level respectively. These differences are mainly due to the different production procedure used with the Porc Negre, as production of the reference product is more automated.

Both Putnam (2000) and Halpern (1999) identify education as the key to the creation of social capital, and greater educational achievement as an important outcome. The **education attainment** indicator, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level, and approaches 1 as the level of education increases. The education attainment indicator for the PDO product is very low at farm level: most workers have a primary (75%) or secondary (21%) educational attainment. At the processing level, the educational attainment level indicator is much higher than on farm level and similar for FQS and REF product.

Another social indicator, **bargaining power,** shows no significant sustainability advantage for the FQS over the reference product, and both supply chains perform well in distribution of bargaining power. At the same time, our calculations show that neither supply chain would be highly resistant to major shocks, although our results show evidence of a small advantage of the FQS over the reference product.

It is noteworthy that the values of the **generational change** and **gender equity** indicators are the same for the two products, for every stage of the supply chain. This may be because breeders and processors tend to work for both products at the same time. It also suggests that:

- At the farm stage (pig breeding), the reference sausage appears to be more sustainable than the Sobrasada Porc Negre, because the Generational Change indicator is higher in the former. However, the Generational Change indicator for the farm stage of both products is lower than 100%, and both products appear endangered in their sustainability prospects because of a high employment level of 45–65 year-olds, compared to 15–35 year-olds. The intergenerational transmission of the knowledge and skills for breeding pigs for Sobrasada Porc Negre appears to be threatened by the low value of the Generational Change indicator.
- There are similar results for the Gender Inequality indicator for both supply chains at the farm stage. The reference product Sobrasada appears to be more sustainable than Porc Negre, in that the Gender Inequality indicator shows a lower value. This reflects very limited female participation and achievement in every domain of the Gender Inequality Indicator: secondary education of employees, female entrepreneurship and female employment. There are significant differences in these values for the reference Sobrasada product.
- However, a somewhat different result is obtained for the meat processing stage. Here Sobrasada Porc Negre appears to be equally if not more sustainable than the reference product on both indicators. On the one hand, reference Sobrasada is only 1% higher for the Generational Change indicator. However, because the indicator for both products is smaller than 100%, both products face significant challenges in their sustainability prospects. On the other hand, there is a very small difference in the value of the Generational Change indicator, and the Sobrasada Porc Negre appears slightly more sustainable than the reference product. The processing stage of both products (Sobrasada Porc Negre, in particular) appears to offer more opportunities to women than pig breeding. However, these results need to be interpreted with caution because the indicators for the processing stage are calculated with the same data as the pig breeding stage for the reference Sobrasada product, where the latter supply chain is highly integrated.
- Mainly because the supply chain of the reference product Sobrasada is characterised by values of the indicators which are the same across the two stages of the supply chain, the reference Sobrasada appears on the whole more sustainable than the Sobrasada Porc Negre according to both indicators. While both products appear somewhat endangered in their sustainability prospects according to the Generational Change indicator, the low level of Gender Inequality indicator for the Counterpart Sobrasada bodes well for its sustainability prospects.

Conclusions

The PGI Sobrasada de Mallorca de Porc Negre is a meat product which protects historical heritage and cultural value of the autochthonous Porc Negre in Mallorca. Besides this, its production ensures the survival of the Porc Negre breed as well as direct income for members of the supply chain. Sobrasada de Porc Negre is mainly sold locally, while the Sobrasada de Mallorca predominates in the national and export sales (GOIB 2014; Vera et al. 2010). Interestingly, research reveals that only the educated palates of habitual or local consumers actually differentiate between the two types of Sobrasada.

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Part V
Dairy Sector

PDO Comté Cheese in France

Elisa Husson, Lisa Delesse, Amaury Paget, Rémi Courbou, Valentin Bellassen, and Marion Drut

Comté and Its *Terroir*

History and Technical Specifications

Comté is a French cheese bearing a Protected Designation of Origin (PDO). It is a raw milk, cooked and pressed cheese. Its terroir is the Jura Mountains, ranging from 200 to 1500 m in altitude. The PDO Comté area extends over three departments of the Jura Mountains: Jura, Doubs (two departments in the Bourgogne-Franche-Comté region[1]), and a portion of Ain (department of the Auvergne-Rhône-Alpes region) (CIGC 2015).

Comté first appeared around the fourteenth century. The terms "*fructeries and fromage à grande forme*" are found in historical records of those times. *Fructeries* are a type of dairy cooperative producing cheese. The *fructeries* enabled farmers to put their milk together in order to store it in the form of large cheeses ("fromage à grande forme") (Androuet 2017). Some documents place the origin of Comté much earlier, at the beginning of the first millennium in Sequanie (Franche-Comté) and in Helvetia (Switzerland). These cheeses were known in Rome (Réseau de communes). Later, in 1850, a drop in the price of cereals intensified indirectly the production of Comté through the specialization of the Franche-Comté Region in milk production, and, in 1880, the fromage à grande forme (large cheese) was recognized under its

[1] French departments are similar to NUTS 3 areas, while regions are equivalent to NUTS 2 areas. NUTS stands for Nomenclature of Territorial Units for Statistics.

L. Delesse · A. Paget · R. Courbou · E. Husson
AgroSup Dijon, Dijon, France

V. Bellassen (✉) · M. Drut
CESAER, AgroSup Dijon, INRA, Univ. Bourgogne Franche-Comté, Dijon, France
e-mail: valentin.bellassen@inra.fr

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first *appellation*: Gruyère de Comté. Since then, Comté has become an identifying element of the region. Between 1882 and 1905, the industrial revolution led to the modernization of equipment, and the appearance of dairy schools and ripening firms. In 1924, the term "Comté" first appeared and producers defined its geographical area of production in 1952 (Androuet 2017).

This historical heritage was recognized in 1958 by the creation of a first appellation, the AOC Comté, which became the AOP Comté, a European PDO, in 1996 (Androuet 2017).

The specifications of the PDO Comté (Table 1) strengthen the link between the product and its terroir, highlighting the importance of grassland and valorizing local know-how for processing and ripening (CIGC 2015).

The total livestock for production of PDO Comté is about 150,000 cows, 95% are *Montbéliarde* and 5% are *French Simmental*. This livestock produced 650 million liters of milk during the season 2015–2016, equivalent to 1,600,000 *Comté* cheeses (weighing 40 kilos) after processing and ripening (CIGC 2015).

Comté is the top French PDO cheese in volume (64,065 tonnes in 2015). Nowadays, *Comté* is processed in 153 cheese manufactures called *fruitières*. Only a few *fruitières* perform both processing and ripening, the others deliver their pre-ripened cheeses to ripening firms. There are 16 ripening firms in the PDO area. Ripening in the cellar takes about 8 months on average, ranging from a minimum 4 months to 24 months (CIGC 2015).

Comté and Its Aromatic Richness

Comté is particular for its connection to the terroir and its taste. CIGC, the Defence and Management Organisation (DMO) of Comté, has worked on the description of the taste. Each Comté cheese has a different aromatic profile. This aromatic richness is explained by several factors. One is the geographical origin of milk, given that there is diversity of grassland in the PDO region, which makes it possible to differentiate vintages, and another is season; cows receive hay in winter and grass in summer. This alters in composition during season, and this food diversity influences the color and taste of Comté throughout the year. Another factor is the know-how of master cheese makers and ripeners, as cheese makers adapt their manufacturing techniques to the milk they receive, and ripeners select cellars and manage the cheeses during ripening. The last factor is the duration of ripening, given that the taste, aromas and texture of Comté evolve during this period. (CIGC 2013).

To characterize the aromatic profile of each cheese, CIGC developed the Roue des saveurs (wheel of flavors). This classifies the 83 descriptors of odors and aromas most frequently identified into 6 families. Generally, in a mature Comté cheese, tasters find 2 to 3 dominant families and cite 5 to 10 descriptors. The 6 families of aroma of Comté are: (i) lactic, (ii) fruity, (iii) torrefied-empyreumatic, (iv) vegetable, (v) animal and (vi) spicy (CIGC 2011).

Table 1 Summary of the specifications of PDO Comté

Territory	
Geographical area	1213 municipalities in Central-eastern France, mostly located in three NUTS3 areas (*départements*): Jura, Doubs and Ain
Varieties/breeds	Only the *Montbéliarde* and *French Simmental* cow breed is permitted.
Arable farming practices	
Fertilization	No more than 50 kgN ha^{-1} of mineral fertilization and no more than 120 kgN ha^{-1} in total (organic and mineral). Average grassland fertilization in France is 27 kgN ha^{-1} of mineral fertilization and 37 kgN ha^{-1} of organic fertilization (Agreste 2011, 2010a, b).
Grassland management	No more than 15% of grassland sown with a single legume species and/or a single grass species.
Plant health	Constraints in terms of phytosanitary products use
Field operations	None.
Animal management	
Fodder self sufficiency	At least one hectare of grassland per lactating cow and no more than 1.3 livestock unit per hectare of fodder. All fodder must come from the PDO area, with exceptions for non-lactating cows. No more than 1800 kg of concentrates per lactating cow and per year. No more than 30% of fodder from non-PDO area.
Grass and pasture	Cows must be grazing for the whole vegetation period, as soon as snow has melted and soil is hard enough. During that period, at least half of the feed must be grazing.
Other animal feed constraints	No fermented fodder (silage, …). Many feed types are not permitted and GMOs are not permitted.
Animal health and welfare	Two milkings per day. Only *Montbéliarde* and *French Simmental* breeds permitted.
Other	Customized milk productivity limit given in liter per hectare of fodder (absolute maximum at 4600 liters ha^{-1}).
Process	
First stage (raw cheese)	*Fruitières* can only collect milk within a radius of 25 km. Raw cheese manufacture must not take place in the same building as ripening. No pasteurizing, thermizing or other processes killing the milk natural microbial flora. Cooking and pressuring: copper tanks mandatory and other specifications on temperatures and pressure. Mixing milk from several farms is mandatory. *Farm Comté* is not permitted.
Second stage (ripening)	Minimal ripening duration of 120 days. No maximum (some cheeses are ripened for 4 years). Cheese must be stored on spruce shelves. Specifications on temperatures
Transportation	Milk must be collected every day.
Conditioning	Whole cheese (*meule*) or pre-packaged (portion or grated).
Cheese attributes	Minimal and maximal fat content (45–54% of dry matter), maximal humidity content (38%) and minimal salt content (0.6%).

(continued)

Table 1 (continued)

Territory	
Other	The entire process, from milking to packaging, must take place in the PDO area.
Governance	
	Supply control through *green plates*.

Comté is also nutritionally rich in calcium, copper, vitamins B2 and B12 and in proteins. No additives or coloring agents can be added in processing and ripening (CIGC 2015).

Comté and Other Geographical Indications in Franche-Comté

The Franche-Comté territory is home to several other Geographical Indications interacting with Comté. Morbier, Mont D'Or and Bleu du Haut-Jura are three cheeses benefiting from a PDO and sharing their production area with Comté (Fig. 1). Breeders producing milk for Comté production can also sell part of their milk for any of the other PDOs, as the specifications for Comté are the strictest.

The "*Centre Technique des Fromages Comtois*" (CTFC, a technical organization for Franche-Comté cheese), set up in 2007, plays an important role in improving the quality of cheeses and dairy products in the region. It is recognized as the collective technical organization of the four PDOs. It provides a technical assistance service: technical support, laboratory analysis, production of lactic ferments, sensory analysis, and statistical studies etc.. CTFC thus allows the makers of the four cheeses to share their technical development.

The cured meat industry (PGI Saucisse de Morteau and PGI Saucisse de Montbéliard) also interact with the Comté value chain. Most of the serum (whey) derived from the production of Comté is used as dehydrated powder for animal or human nutrition. But around 20% of it is directly fed to pigs belonging to *fruitières* or to independent pig breeders. Whey is a high energy feed thanks to its high lactose content (50 g per liter on average). A minimum of 15% of whey in the diet of pigs is required in the two specifications for these PGIs (Association de défense et de promotion des charcuteries et salaisons IGP de Franche-Comté 2011).

About 60,000 of the 92,000 pigs in Franche-Comté eat whey, half of which comes from cheese factories. The downstream of the pig industry in Franche-Comté is a significant economic activity: it involves more than 1000 jobs and 250 million euros turnover (CIGC 2013).

There are also several PDO wines in the region: Vin d'Arbois, L'Etoile and Côtes du Jura. These wines are said to be particularly suited to Comté. Many cheese manufacturers have a store where these PDO wines can be purchased.

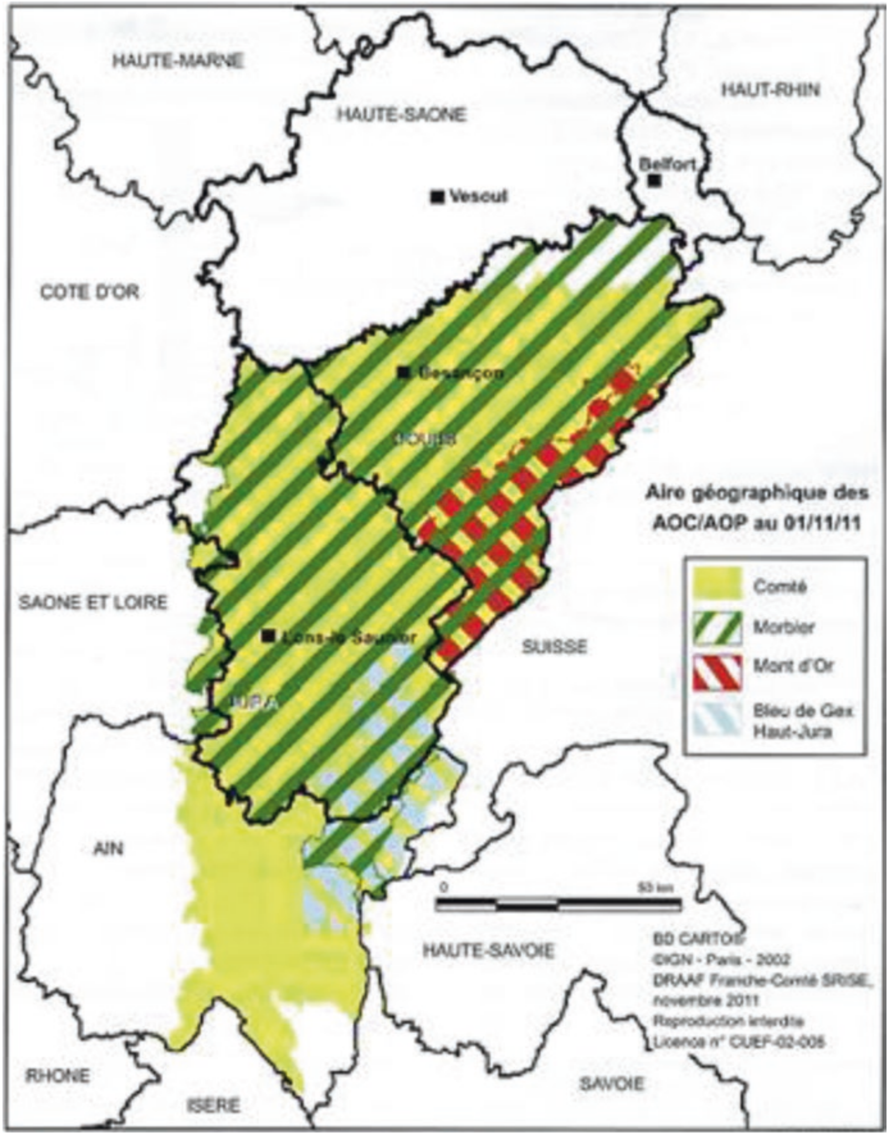

Fig. 1 Geographical area of PDO cheese in Franche-Comté region

Comté Market

Sales

The Comté market was a regional market until the 1990s, when sales increased considerably (Fig. 2). The volume of sales rose from 37,305 to 42,580 T between

Fig. 2 Comté production trends (1996–2015)

1990 and 1996 (Jeanneaux and Perrier-Cornet 2011). This growth can be explained by a host of factors including investment in research, improvement of product quality, and a big advertising budget. Another factor is the arrival of national cheese companies which invested heavily in ripeners or *fruitières*, sometimes restoring their financial health (Jeanneaux and Perrier-Cornet 2011). In 25 years, the companies with national capital obtained a large market share, of approximately 45% in volume. These groups brought changes in the marketing of Comté: there was an increase in mass distribution and "de-regionalization" of sales. They also brought two assets which contributed to the increase in quantity and quality: the notion of time, the long maturation of the cheese meaning better taste and excellence, and the production of pre-packaged Comté sold in supermarkets. This accounted for 54% of total Comté sales in 2006, up from 20% in 1990.

Between 1997 and 2008, Comté sales levelled off at around 50,000 tons. Because of the economic crisis and the poor forage crop in 2007 and 2008, Comté sales decreased slightly in 2009. But sales rose again from 2010 onwards. Interestingly, sales growth went in parallel with price increase, and this growth is generally considered as structural rather than short-term.

The Comté market is largely national, and more than 90% of sales are in France. It is considered a mature market and prospects for growth in France are considered to be limited (Elisseeff 2015). The European market and the world market are open markets which interest Comté producers. In 2014, 4573 tons were exported.

Furthermore, a key factor in the success of Comté is the long period of maturation, which makes large storage capacity necessary. This in turn makes it possible to buffer supply and keep it in equilibrium where there are temporary imbalances on the market.

Supply Control

Control over supply by volume quotas was introduced in the 1990s. In previous years it had been noted that big variations in stocks and output harmed product quality, investment and the maintenance of know-how. CIGC organized a volume regulation mechanism, in compliance with laws on free competition. Studies have shown that although supply control generates market distortion, it is not a strong effect. The French Ministry of Economy and Finance keeps a close watch on supply chain control by CIGC.

Since 2012, the "*mini-package milk*" of the Common Agricultural Policy (CAP) has permitted sectors under PDO and PGI to manage the quantity of marketable cheese for 3 years. The current three-year plan established by CIGC was due to end in 2018.

The quota system is run by CIGC. To fix levels, it first takes into account the economic context, by looking at output and sales of the previous year, and stocks as of December 31st. In general, the target volume is the same as the previous year, but can be adapted according to analysis of the situation of markets and production, consumption and stock forecasts. When an increase in production is decided, CIGC takes into account mainly past figures of "fruitières", each of them receiving an additional quota depending on the specialization rate of what percentage of milk is used for Comté. The rights to produce are allotted according to certain criteria. For example 2015–2018, the additional rights to produce totalled 920T per year: 300T distributed to young farmers, 100T to new producers, 180T for the development of exportation, etc. (Elisseeff 2015)

The number of casein labels, or *green labes*, sold to every *fruitière* ensures that the production quota is not exceeded. These labels are affixed to each wheel of cheese to guarantee the identification of the cheese. Each *fruitiere* is entitled to a limited number of labels. Labels can also be purchased from other *fruitieres* but they become very expensive.

Th labelling system also finances the CIGC as well as ensuring traceability and quotas. An additional volume of Comté which can be produced is negotiated by the DMO and the public authorities within the framework of annual plan, and based on the economic context. In an economic crisis a reduction in the volume of *Comté* is permitted. In an authorized exception to free competition laws, mechanisms are in place to adjust the additional volume according to market trends at the beginning and during the production season. This does not seem to generate significant price distortion at consumer level (Merel 2009).

Regulation of Economic Operator Relationships

The mandatory production specifications of a PDO tend to conflict with the classical economic strategy of cost competition. The Comté value chain has in fact put rules in place to protect an original system:

– It has step by step discouraged the intensification of milk production in the Jura massif by specifying permitted cow breeds, minimal grassland area (1 ha per cow), limits on fertilizers with a maximum of 120 kgN organic and mineral per ha and per year (Cahier des charge 2015), and, since 2015, limits on milk productivity per hectare. This measure is based on academic studies demonstrating a correlation between intensification of the dairy production in a territory and organoleptic quality of cheeses. The limit on productivity is calculated on the basis of past figures of farm production and cannot exceed 4600 liters per hectare. The average productivity of the Comté sector is 3000 liters per hectare (Elisseeff 2015). These decrees do not greatly affect breeding practices at higher altitudes, but they clearly impose opportunity costs on lowland breeders.

– A limit on the size of *fruitières* in terms of production capacity. The maximum size is not much higher than the size of an artisanal *fruitière*. The consequence is that production costs of big companies and small regional cooperatives are similar. For example, Lactalis, one of the main private dairy groups in France, has in the Comté area a *fruitière* with a capacity of twenty million liters. In Western France, on the other hand, Lactalis owns a *fruitière* which produces 30,000 tons of Emmental cheese and handles 300 million liters of milk annually. This is fifteen times bigger than its own Comté *fruitière*, and one hundred times the size of an average *fruitière*;
– industrial dairy groups are under no constraints as far as ripening is concerned, but there is limited possibility for vertical integration between *fruitières* and ripeners. For example, the processing of milk into raw cheese must take place in a different building from the ripening. The large dairy groups nevertheless obtained that pre-packaged Comté must be packaged mandatorily in the PDO area. This requirement gives them a competitive advantage against the traditional ripeners and firms not located in the area who do not possess packaging facilities there.

Furthermore, there are contracts between ripeners and fruitières. These contracts are regularly renewed but the fruitières rarely change ripeners. Contracts are renewed regularly because cheese prices vary. The price fixed in contracts is based on a price published monthly by the CIGC, and ripeners thus offer similar prices. There is high visibility of the price for every stakeholder of the Comté value chain (Bérion, on 2017).

By outlawing intensification and economies of scale, Comté production specifications and contracts thus maintain traditional production, local employment and a milk price paid to breeders much higher than the national average (Fig. 3). The strategies of companies are limited by strict rules on the conditions of production and size, and by the separation of the fruitières from the ripeners. Classical competition based on costs thus faces multiple obstacles.

Description and Governance of the Value Chain

Comté Value Chain

Figure 3 shows how the Comté value chain is organized. Each type of stakeholder is described in more detail below.

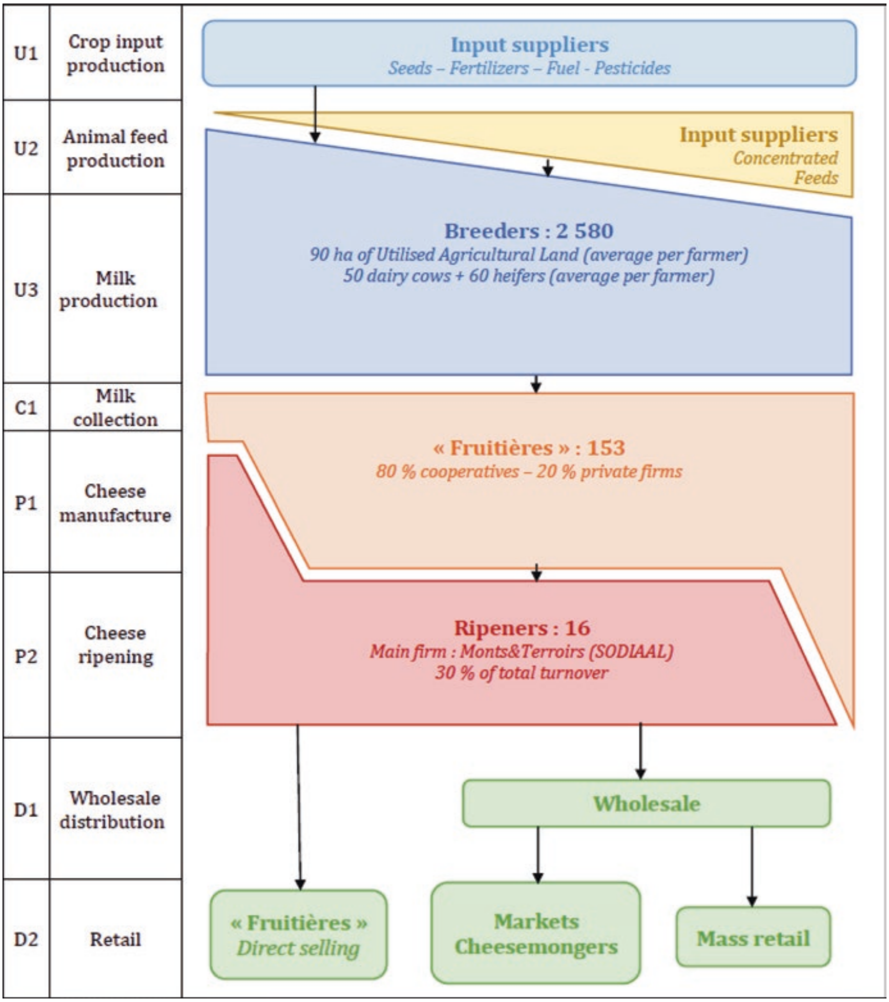

Fig. 3 Value chain map of the PDO Comté cheese (2015)

U1 and U2: Milk production is mostly based on pastures which do not require a lot of inputs, so input producers are not important stakeholders in the Comté value chain.

Farmers (U3): The number of breeders in the Comté sector fell by a smaller percentage (−25%) than nationally (−34%) between 2000 and 2010 (Agreste 2010a, b; Agreste Franche-Comté 2014). CIGC figures show that an average farm has around 90 ha of total cultivated area and owns 50 dairy cows and 60 heifers.

Collection (C1): Milk is almost entirely collected by cheese manufacturers (P1). In some cases, breeders deliver milk to manufacturers by their own means.

Processing (P1): There are two steps in production of this FQS product: cheese manufacturing (P1) and ripening (P2). These two steps are traditional and carried out mainly by *fruitières* are a key element of product reputation. Each *fruitière* collects the milk of producers within a radius of 25 km, as the crow flies, which prevents concentration. However, since 1990, cheese manufacturing in the area has changed and many *fruitières* have abandoned the production of Emmental cheese and opted to specialize in Comté. They have often invested in new machines and buildings and some have merged with neighboring cooperatives. Since 1990, the sector has also seen firms from outside the PDO area entering cheese manufacturing. The new entrants, both cooperatives and private firms, have increased competitive pressure at this level of the supply chain. Today, 80% of the milk is processed by cooperatives at P1 level and the remaining 20% by private firms.

Production (P2): Ripening is carried out by 16 firms, although there are also some *fruitières* with a very small market share. Some of these firms are family businesses which CIGC terms "of heritage interest and value". Others are capitalist firms with no traditional family owner, and / or owners not even resident in the PDO Region. The degree of vertical integration varies between firms. The relationships between *fruitières* and ripeners is based on close historical bonds and confidence. Switching from one ripener to another is very expensive for a *fruitière* in terms of social cost, and therefore rare.

Downstream level (D): There is little information about downstream level actors. The only data possessed by CIGC relates to the amounts sold by full cheese wheel, cut, or packaged, and to export by ripeners. If a ripener sells to a wholesaler for export, the amount is not recorded by CIGC.

Interbranch and other support structures for the FQS: CIGC (*Comité Interprofessionnel de Gestion du Comté*) is the official interbranch of the FQS. It has been recognized by the French government since 1963 and by the European Union since 1996. Other structures also involved with Comté production include the CTFC, local Agriculture Councils and official milk authorities.

Democratic Governance by CIGC

CIGC, as described above, is the key entity in the governance of the PDO. The stakeholders described in 3.2. are represented in the CIGC through four "*colleges*":

College 1: Milk producers (U3) represented by farmer union representatives at (regional) department level.

College 2: Cooperative cheese manufacturers (P1) represented by their own union (FDCL, French Federation of Dairy Cooperatives[2] at (regional) department level)

[2] Fédération des Coopératives Laitières

College 3: First and second processors (P1 + P2) represented by their own unions (FNIL, French National Federation of Dairy Industries[3] for non-cooperative cheese manufacturers and CEC, Entreprise Chamber for Emmental and Comté[4], for ripeners)

College 4: Ripeners (P2) and packers, represented by FNIL and CEC

This structure guarantees equilibrium between farmers (Colleges 1 and 2) and non-farmers (Colleges 3 and 4). In any case, decisions are taken only where all four colleges agree.

CIGC has a key role in spreading transparent information in the FQS, in the management of volume and contracts, in distribution of profits and in advertising. It also carries out research for innovation and marketing. More than 50% of the CIGC budget is spent on advertising. The next largest items are supervision and quality development.

Even though the Comté value chain is known to have a secure structure (Torre 2002), there are occasional conflicts in the sector. In 2016, a farmer and a "fruitière" were involved in legal proceedings because the specifications were unclear on the use of milking robots for Comté milk. This led to specifications being updated to ban the use of milking robots. The case raised the more general issue of whether PDO/PGI specifications leave enough room for methods of production that are both innovative and "genuine and true".

Key Issues for the Sustainability of the Comté Value Chain

On the basis of interviews with 13 key stakeholders in the *Comté* value chain, the following issues were identified as important to ensure the sustainability of Comté production:

Water Quality

The PDO zone has a heterogeneous pedoclimatic context. Soil characteristics in particular differ between departments. Soil quality partly drives milk production per cow, and in some departments such as Jura, it entails lower productivity than in the rest of the PDO area. Because of this natural variability, breeding practices differ and the share of grass and its use are not the same throughout the PDO zone.

The karstic geology of the PDO area makes it sensitive to environmental degradation caused by manure management and nitrate leaching. Breeders have recently been blamed by local environmental and fishing associations for the pollution of the

[3] Fédération Nationale des Industries Laitières (FNIL)

[4] Chambre des Entreprises de l'Emmental et du Comté (CEC)

Loue river (Vindimian 2015). These environmental issues are also linked to societal issues: the media coverage of production-related pollution can have an impact on the consumer's image of the sector.

To address this risk, the *Comté* value chain tries to reduce environmental risks. A change in the specifications was adopted in March 2015, limiting milk production per hectare. CIGC also increased its communications and research into the positive externalities of *Comté* production.

Balanced Governance Faced with Concentration

The *Comté* chain is decentralized and includes 2600 PDO milk producers, 153 "fruitières" and 16 ripeners in the area. This territorial network makes it possible to generate a territorial rent and to maintain economic vitality in the PDO territory.

Nevertheless, the organization of the *Comté* value chain is facing increased competition because of the penetration of national dairy companies such as Lactalis and Sodiaal into the sector. "Fruitières" themselves are therefore tending to concentration, and their number has fallen from 162 in 2005 (Colinet et al. 2006) to 153 today. Territorial cohesion may therefore be affected.

Maintaining the Appellation Premium

Another issue for the *Comté* value chain is to preserve the profits it obtains from the appellation and to justify them. When negotiating large contracts, this rent is often questioned. The price of *Comté* is in fact high compared to similar non-PDO cheeses, and the price of *Comté* sold in supermarkets (64% of sales at €12.5/kg) is lower than price of *Comté* sold freshly cut (36% of sales at €15.6/kg) (CIGC 2015). The traditional market is required to justify this price difference in the face of large groups like Lactalis and Sodiaal. These groups produce large volumes and sell their output more cheaply in supermarkets than other ripeners. For these ripeners, the price of *Comté* is justified by the quality of the product, by the know-how of the ripeners who make this product typical, and by the investments in more environmentally friendly production.

Generation Renewal and Transmission of Know-how

The *Comté* value chain is also facing problems of generational renewal and maintenance of know-how at breeding and manufacturing levels. Cheese manufacturing jobs are no longer attractive. This issue is related to technical innovation within the sector; where cooperatives are getting bigger, better structured and more modern, health and safety issues have to be taken into account and hard work is required. Compared with non-PDO value chains, technological changes face an additional obstacle, because it is necessary to check that new technologies are compatible with the *Comté* specifications. For example, milking by robots has recently been prohibited (see above). The PDO *Comté* sector needs to combine new technologies, modernity and tradition in the PDO Comté. A careful balance between tradition and modernity is required.

Quality Versus Quantity

The abolition of milk quotas and the liberalization of markets is also an important issue for the *Comté* value chain. Milk producers may be encouraged to increase production to the detriment of milk quality. The CIGC limits the production of PDO milk, so any surplus production has to be sold on the standard circuit. Thus, the sector needs to take account of possible reorientation of the strategy of some producers (Kroll 2008). Additional distribution channels as well as international export are being developed. Moreover, in order to conserve milk quality and limit production, the entire *Comté* value chain has mobilized by modifying the specifications. Maintaining the volume regulation and price stabilization mechanisms is seen by several stakeholders as key to sustainability of the value chain.

Export Markets

Finally, CIGC figures show that the national market for Comté is saturated, and the *Comté* value chain is constantly looking for new markets. Export is one of its key development areas. The CIGC communication department promotes Comté through media, trade fairs and sector events, and also raises funds (€1.410 million in 2014) to support of export sales in such countries as Belgium, Germany, United Kingdom, USA, Japan, and China. Moreover, each stakeholder in the value chain is required to promote the product in France and abroad. This strategy may also raise profits. But exporting a cheese made of raw, unpasteurized milk is a challenge because of health and microbial standards in countries such as the USA.

Sustainability Assessment of Comté Cheese

The sustainability performance of Comté cheese has been assessed using the Strength2Food method (Bellassen et al. 2016). For economic indicators, the reference product for Comté is Emmental cheese. For other indicators, the reference is the French national average for milk or cheese production.

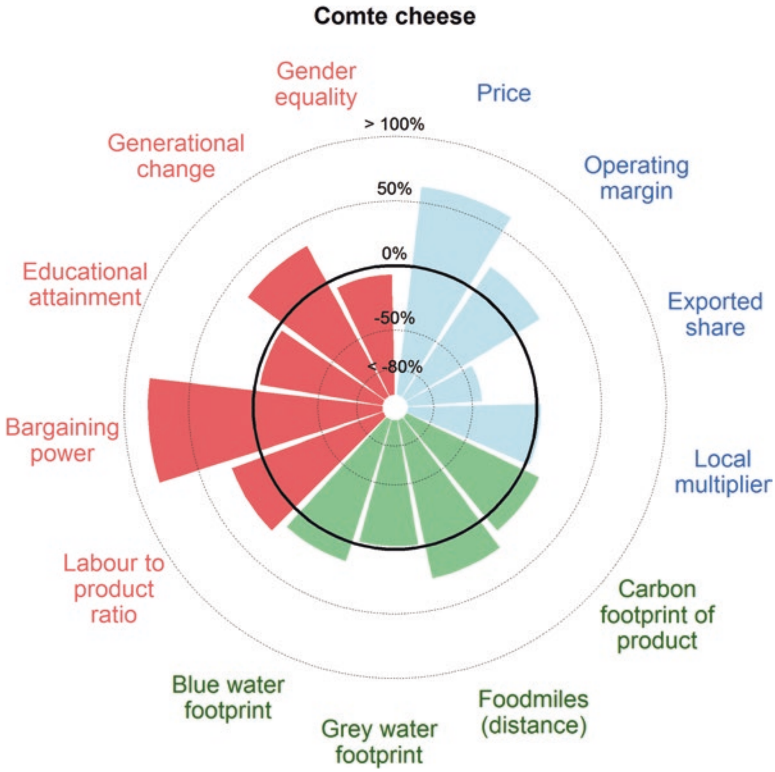

Fig. 4 Sustainability performance of PDO Comté cheese (supply chain averages). (Each indicator is expressed as the difference between PDO Comté cheese and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower)). Data sources for each variable are transparently documented in the data repository: https://www2.dijon.inra.fr/cesaer/informations/food-sustainability-indicators/)

Comté cheese almost always performs better than its reference products (Fig. 4). Its average 62% price premium is particularly impressive. CIGC notes that this price premium makes the strict technical specifications acceptable to farmers and processors, which in turn generates other sustainability benefits. The only notable exceptions to this picture are exports, which are 40% lower than Emmental, and the CO_2 emissions related to milk transportation.

Economic Indicators

The **price premium**, i.e. the difference in prices, increases along the supply chain, with a large gap at processing level. **Profitability indicators** are also higher for Comté cheese than for reference cheese upstream and at processing **levels**. Upstream there is an increase in GOM compared to GVA due to the presence of subsidies in gross operating margin calculated. The **international market** for Comté and reference cheese is the European one, and Emmental is more exported (Table 2).

The local multiplier effect of Comté is 3% higher than its reference product: each euro of turnover for Comté triggers 1.70 euros of re-spending in the same region versus 1.62 euros for Emmental. Several elements drive this difference:

- technical specifications ensure that for Comté, 80% of animal feed is local, versus only 50% for the reference;
- stakeholders of most Comté processors are local, and the margin is therefore mostly re-spent locally;
- the higher margin of Comté businesses re-spent locally.

The location of workers, and therefore their local spending, is however very similar between Comté and its reference.

Environmental Indicators

Carbon Footprint

The carbon footprint of Comté (excluding transport) is 15% lower than its reference (Table 3), mainly thanks to higher processing efficiency (10 liters per kg of Comté compared to 12 per kg of Emmental). In fact, at farm level, the carbon footprint of milk is almost the same (1.131 and 1.126 tCO_2e t of milk^{-1} respectively). In fact, the

Table 2 Economic performance of PDO Comté cheese along the supply chain

	FQS	Reference	Difference
Price (€ kg^{-1})			
Farm level	0.47	0.36	**+29%**
Processing level	7.87	4.54	**+73%**
Retail level	13.53	7.32	**+84%**
Gross value-added (% of turnover)			
Farm level	35	27	**+27%**
Processing level	13.0	12.9	**+1%**
Gross operating margin (% of turnover)			
Farm level	55	47	**+16%**
Processing level	5.6	4.4	**+27%**
Net result (% of turnover)			
Farm level	33	25	**+32%**
Processing level	3	1	**+141%**
Share of volume exported within Europe (%)			
Processing level	6.8	11.8	**−42%**
Share of volume exported outside Europe (%)			
Processing level	1.6	2.2	**−27%**

Table 3 Carbon footprint of PDO Comté cheese along the supply chain

	FQS	Reference	Difference
Carbon footprint of product (t CO_2e t^{-1})			
Farm level	1.13	1.13	+0%
Farm & processing levels	10.6	12.5	−15%
Carbon footprint of area (t CO_2e ha^{-1})			
Farm level	4.2	6	−29%
Farm & processing level[a]	3.9	5.3	−28%

[a]Emissions per hectare are lower when the processing level is added because parts of emissions are then allocated to whey and therefore subtracted from the carbon footprint of cheese

higher share of pasture saves some emissions from fertilizer and machinery, but these savings are offset by a 4% lower milk productivity of cows and by a higher share of rapeseed in the ration. The carbon footprints at farm level are within the 0.52–2 tCO_2e t of milk^{-1} literature range (Meier et al. 2015).

Extended Food Miles

Concerning food miles, the PDO supply chain was compared to the conventional cheese chain in France, from U3 to D1 (Table 4). Over the entire supply chain, from farms to distribution units (U3-D1), PDO Comte cheese travels 25% shorter distances (1000 t.km t^{-1} *vs* 1300 t.km t^{-1}) and releases 15% less emissions (150 *vs* 175 kg CO2e t^{-1}) than the average cooked and pressed cheese in France. This difference is mainly due to the difference in technical specifications of the products, and more precisely by product concentration (0.1 *vs* 0.08). Less milk is needed to produce 1 kg of FQS cheese, and this drives distances and emissions down. The difference is to a lesser extent due to the smaller share of exports of the FQS (8% against 14% for the reference) which means shorter distances and less emissions than for the reference product. Regarding food mile indicators, PDO Comte cheese is more sustainable than its reference products in terms of distance traveled (−25%) and emissions released at the transportation stage (−15%).

Water Footprint

The grey water footprint of Comté, an indicator of water nitrate pollution, is 2% higher than its reference. More organic nitrogen on barley (68 vs 58 kgN/ha) and on grass (36 vs 31 kgN/ha) implies a higher grey water footprint per ton of fodder (105 vs 90 m3/tDM) despite a higher share of grass in the diet. This higher grey water footprint of fodder is slightly reinforced by the slightly lower productivity of Comté cows – 6.52 vs 6.76 ton of milk per year – for approximately the same dry matter intake. This difference at farm level is almost offset by the higher processing efficiency (10 L per kg of cheese for Comté vs 12 for the reference). Note that on a per hectare basis, the grey water footprint of Comté is 27% lower than its reference due to the lower yield of Comté fodder.

The blue water footprint of Comté, an indicator of water withdrawal from ground and streams, is 2% lower for Comté than for its reference. It is however very small for both cheeses. Finally the green water footprint, which measures total consumption of water, is also slightly lower for Comté. The rather high green water footprint of grass is offset by the very green water footprint of soy. While this is not currently a concern, given the sufficient rainfall in the Comté area, it may become one if droughts were to become more frequent.

Social Indicators

Employment

Employment is investigated using two indicators: the labour intensity of production, expressed in working units per ton of product, and labour productivity expressed in euro of turnover per working unit. The labour use ratio indicator, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). Results for the employment indicators are presented in Table 5.

The allocation of labour to production is higher for Comte cheese than for its non-PDO reference (French Emmental). At farm level, it takes 13 hours of work to produce one ton of milk, but the reference product requires only 10 hours. The dif-

Table 4 Extended food miles for PDO Comté cheese and its reference

	FQS	Reference	Difference
Distance traveled (ton.km ton^{-1})			
Processing level	745	915	**−19%**
Retail level	243	413	**−41%**
Value chain	988	1329	**−26%**
Carbon emissions related to the transportation stage (kg CO_2e ton^{-1})			
Processing level	133	146	**−9%**
Retail level	16	30	**−47%**
Value chain	149	176	**−15%**

Table 5 Employment for PDO Comté cheese and its reference

	FQS	Reference	Difference
Labour-to-production ratio (AWU.t^{-1})			
Farm level	0.007	0.005	+34%
Processing level	0.016	0.014	+16%
Turnover-to-labour ratio (€.AWU^{-1})			
Farm level	66,968	67,823	−1%
Processing level	500,190	333,916	+50%

ference (13%) indicates that the PDO product generates more jobs than the reference system. The relative difference is slightly less important at the process level; it takes 28 hours of work to prepare a ton of PDO-Comté cheese against 24 hours for the non-PDO Emmental cheese. This is consistent with the technical specifications. At farm level, the limitation on concentrate and the emphasis put on pasture may require a higher amount of labour. Similarly, the absence of vertical integration, the minimum ripening time and the constraints on milk collection likely require more labour at processing level. It seems however to be worthwhile. In fact, the turnover-to-labour ratio indicator, which provides an insight into labour productivity, is similar at farm level but 50% higher for Comté at processing level. Note that to prevent an artificially high level of inflation for Comté, reflecting the absence of vertical integration, only the turnover of ripeners was used as the numerator for this indicator.

Bargaining Power

The bargaining power distribution indicator reflects the balance of bargaining power between the different levels of the value chain. It combines a simplified Herfindhal index with other more qualitative elements. It varies between 0 – perfect equality – and 1 where one level of the value chain dictates its will to the other levels. Results for the bargaining power indicator are presented in Table 6.

Bargaining power is very evenly distributed across different levels of the supply chain, although the second level of processing (ripening) has a slight advantage over the first level of processing (cheese manufacturing cooperative, integrating breeders), mainly due to the fact that there are fewer ripeners than cheese manufacturers. Bargaining power is less evenly distributed among levels of the reference product, to the benefit of the first processing level and at the expense of the milk production level. This is mainly because there are far fewer processors than milk producers at both levels.

Looking at bargaining power for each level of the Comté supply chain, bargaining power scores are high (>0.5) at all levels, which indicates that bargaining power position is strong at all levels of the supply chain. This indicates that levels of the supply chain can be considered as robust enough to cope with a significant modification in the structure of the Comté supply chain. On the other hand,

Table 6 Bargaining power for PDO Comté cheese and its reference

	FQS	Reference	Difference
Bargaining power			
Farm level	ie	0.33	–
P1	0.58	0.67	−13%
P2	0.78	–	–
Bargaining power distribution			
Value chain	0.02	0.11	−82%

bargaining power values for the reference product are relatively low (reaching a score below 0.5). This shows that bargaining power positions in the supply chain are weak, especially at production level. For this product, any significant change in the competitive environment of the supply chain would have significant consequences on all of its levels.

Educational Attainment

Both Putnam (2000) and Halpern (1999) identify education as a key to the creation of social capital, and greater educational achievement as an important outcome. The education attainment indicator, which shows the highest level of education that an individual has completed, is an indirect measure of certain components of social capital. Results for the educational attainment indicator are presented in Table 7.

This indicator is close to 0 where the majority of workers have a primary education level and approaches 1 as the level of education increases. There is no difference in the profile of education levels between producers of Comté cheese, at farm level, and those in the French milk conventional sector. The level of education is dominated by secondary or middle school leaving certificates (74–78%).

Generational Change and Gender Equality

The PDO supply chain was compared to the national cheese supply chain from the farming to the processing stage (dairy manufacturing and to a lesser extent ripening) regarding generational change and gender equality. Results reported in Table 8.

At farm level, Comté Cheese appears to be more sustainable than its counterpart, both in terms of Generational Change (52% vs 34%) and Gender Inequality (0.16 vs 0.20). However, the Generational Change indicator is smaller than 100%, and the farm stages of both supply chains appear somewhat endangered in their sustainability prospects due to a low level of employment of 15–35 year-olds, compared to 45–65 year-olds. Moreover, regarding gender inequality, women are markedly underrepresented in the workforce, and a larger share of male employees obtain a secondary school certificate in the other supply chain.

Table 7 Educational attainment for PDO Comté cheese and its reference

	FQS	Reference	Difference
Educational attainment			
Farm level	0.51	0.53	–4%
Processing level	0.46	–	–
Wage level (€.AWU^{-1})			
Farm level	23,104	17,566	+32%
Processing level	54,838	47,524	+15%

Table 8 Generational change and gender equality for PDO Comté cheese and its reference

	FQS	Reference	Difference
Generational change (%)			
Farm level	52	34	+53%
Processing level	73	65	+12%
Retail level	73	–	–
Value chain	66	49	+35%
Gender inequality (%)			
Farm level	0.16	0.20	−20%
Processing level	0.29	0.04	+625%
Value chain	0.28	0.12	+133%

At processing level, Comté cheese appears much more sustainable than the reference product in terms of Generational Change (73% vs 65%), which appears to bode well for the preservation of crucial cheesemaking know-how. However, there is a higher level of inequality in female opportunities, compared with the national average (0.29 vs 0.04). This result reflects the very low rate of female ownership of dairies in Comté, while more than a third of conventional cheese dairies are run by females.

Over the entire supply chain, we conclude that on average Comté cheese is more sustainable than its reference product in terms of generational change (66% vs 49%) but less sustainable in terms of gender inequalities (0.28 vs 0.12).

Conclusion

Comté is either similar or better performing than its non-PDO reference products, either industrial Emmental cheese or the average French dairy/cheese sector, on most economic, environmental and social indicators. The only exception is export; Emmental is much more exported than Comté. Comté substantially outperforms its reference products on price premium, operating margin, food miles, employment, bargaining power and generation renewal.

Our conclusion needs to take account of two important considerations: first, outperforming the reference product does not necessarily mean performing well. For example, despite the fact that the Comté value chain manages to attract more young workers than its reference, in particular farmers, the number of older workers is twice as high as the number of younger workers, which mean that there are problems in store for the renewal of the workforce and the transmission of know-how. Second, while the supply chain is overall well documented, some aspects of this study, such as local multipliers, still rely heavily on expert knowledge rather than actual surveys and some of the survey data is too infrequently collected to ensure the possibility of monitoring progress in sustainability indicators.

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PDO Parmigiano Reggiano Cheese in Italy

Elena Cozzi, Michele Donati, Maria Cecilia Mancini, Marianna Guareschi, and Mario Veneziani

Historical Background

Since the Middle Ages, Parmigiano Reggiano PDO has symbolized the production area and Italy in the world. The first reference to Parmesan, in 1254, documents that a noble woman from Genoa traded her house for an annual supply of 53 pounds of cheese produced in Parma. Historians agree on locating the first production of what was then called Grana in an area to the south of the river Po, by Benedictine monks (De Roest and Menghi 2000).

Intensive farming activity and the expropriation of the land of the Benedictine and Cistercian monasteries in the plains of Parma and Reggio Emilia led to the development of *grancie*, farms breeding cows for farm work and milk production. Cheese production developed thanks to the availability of the salt extracted from the nearby saltworks in Salsomaggiore, which strongly characterized the local area. The monks first produced Parmigiano Reggiano PDO with the aim of making a cheese that could be preserved for a long time. They achieved this by drying the compact mass of curd grains and increasing the size of the wheels, enabling the cheese to be preserved and thus sold also outside the production area and further afield. The milk was heated twice, once at a moderate temperature and once at a much higher temperature. This production technique is not very different from the technique in use today. Since then there have been no significant innovations in the salting and ripening phases, although the use of whey and steam heating were introduced at the beginning of the twentieth Century. This improved the quality of the cheese and changed the operation of dairies.

E. Cozzi · M. C. Mancini · M. Guareschi · M. Veneziani
Department of Economics and Management, Università di Parma, Parma, Italy

M. Donati (✉)
Department of Chemistry, Life Sciences and Environmental Sustainability, Università di Parma, Parma, Italy
e-mail: michele.donati@unipr.it

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Intrinsic Attributes

Parmigiano Reggiano PDO is a hard, granular cheese with a long and natural ripening period. It is a dry cheese which contains only 30% water, and is very rich in proteins, vitamins and minerals. The wheel is cylindrical in form with slightly convex or almost straight sides, and slightly edged flat top and bottom. The diameter of the flat faces is 35–45 cm, and the height is 20–26 cm. The minimum weight of each wheel is 30 kg (the weight of regular wheels is about 40 kg), and the crust is about 6 mm thick. The crust is of a natural straw colour, and the body is light straw colour. The fat content is at least 32% of dry content. Parmigiano Reggiano PDO has a very distinctive fine grained and flaky consistency, a fragrant aroma and a delicate taste, which is flavoursome without being pungent, and it has a high level of solubility and digestibility (EC 2006). It is a very versatile cheese that has been widely used in cooking since ancient times and can also be enjoyed as a single food item.

Extrinsic Quality Attribute

Link with the Territory

The production area of Parmigiano Reggiano PDO includes the provinces of Parma, Reggio Emilia, Modena and parts of the provinces of Mantova and Bologna between the Po and Reno rivers. The characteristics of the soil in the production area, in combination with the climatic conditions, have a direct influence on the composition of the natural bacterial flora and the specific fermentation characteristics of the cheese. The characteristics of the milk, with its particular physical, chemical and microbiological properties, depend on the feeding of the dairy cows, based on fodder from the local area while the use of silage is strictly forbidden. Local climatic conditions also help the cheese to acquire the typical characteristics of the Parmigiano Reggiano PDO through particular enzymatic processes. The historical importance of the cheese to the local economy is another important element which links the product with the territory. The production process used today in fact originates from the traditional cheese-making techniques established over the centuries in this geographical area (EC 2006).

The Historical Development of the QAS-PR

In 1934, the birth of the Consorzio Volontario Interprovinciale del Grana Tipico (The Voluntary Inter-Provincial Consortium of Typical Grana) marked a milestone in the evolution of the Quality Assurance Scheme of Parmigiano Reggiano PDO (QAS-PR). This Consortium was established by all dairy cooperatives and producers of Grana Parmigiano Reggiano PDO. The Consortium introduced the brand name Parmigiano Reggiano PDO, still in use today, and committed to safeguarding the name and promoting the cheese for the collective benefit of Consortium members. In 1934, the Consortium established a geographical area of origin including the provinces of Parma, Reggio-Emilia, Modena, and an area south of the Po River in the province of Mantova. In 1937, the area of origin expanded to part of the province of Bologna. The geographical area of origin defined at that time is still recognised today. The term Parmigiano Reggiano PDO was used officially for the first time in 1938.

In 1954, the Consorzio Volontario Interprovinciale del Grana Tipico was reorganized and became the Consorzio del Formaggio Parmigiano Reggiano PDO (Consortium of the Parmigiano Reggiano PDO Cheese, CFPR), which is still protecting and promoting the product and its quality today. The area of production, trademark and governance bodies remain unchanged compared to 1934, but the CFPR now operates under national legislation on Designation of Origin and the protection of national (Italian) cheeses passed in 1954 (De Roest 2000).

Since 1954, the CFPR has played a key role in developing the local agri-food system of the Parmigiano Reggiano PDO and advertising the Parmigiano Reggiano PDO cheese with its own distinctive Consortium label. A 1955 law (D.P.R. 30 May) officially acknowledged the safeguarding role of the Consortium, awarded the PDO label to the product, defined the term "area of origin" and the product standards as well as the inspection procedures and the legal tools for safeguarding the product (Table 1).

Table 1 Summary of the technical specifications/code of practice of the QAS-PR and elements that generate its quality

Territory	
Geographical area	Provinces of Parma, Reggio Emilia, Modena and parts of the provinces of Mantua and Bologna between the Po and Reno rivers.
Arable farming practices	
Fertilization	No direct specification. However, alfalfa fixes substantial amounts of nitrogen, much of which is stored in the crown and roots, such that it improves the structure of the soil, so that fertilizer is generally not required for alfalfa production. Manure is added to the soil before seeding and a small quantity of nitrogen can be used in springtime.
Animal management	
Breeds	Cattle breeds: White; Black; Simmental; Brown Swiss; Modenese; Friesian and Canadian crossbreed.
Fodder self sufficiency	At least 50% of the forage dry matter must be hay and at least 75% of the forage dry matter must originate in the production area
Grass and pasture	Grazing on pasture is not expected in amounts sufficient to alter the quality of the diet or productivity of the cows.

(continued)

Table 1 (continued)

Other animal feed constraints	Ingredients not permitted in feeding ration: overheated forage (due to the risk of fermentation); forage treated with additives; forage that is obviously mouldy and/or infested with other parasites, soiled or contaminated by toxic or noxious substances; colza, rape, mustard, fenugreek, fruit-tree leaves and other leaves, wild garlic and coriander; maize and sorghum rapiers, maize bracts and corncob, straw from rice, and soy, lucerne and seed clover; vegetables in general, including fresh and preserved discarded produce, waste and by-products; fresh and preserved fruit, as well as all fresh by-products of fruit processing; sugar and forage beets, including leaves and tops; liquid molasses (without prejudice for the use provided for in Article 6), moist yeasts, residues of brewery distillation, distillations, cereal fermentation by-products, marc, grape seeds, grape stalks and other agri-food industry by-products; all slaughtering by-products, including the content of rumen; all by-products of the dairy industry.
Animal health and welfare	Antibiotics are forbidden. They are allowed with heifers or in case of cow illness, but that milk will not be used for producing Parmigiano Reggiano PDO cheese.
Processing	
First stage	The milk (the skimmed and whole milk) is coagulated with calf rennet and fermented whey in cauldrons heated by steam. The curd which forms is broken down into tiny granules using a traditional tool called "spino". When the cooking is finished, the cheesy granules sink to the bottom of the cauldron forming a single mass. After resting for some 30 minutes, the cheese mass is carefully removed by the expert cheesemaker. Cut into two parts and wrapped in typical cloths, the cheese is then placed in a mold which will give it its characteristic shape. Salting takes place in the "salamoia" room. Here the cheese is submerged in a water and salt-saturated solution for less than a month to allow salt to be absorbed through the crust. This is the last step of the production cycle, giving way to the ageing which lasts at least 12 months.
Second stage	Most dairies store the cheese wheels until the 12th month of maturation. Cheese wheels are then taken to ripening facilities where they complete the maturation stage. Ripening occurs in airconditioned wharehouses and cheese wheels rest on wooden planks at a temperature not below 16 °C
Transportation	None.
Retailing	In order to guarantee the authenticity and identification of pre-packaged, grated or portioned Parmigiano Reggiano PDO cheese placed on the market, each package bears the label of the CFPR and the PDO logo. Parmigiano Reggiano PDO portions may also be cut to the desired size and packaged at the retail outlet. Parmigiano Reggiano PDO wedges must be sold with their own crust, so that the "Parmigiano Reggiano PDO" (or parts thereof) words branded on the crust remain visible.

The System of Designation of Parmigiano Reggiano PDO

The QAS-PR was set up before EC Regulation 2081/92 entered into force. The QAS-PR had in fact already been operating for several decades when the Italian government recognized the production of Parmigiano Reggiano PDO legally and set up the QAS-PR with the "Decreto Ministeriale 17 giugno 1957". The QAS-PR has a private dimension, in that the owners of the scheme are dairies who founded a "Private Consortium" and created a "Private Collective Brand" to ensure the quality of Parmigiano Reggiano PDO cheese, to promote its sale and to increase the profits obtained from it. The scheme also has a public dimension that stems from its recognition under Italian and European legislation.

The QAS-PR dealing with the labelling of Parmigiano Reggiano PDO has two objectives. The first objective is to safeguard the Parmigiano Reggiano PDO brand against illegal appropriation and fraud, and the second is to ensure the cheese achieves a certain quality and ripening period.

The production standards cover the area of production and the method of processing milk into cheese. The production regulation is important insofar it ensures that traditional artisan methods are followed.

In order to produce Parmigiano Reggiano PDO cheese and use the brand, a producer needs to be enrolled with the certification body of Parmigiano Reggiano PDO, the Organismo Controllo Qualità Produzioni Regolamentate, and obtain permission from the Consorzio del Formaggio Parmigiano Reggiano PDO (CFPR). The same holds for milk producers and ripening and processing facilities, while there are no specific requirements for cheese traders. Current CFPR regulations specify an initial period of 12 months in which the cheese must be produced and ripened strictly within the area of production described in the code of practice. After the first 12 months, the cheese can be moved to a different area for the second phase of the ripening process.

The QAS-PR regulations cover three domains (defined in 1957 by the CFPR):

(a) Feeding the dairy cows;
(b) Parmigiano Reggiano PDO production standards;
(c) Branding the Parmigiano Reggiano PDO wheels.

The requirements on dairy cow feeding ensure the required milk quality, and lie at the core of the QAS-PR. The main ingredient in the daily feed ration is local forage. At least 50% of the forage dry matter must be hay[1] and at least 75% of the forage dry matter must originate in the production area.[2] The feed base, consisting of forage, must be supplemented by various diet nutrients. Milking cows must not be fed with fodders that give the milk anomalous aromas and flavours and alter its characteristics, or with contaminated or poorly conserved fodder. Compound feed prepared on farm may be used, with some limitations,[3] and without including silage or certain other raw materials.[4]

All these aspects are controlled by the Organismo Controllo Qualità Produzioni Regolamentate. The regulations impact heavily on the organization and management of the whole farm, since they directly and indirectly raise production costs.

[1] Art 2 of Feeding Regulation for dairy cows.

[2] Art 3 of Feeding Regulation for dairy cows.

[3] Art 10 of Feeding Regulation for dairy cows.

[4] Art 6 of Feeding Regulation for dairy cows.

They impact directly through the production of hay and the use of diet supplementary concentrates, and indirectly, through the lower productivity of the cows because of the strict feeding regulations. Another consequence of applying this code of practice is on land use. Because at least 75% of the forage dry matter must originate in the production area, several dairy farms producing milk for Parmigiano Reggiano PDO cheesemaking also grow fodder crops, such as alfalfa. While this requirement has a very positive impact on the landscape and on the environment, because of the nitrogen fixing capabilities of alfalfa and its lower need for chemicals and fertilizers, it also means that land cannot be cultivated with more productive field crops.

The requirements on processing cow milk for Parmigiano Reggiano PDO also influence milk production techniques and costs. The most important provisions are:

(a) The milk used is raw and must not undergo heat treatment. The use of additives is strictly forbidden.
(b) The milk from the evening and morning milking is delivered to the dairy within 2 hours from the end of each milking. Milk is cooled immediately after milking and kept at a temperature not below 18 °C.
(c) The milk from the evening milking is semi-skimmed by removing the cream naturally floating to the surface in open-top stainless-steel basins. As soon as it reaches the dairy, milk from the morning milking is mixed with the semi-skimmed milk from the previous evening and poured into the typical copper vats shaped like truncated cones. Calf rennet is added. The only permitted additive is "starter whey" obtained from the milk of the previous day.
(d) After curdling, the curd is broken up into grains and cooked. These curd grains are then left to collect at the bottom of the vat and form a compact mass, which is put into special moulds for the moulding process.
(e) After a few days, the cheese wheels are salted in a salt solution. Ripening must last for at least 12 months. In summer, the temperature of ripening rooms must not be lower than 16 °C. Salt is the only preservative.

Description of the Territory and the Local Production System

The area of production of Parmigiano Reggiano PDO lies in the middle of Emilia Romagna (Fig. 1), an Italian region characterized by a strong reputation in the food industry due to the production of many typical products and the presence of important Italian agribusiness companies.

In this section we analyse the characteristics of the provinces of Modena, Parma and Reggio Emilia where the production of the cheese is concentrated (Table 2).

Each of these three provinces is characterized by the presence of plain, hillside and mountainous areas. These feature big social, environmental and economic differences, which translate into distinctive characteristics of the product.

Mountain areas are fragile because of low population density, modest economic activities and severe hydrogeological problems. Plain areas on the other hand enjoy much better conditions: average annual per capita income exceeds 30,000 EUR,

Fig. 1 The area of production of Parmigiano Reggiano PDO

Table 2 Number of wheels of Parmigiano Reggiano PDO by province and altitude (2011–2016)

Province	Altitude	2011	2014	2016
Modena	Mountains	206,472	202,096	217,807
	Hills	244,011	255,551	264,857
	Plain	185,028	183,996	211,395
Total Modena		635,511	641,643	694,059
Parma	Mountains	258,915	250,940	257,832
	Hills	410,247	417,410	446,919
	Plain	497,938	511,697	517,815
Total Parma		1,167,100	1,180,047	1,222,566
Reggio Emilia	Mountains	223,969	227,561	259,855
	Hills	414,741	422,255	466,610
	Plain	374,040	384,994	391,651
Total Reggio Emilia		1,012,750	1,034,810	1,118,116

Source: CLAL (2018)

high population density shows there is a thriving economy, centered on the industrial sector and supported by advanced services. These mountain areas are considered Less Favored Areas according to the European Economic Community Directive 75/268 and receive funding to revitalize the municipalities.

Several factors characterize the area from the point of view of production and organization. These factors include the coexistence in the same area of intensive and high-productivity farming; the possibility of producing typical PDO and PGI products known all over the world for quality and reputation; the presence of large agri-food industries specialized in processed tomato production (50% of Italian processed tomatoes are processed in Parma), sugar production, the milling and pasta industries (Barilla is the most important company), and the dairy and pork industries. A further strength of the area is the presence of firms supplying services and innovation to the food industry. The Parma area is known worldwide for the presence of food manufacturing enterprises benefitting from cutting-edge technologies in food processing, preservation, storage and packaging.

It is important to note that there are institutions connected to these industries, which support both specific food chains and local development. The main institutions include the Consortia representing the local PDO and PGI products, the "Tomato District of Parma" created by tomato producer organizations and processing industries and the eno-gastronomic routes which develop place-based marketing strategies promoting tourism, which – in turn - enhances food production. Other important institutions located in the area include: farmer unions, the Experimental Station for the Food Preserving Industry (SSICA), the European Agency Food Safety Agency (EFSA), the certification bodies of food products; intermediate institutions such as the Chambers of Commerce, the LEADER agencies, the Ente Fiera (Trade fair organisation) and other public entities including the "Mountain Communities" and regional parks. All these bodies work towards common goals and common benefits for the territory. They work in close cooperation, reducing transaction costs, facilitating both decision-making and agreements about strategic development. This strategy creates a very positive effect as each institution aims to improve the overall reputation of the province as well as of producers.

The Local System

The area strongly characterizes the production system of Parmigiano Reggiano PDO. Thanks to the PDO designation, acquired in 1992, it is considered a typical area. Milk must come from breeding farms located there, and the dairies must be located exclusively in the typical area. Raw materials used to feed cows must also come in part from the area of production. Finally, the first 12 months of the ripening period and the portioning of the cheese must also take place within the area defined by the production regulations. Producers are thus bound to the area in terms of natural resources and legal obligations. But although the Parmigiano Reggiano PDO system is rooted in the typical area, consumption occurs far beyond its borders: most of the cheese is sold on Italian and European markets and the system has important trade relationships with other regions.

The organization of the Parmigiano Reggiano PDO chain and its production and marketing strategies can be considered the output of a process where different actors with different interests are in a functional balance. They are thus enabled to improve relationships among themselves and with the market, responding better to the demands of technological innovation and agricultural policies. The current Parmigiano Reggiano PDO system includes actors that operate and interact along the value chain as well as other actors operating and interacting inside and outside the production area. Both dimensions, value chain and territory, overlap in part because some of the actors, milk and cheese producers and the Consortium, are simultaneously in the territory and the value chain, while others are either in one or the other. The supply chain represents just one of the components of the Parmigiano Reggiano PDO system. The system is currently supported by other actors, including: institutions, researchers, advisors and consultants, technical assistants, and suppliers of inputs for breeding farms and dairies.

The chain produces a total of more than 3,400,000 wheels, in 339 dairies, which collect milk from 3,500 breeding farms (2016 data). Parma is the province with the

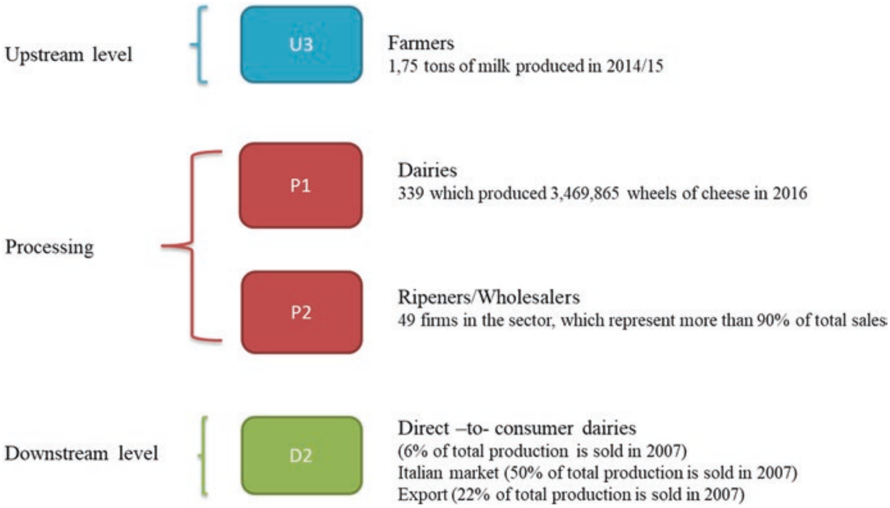

Fig. 2 Description of the value chain

highest production volume (35%) and the highest number of dairies (46%). In order of importance the provinces are Parma, Reggio Emilia, Modena, Mantova and Bologna (Fig. 2).

The chain of Parmigiano Reggiano PDO is complex. The main members are the three types of agents in the supply chain (dairy farms, dairies and traders) who interact with one another, a Consortium providing qualitative and strategic governance for its members, and other public and private players which actively or passively influence the chain.

From dairy farmers to consumers the following actors can be identified:

- Farmers
- Dairies
  - Dairy cooperatives
  - Private dairies
  - Farm dairies
- Ripeners and wholesalers
- Retail system

Farmers

The production structure of Parmigiano Reggiano PDO is based on a dense network of farms which supply milk to co-operative and/or private dairies located within the area defined by the code of practice. The milk is produced according to the closely guarded regulations set by the CFPR on dairy cattle breeding and milking and storage methods. Dairy cattle farmers have a direct influence on the strategies of other participants in the chain, because they influence the overall supply of milk. The concentration of production structures has led to the adoption of more intensive breeding techniques and to increasing investment in technological equipment. On the one hand, this has improved standards of performance, but on the other hand, these improvements have raised production costs, and forced farmers to resort to external credit.

In 2014/2015, the number of dairy farms (3,225) in the production area of Parmigiano Reggiano PDO (Provinces of Bologna, Modena, Parma and Reggio Emilia) accounted for more than 95% of the total dairy farms in Emilia Romagna (SI-PR, 2018). Similarly, the number of dairy cattle in the area (249,230) accounted for more than 85% of the total dairy cattle in Emilia Romagna. There was an overall fall in the number of dairy farms over the period 2010/2011–2014/2015 in the Parmigiano Reggiano PDO area and in the region, affecting especially small farms, which today, in average, produce up to 800 tons of milk a year. The number of cattle fell slightly in the period 2010/11–2014/15. In 2014/15, 1.75 million tons of milk were processed to produce Parmigiano Reggiano PDO, the same quantity as previous years (Parmigiano Reggiano Consortium 2016). Subtracting the amount of milk processed to produce Parmigiano Reggiano PDO from the total milk produced in every province of the area of origin reveals that the province of Bologna used just 41% of its milk to produce Parmigiano Reggiano PDO. This means it exports milk for Parmigiano Reggiano PDO cheesemaking to the other provinces. The provinces of Modena, Parma and Reggio Emilia import milk for Parmigiano Reggiano PDO cheesemaking from other provinces in the area of production. In the total area considered, up to 99% of the milk produced is processed into Parmigiano Reggiano PDO, which shows that there is a strong specialisation of dairy farms in milk production for the famous cheese.

Dairies

In the Parmigiano Reggiano PDO area, there are three different types of dairy: dairy cooperatives, private dairies, and farm dairies.

Dairy Cooperatives

Dairy Cooperatives are at the core of the Parmigiano Reggiano PDO system, representing 63% (213) of total dairies which processed about 1,064,312 tons of milk (68% of total milk) in 2014 (SI-PR, 2018). They are a form of aggregation for both producers and society and impact on the families of member and manager farmers. They are often the main, if not the only, source of income for farms, and the life-cycle of a cooperative very often coincides with the life-cycle of those farming families that deliver their milk to it. The strategy of cooperatives thus tends towards protection of farmer interests rather than those of the cooperative itself, and can therefore be considered a somewhat short-term strategy. Most cooperative dairies age the cheese in their warehouses for the shortest possible time, selling their output to dealers and ripening firms as soon as the quality and market conditions make it possible.[5] Just 30% dairy cooperatives age their cheese for more than 12 months (De Roest 2000), and only few of them sell their cheese directly to modern distribution under their own brand. Most of them sell to wholesalers. Unlike other sectors where cooperatives usually pay for their raw materials through regular down payments, Parmigiano Reggiano PDO cooperative dairies pay for almost all the milk only when the cheese is sold.

Private Dairies

Private dairies are important in the supply chain of Parmigiano Reggiano PDO as they account for a great deal of innovation in the sector. In 2014, they accounted for 16% (56) of total dairies and processed about 349,583 tons of milk (22% of total milk) (SI-PR, 2018). They tend to be strongly market-oriented, and lean towards scale economies and innovation. They take milk mainly from large farms, which are unable to bear with the long payment terms imposed by cooperatives. Unlike cooperatives, they pay a monthly advance payment for the milk they process and settle the balance according to the final sales price of cheese.[6] There can thus be competition with cooperative dairies to retain suppliers, which is often detrimental to cooperatives. Because of their organisation and structure, private dairies pay more attention to cost saving production techniques, and adopt quality systems for lowering technological risks in producing cheese from milk. There are in fact two types of private dairy. The first ripens cheese up to 12 months and sells it on to other ripeners. The second type carries out ripening after 12 months and sells the cheese under their own brand name. This type of private dairy is particularly dynamic and often adopts active sales policies; although with a few exceptions, their market share is fairly low.

Farm Dairies

These are dairy farms which produce Parmigiano Reggiano PDO directly from their own milk. They have developed recently from larger farms, and exploit scale economies, market opportunities and subsidies from Regional Rural Development Plans.

[5] Parmigiano Reggiano PDO cheese can currently be sold at a minimum of 12 months in four-month age groups: January–April, May – August and September–December.

[6] This price is the 'reference price' and is fixed by the Chamber of Commerce once most of the year's output has been sold.

In 2014, they accounted for 20% of all the dairies (69) and processed 149,539 tons of milk, or 9.5% of total milk (SI-PR, 2018). Some of them also sell cheese to ripeners after 12 months, while others continue the ripening process and sell cheese to wholesalers or retailers, or directly to consumers, either online or through farm shops.

Ripeners/Wholesalers

Ripeners/wholesalers carry out ripening of cheeses after the first 12 months until it is ready for sale. They thus carry out the technical function of ripening and bear the economic risk of trading on price variations. There is an important distinction between operators active in the supply chain, who take technical and economic risk, and operators who merely rent out premises for ripening. The latter are usually banks or specialised entrepreneurs, and they play a technical and service role in the supply chain allowing ripening operations to be set up or providing financial credit to the operators in the supply chain using Parmigiano Reggiano PDO cheese wheels as collateral. Traders however play a key role in the marketplace. They are supplied by cooperative or private dairies, or by ripeners. They buy 12-month cheese and fully ripened cheese, (more than 18–20 months old) and sell it to supermarkets under their own name and logo. Only a small proportion of them are based in the area of production specified by the CFPR. The largest traders also deal in Grana Padano cheese[7] and carry out ripening outside the production area. However, pure ripeners/wholesalers are becoming less common and tend to integrate vertically with dairies because of the large amount of capital investment required, the technical and financial risk they face, and the difficulty of selling to large retailers and supermarket chains.

Retail Stores in Italy

The retail system is differentiated as Parmigiano Reggiano PDO is an essential product in the assortment of all retailers, and often a key element in the retailers' policies of discounting to attract customers and retain loyalty. This is achieved through pricing policies (i.e. low prices, discounts, special offers) and quality policies (i.e. high quality and product differentiation according to the age of the cheese).

[7] The ten largest firms selling Parmigiano Reggiano PDO cover 58% of the market. Five are outside the production area as they are also producers of Grana Padano. These five have a market share of 26%. The CRPA (Centro Ricerche Produzione Animale di Reggio Emilia) estimated that as much as 49% Parmigiano Reggiano PDO was ripened outside the area of origin in 2002.

In 2010, most Parmigiano Reggiano PDO[8] was sold in hypermarkets (30.73%), supermarkets (39.72%), superettes (4.6%) and hard discount stores (5.1%) and 19.8% per cent was sold through traditional/specialty shops (Giacomini 2012).

Governance of the Food Quality Scheme

The governance system in Parmigiano Reggiano PDO chain has two dimensions: the role of the Consortium and its decision-making, and the different models of chain management of internal and external relations.

The Consortium of Parmigiano Reggiano PDO

The Consortium of Parmigiano Reggiano PDO (CFPR), sets "common rules for all members of the supply chain, and exercises control over and promotion of the product on the market" (Giacomini et al. 2011/12:139). It protects the designation of origin and is responsible for monitoring the production and sale of Parmigiano Reggiano PDO cheese. The Consortium also promotes the consumption of the cheese in Italy and abroad developing and supporting any commercial or consumer-education initiative aiming to enhance the image and reputation of Parmigiano Reggiano PDO, including the participation in and establishment of consortia companies or organisations (EEC 2081/92).

The CFPR governing bodies are (Art. 20):

(a) Section Meetings and Boards;
(b) General Assembly. Functions are to approve the draft budget and financial statements, ratify the appointment of the directors by the Section Meetings, appoint the Board of Auditors, ratify the contributions and penalties due from members, and during extraordinary meetings, approve and modify the production specification, which is considered the main and most sensitive task of the Assembly;
(c) Board of Directors: lays down the management programmes of the consortium;
(d) Executive Committee: responsible for executing the programmes of the consortium;
(e) President;
(f) Board of Auditors with administrative and accounting control function.

The three criteria used to define representation and voting methods in the consortium bodies (Meetings, Boards and Executive Committee) are laid down by the

[8] CRPA considered cheeses produced in 2005 and branded in 2006.

Articles of Association. The criteria are: the territorial distribution of the members into sections, the different member categories and the respective cheese production volumes.

Chain Governance

"Chain governance is a relevant attribute for both local and global chains where the PDO producers are represented by a collective body" (De Roest et al. 2014:50), which in this case is the CFPR. In their analysis of the Parma Ham chain, De Roest et al. (2014) identified qualitative indicators for monitoring chain governance which can also be used in the analysis of the Parmigiano Reggiano PDO chain. De Roest et al. (2014) aimed to describe "the specificity of chain management regarding the capacity to manage internal and external relations and thus to adopt appropriate and effective management actions" (De Roest et al. 2014:54). Such strategies or actions were identified as: a) trust-based internal relationships; b) trust-based external relationships; c) self-governance capacity; d) chain-based value governance. Chain-based value governance is differentiated across the types of supply chains identified by Gereffi et al. (2005) on the basis of the complexity and codification of transactions and the capability of suppliers. Supply chain governance can be one of five types: *market, modular*, *relational*, *captive*, *hierarchical.*[9]

Gereffi et al. (2005) enrich their classification of governance types with three additional characteristics: the *complexity* of information and knowledge; the extent to which this information and knowledge can be *codified* and, therefore, transmitted efficiently between the parties; and the *capabilities* of actual and potential suppliers in relation to the requirements of the transaction. This generates eight possible combinations with the five types of governance (Table 3):

Table 3 Key determinants of global value chain governance

Governance type	Complexity of transactions	Ability to codify transactions	Capabilities in the supply-base	Degree of explicit coordination and power asymmetry
Market	Low	High	High	Low ↕ High
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	
Hierarchical	High	Low	Low	

Source: Gereffi et al. (2005:84)

[9] *Market*:the market links can be transitory or can persist over time, with repeated transactions; the costs of switching to new partners are low for both parties; *modular*: suppliers produce to a customer's specifications and take full responsibilities for the process, the technology and the skills required; *relational*: there are complex interactions between buyers and sellers, which often create mutual dependence and high levels of asset specificity; *captive:* small suppliers are transactionally dependent on much larger buyers and they face significant switching costs; *hierarchical:* characterized by vertical integration.

There are eight possible combinations of the three variables. Five of them generate global value chain types. The combination of low complexity of transactions and low ability to codify is unlikely to occur, which excludes two combinations. Of course, if the complexity of the transaction is low and the ability to codify is high, low supplier capability would lead to exclusion from the value chain. This is an important outcome but does not generate a governance type.

In the case of Parmigiano Reggiano PDO, *trust-based relations* distinguish the chain in both *internal and external dimensions*. On the one hand, actors of the chain interact constantly, and interaction is based on mutual trust concerning compliance with CFPR production regulations. Mutual trust and loyalty to the cheese dairy on the part of the chain members are the key to holding this social organization together (De Roest 2000). On the other hand, the Parmigiano Reggiano PDO chain is also closely connected with territorial and policy stakeholders. The quality scheme has a public dimension, thanks to its recognition in Italian and European legislation. Public institutions thus plays a key role in the supply chain. They protect and guarantee production reputation and quality among producers and processors along and outside the chain; ensure that a high level of quality is maintained, and punish fraud and other infringements. This all helps to create customer loyalty and trust in the product (Arfini et al. 2006). The chain is supported by universities and other institutions such as the Emilia-Romagna regional government and local Chambers of Commerce which promote research on the chain in order to enhance production and marketing and promote appropriate policy intervention. *Self-governance capacity* is related to the capacity of creating distinctiveness. Parmigiano Reggiano PDO cheese is closely linked to the area because of its historical relevance in the local economy and culture. Production in fact still uses centuries-old artisan techniques. At the same time, soil characteristics and climate conditions have a direct influence on the composition of the natural flora and the specific characteristics of the cheese. This means that Parmigiano Reggiano PDO encapsulates a high level of distinctiveness which facilitates its capacity to mobilize institutional support to remain competitive in global markets. Three different levels of *chain-based value governance* can be distinguished:

(a) Farm dairies: at this level, governance is mainly *hierarchical* for cooperative dairies, given the vertical integration of the chain, and *captive* when the relationship is established by contract; (b) 12 month cheese: governance is also mainly *hierarchical* or *captive* due to the strong integration of the chain and the high cost of switching. Producers depend increasingly on the market and traders, as now that PDO specifications and certification guarantee product quality large retailers are gaining increasing power; (c) up to 12–24 month cheese and older: at this level, governance reflects a combination of *market* and *hierarchical* models, with relatively unstable trade relationships and strong positions for large-scale product purchasers.

Sustainability Performance of Parmigiano Reggiano PDO Cheese

The sustainability performance of Parmigiano Reggiano PDO was assessed using the Strength2Food method (Bellassen et al. 2016). The reference product for comparison with Parmigiano Reggiano PDO is milk produced in provinces which are outside the Parmigiano Reggiano PDO area of production but may be in the Grana Padano area of production. At the processing stage, the reference product is a generic hard cheese produced in Nothern Italy. All the index calculations are based on primary data collected from supply chain members (Consortium of Parmigiano Reggiano PDO, dairies, dairy farms) and secondary data extrapolated from scientific and technical literature, farming handbooks and farming databases (e.g. Italian FADN) (Fig. 3).

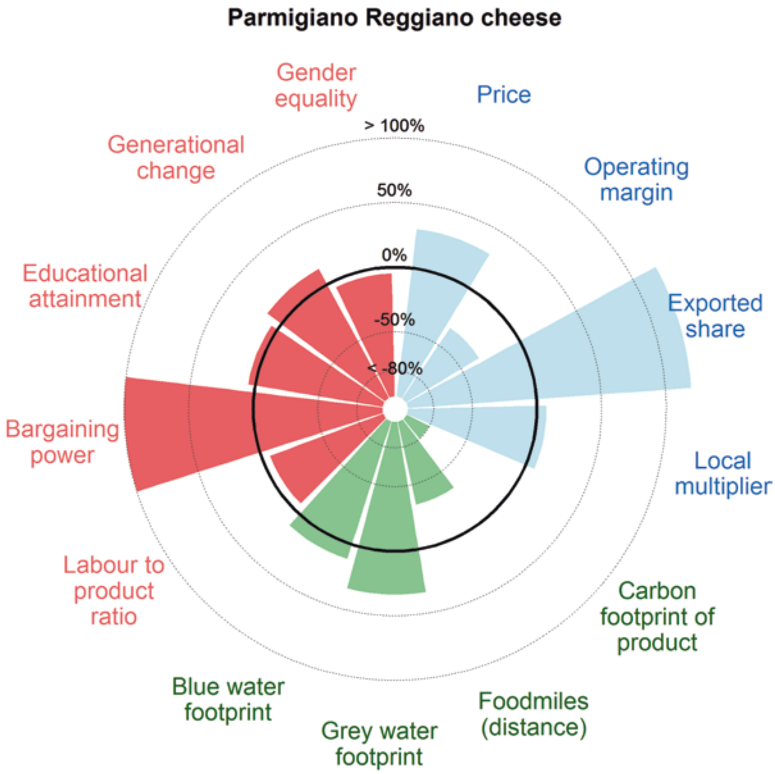

Fig. 3 Sustainability performance of Parmigiano Reggiano PDO cheese (supply chain averages). (Each indicator is expressed as the difference between Parmigiano Reggiano PDO cheese and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

Economic Indicators

Price Premium, Profitability and Value Distribution

Milk price for Parmigiano Reggiano PDO is 6.5% higher than its reference product, while at the processing level the price is 61% higher. This is due to the longer period of ripening and the higher cost of processing. At the distribution level, there is a smaller difference with the reference product (Parmigiano Reggiano PDO +24%) reflecting that Parmigiano Reggiano PDO is frequently retailed at promotional prices to attract consumers.

The gross value added is higher at farm level, while at processing it is lower (−47%), than the one for the respective stages of the reference product. This percentage incorporates the processing value which in the cooperatives is transferred to farmers. The objective of cooperatives, which deal with more than 60% of the entire production in the Parmigiano Reggiano PDO sector, is to maximize the benefits for their members, the dairy farms. The price paid for milk is thus set after the payment of the other costs, leaving the cooperative net result at zero. All the economic margins earned by the cooperatives are transferred to the members. Taking into account all types of producer, the gross operating margin is lower at farm level (−5%) and at the processing stage (−62%). A couple of reasons could determine the lower level of gross operating margin at the farm level for Parmigiano Reggiano PDO, compared to the reference product (even in presence of the aforementioned relevance of the cooperative organization of dairies). On the one hand, the farm data drawn from the Italian FADN employed to calculate the gross operating margin at the farm level may underrepresent those farms which produce for cooperative dairies and which may benefit from such a transfer of the gross operating margin. On the other hand, this could be representing a structural feature of the Parmigiano Reggiano PDO system in which dairy farms, especially those which are not integrated downstream with their own processing facility, try to ride out the downward price cycle (typically lasting around 4 years) and suffer a low/negative profitability aiming to be able to benefit from the following pick-up in price and a return to profitability. In this sense, we would interpret these figures as representing a short-run phenomenon, possibly highlighted by the peculiar data used.

Local Multiplier

The local multiplier for Parmigiano Reggiano PDO is 7.3% higher than for its reference product. In both cases, the indicator is higher than two, or in other words, one euro spent at the processing phase generates more than one euro of extra financial flow in the local area. For Parmigiano Reggiano PDO the local multiplier is 2.64, and for the reference product it is 2.46. Therefore, the reference cheese also contributes positively to the local economic dynamism, although not as much as Parmigiano

Reggiano PDO. The main determinant of this result is the geographical origin of raw milk. The location of dairy farms is therefore a key variable in the high local multipliers for both products. If the raw milk is assumed to come from outside the local area, the local multiplier halves for Parmigiano Reggiano PDO, and for the reference product it falls by 37%. Hence, the higher value of the local multiplier for Parmigiano Reggiano PDO is explained by the higher share of raw milk provided by local milk producers.

Environmental Indicators

Carbon Footprint

The carbon footprint of Parmigiano Reggiano PDO is 79% higher than its reference, mostly due to its higher density (16.7 litres of milk per kg of Parmigiano Reggiano PDO compared to 7.7 litres per kg of the generic hard cheese). However, at farm level, the carbon footprint of milk is 18% lower for Parmigiano Reggiano PDO than its reference product (1.6 and 1.95 tCO_2e t of $milk^{-1}$ respectively). The two main drivers of this difference are the longer lifetime of dairy cows producing milk for Parmigiano Reggiano PDO, which lessens the "carbon deadweight" of unproductive heifers and cull cows, and the composition of their diet. Dairy cows producing milk for Parmigiano Reggiano PDO eat substantially more alfalfa and mowed grass, which both require less fertilizer and less fuel for field operations than silage maize. Breeders of dairy cows in the area of production of Parmigiano Reggiano PDO also obtain slightly higher yields for some crops such as alfalfa. The difference in diet composition is largely due to the technical specifications which limit components like maize, soy, cereals, but not alfalfa and grass. The carbon footprints at farm level are within the 0.52–2 tCO_2e t of $milk^{-1}$ range reported in the literature (Meier et al. 2015).

Extended Food Miles

Over the entire supply chain, from farm to distribution (U3-D1), Parmigiano Reggiano PDO cheese travels distances 35% longer (2500 vs 1900 t.km) and releases almost twice as many emissions (430 vs 225 kg CO2 eq.) as the reference cheese. The longer distance embedded in the PDO cheese can be explained by the longer distance travelled by exported PDO cheese, which is sold to a larger extent outside Europe (34% vs 13% of the exports are sold outside Europe), and by the larger share of exports for PDO (38.2% vs 11.4%). However, the larger emissions generated by the PDO are entirely driven by the more carbon intensive mode used at processing level; light goods vehicles, rather than heavy goods vehicles. In fact, although distances travelled by exported PDO cheeses are longer, the larger share of exports using sea freight contributes to lowering the carbon bill. The distribution level (P1-D1) concentrates more than 60% of the kilometres embedded in the product, whereas the processing level (U3-P1) concentrates from 25% to 50% of the emissions generated along the value chain. Regarding food mile indicators, Parmigiano Reggiano PDO is less sustainable than its reference product both in terms of distance travelled (+35%) and in terms of emissions released at the transport stage (+91%).

Water Footprint

Overall Parmigiano Reggiano PDO shows a lower water footprint than the reference product. More specifically, Parmigiano Reggiano PDO consumes 9.5% less water. This is mainly due to the different agricultural practices characterising Parmigiano Reggiano PDO compared to the reference product, and the fodder crop yield. The Parmigiano Reggiano PDO code of practice forbids the use of silage in animal feeding, but it is permitted for the reference product. Silage, in particular maize silage, requires more water than other fodder crops. However, the milk-to-cheese yield has a big effect on the results for different water footprints.

At farm stage, Parmigiano Reggiano PDO consumes approximately 45% more green water (4.33 m^3/kg vs. 2.98 m^3/kg) and approximately 26% more blue water (7.33 m^3/kg vs. 5.84 m^3/kg), than its counterpart product. It consumes less grey water by some 34% (0.51 m^3/kg vs. 0.77 m^3/kg). At processing stage, Parmigiano Reggiano PDO consumes 15% less blue water than the reference product (51.46 m^3/kg vs 60.75 m^3/kg).

Social Indicators

Employment

The labour use ratio indicator, calculated based on output, reflects labour requirements per unit of physical output (Just and Pope 2001). At farm level, the allocation of labour to production is lower for Parmigiano Reggiano PDO cheese than for its non-PDO reference (Italian milk specialised farms). At farm level, it takes 6 hours of work to produce a ton of milk, while the reference product requires 9 hours. The difference (−37%) indicates that the PDO product generates less employment than the reference system. This result should be interpreted with caution, as it may reflect the fact that in Parmigiano Reggiano PDO dairy farms, rather than labour being hired, it is more frequent for family members to work and their hours tend to be underestimated. The latter effect may be due to Parmigiano Reggiano PDO dairy farms being smaller than those producing milk for the reference product such that they require less labour, as a whole.

At processing level, the relative difference is slightly smaller in absolute terms and is favourable to the PDO cheese, since it takes 46 hours of work to produce one tonne of cheese compared to 37 hours for the reference product. This reflects the milk-to-cheese ratio and the artisanal nature of the processing "technology" of Parmigiano Reggiano PDO.

The turnover-to-labour ratio indicator provides an insight into labour productivity. The average turnover per employee is higher for the PDO farm than for the reference (+69%). The productivity levels are much higher at the processing level, with a slightly smaller relative difference (+38%) in favour of Parmigiano Reggiano PDO. These differences may be due to the combination of the price premium and the lower AWU at farm level, while at processing stage it reflects the price premium of Parmigiano Reggiano PDO compared to the reference.

Bargaining Power

Bargaining power is fairly evenly distributed among producers and processors for Parmigiano Reggiano PDO, although processors enjoy an advantage over farmers, thanks to their collective organization in a professional union. By way of contrast, bargaining power is very unevenly distributed for the reference product, because there are far fewer processors than farmers.

Educational Attainment

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The education attainment indicator, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases.

At farm level, the level of educational attainment is higher in Parmigiano Reggiano PDO than in its reference (+8%), while at processing level the indicator for Parmigiano Reggiano PDO is lower by 5%. At processing level, the result may reflect the use of immigrant labour employed in the production process. It could also be due to the more industrialised production processes in the reference product which require higher levels of education and skills are needed to operate the processing equipment.

Generational Change and Gender Equality

At farm stage, the supply chain of Parmigiano Reggiano PDO is only slightly more sustainable than that of the reference product as shown in the generational change indicator. In absolute terms, the dairy farming stage of the supply chains of both products appears to be endangered in its sustainability prospects, because the value of the indicator is smaller than 100%. This is brought about by a limited participation of 15–35 year-old workers compared to 45–65 year old workers at the farming stage. The gender equality index calculated at the farming stage suggests that this stage of the Parmigiano Reggiano PDO supply chain is slightly more unsustainable than the same stage for the reference product, because the value of the indicator for the PDO is slightly lower than the value of the indicator for the reference product. This is largely due to the lower percentage of female farmers, compared to the reference case.

At the dairy processing stage, Parmigiano Reggiano PDO appears more sustainable than the reference product with regard to the generational change indicator. However, because the values of the indicator for both supply chains are lower than 100%, both products appear somewhat endangered in their social sustainability prospects because of the low rate of employment of young compared to older people. On the contrary, in terms of the gender equality indicator the reference product is more sustainable than the Parmigiano Reggiano PDO, mainly due to the low level of dairy female ownership in the system of the Parmigiano Reggiano PDO, compared to the reference product.

Overall, and on average across all the stages of the supply chains for which indicators were calculated, the supply chain of the Parmigiano Reggiano PDO is slightly more sustainable than the supply chain of the reference product according to the generational change indicator. However, the reference product is more sustainable than the Parmigiano Reggiano PDO according to the gender equality indicator. In absolute terms, the supply chains of both products appear to be characterised by limited social sustainability, given that the supply-chain average of the generational change indicators are lower than 100% for both products and the value of the gender equality indicators are very low.

Conclusions

The Parmigiano Reggiano PDO system is very complex as it includes numerous different private and public agents. Chain members are linked closely to one another and with the area. Enviromental, economic and social dimensions are connected through tecnological and sociological aspects. The Parmigiano Reggiano PDO system is strongly integrated into local development, which entails a lively and efficient production system. This makes the link between the Parmigiano Reggiano PDO system and the economic district stronger, and above all it explains the economic viability and sustainability (i.e., survival over time) of the Parmigiano Reggiano PDO system. De Roest (2000:252) writes: “the integration of positive externalities generated within the district into a firm balance alleviates the higher costs generated by limited economies of scale”. In the central zones of the Parmigiano Reggiano PDO production area "information on the market prices of Parmigiano Reggiano PDO cheese, new technologies and compliance with the regulations covering the production (mutual social control) circulates intensely. The consiousness of belonging to the Parmigiano Reggiano PDO system and of sharing this common culture is the primary force that ensures the continuity of the system". The link between the Parmigiano Reggiano PDO system and the economic district depends on both social structure and values and on institutional support. Local research centres and public administrations support the technological development of the Parmigiano Reggiano PDO system which maintains the quality of the cheese and its artisan characteristics.

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Organic Yoghurt in Germany

Michael Böhm, Lisa Gauvrit, and Burkhard Schaer

Market Development of Organic Cow Milk Yoghurt in Germany[1]

Consumption of organic food has grown steadily in Germany in recent years. In 2016, the turnover of the organic food sector was around 9.5 billion euros, which is an increase of about ten percent compared to 2015 (Fig. 1).

However, the market share of organic food products in Germany in 2016 was still low, accounting for only 5% of the total private spending for food. With a market share of 4.3%, the market for organic milk products at consumer level is more important than that of other similar animal products.

The market share of organic yoghurt in the total yoghurt market was 5.5% in 2016 (Fig. 2). And for natural (non-flavored) organic yoghurt, the market share of 7.3% is even higher than that for drinking milk (BLE 2018b; AMI 2017b).

In Germany 2016, approximately 175,500 organic certified dairy cows were reared on around 4000 organic farms (Destatis 2017). The number of dairy cows has risen by almost 16% compared to the previous year (AMI 2018a).

Organic milk production is concentrated in the southern regions of Germany. Overall, nearly two thirds (65%) of the total organic milk production is located in the two southern Länder, Bavaria and Baden Wurttemberg. Compared to organic milk production, conventional production is less concentrated and more evenly distributed throughout Germany (Fig. 3).

[1] This chapter refers to available market data on organic natural yoghurt (non flavored) from cow's milk in Germany. In cases where the market data for organic natural yoghurt was not available, we used market data for both, flavored and unflavored yoghurt or even for the organic dairy market as a whole. Unless otherwise stated, the market data refers to Germany and the reference year 2016.

M. Böhm (✉)
Ecozept, Freising, Germany
e-mail: boehm@ecozept.com

L. Gauvrit · B. Schaer
Ecozept, Montpellier, France
e-mail: gauvrit@ecozept.com; schaer@ecozept.com

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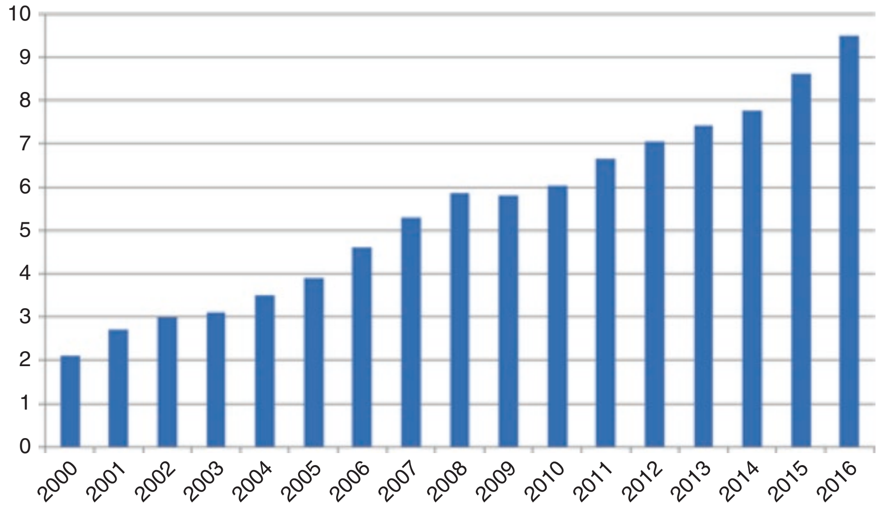

Fig. 1 Organic food turnover at retail level in Germany (in billion €). (Source: Graphic of Ecozept based on Statista 2017)

In 2016, total German production volume of organic milk was 794,700 tons, whereas 31,972,700 tons of conventional milk was produced (AMI 2018a; BLE 2018). In recent years, the organic milk market as a whole has experienced significant growth. In 2016, the milk market grew by 8.5% compared to the previous year (AMI 2017a, b). Compared to 2008, organic milk production in Germany in 2016 had increased by over 70% (AMI 2017a, b).

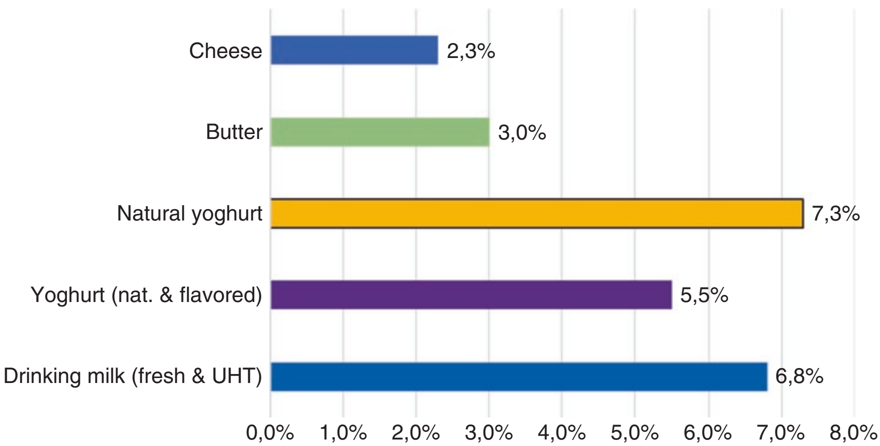

Fig. 2 Market share of selected organic milk products compared to the respective global milk markets in Germany (2016, in terms of quantity purchased). (Source: Ecozept on basis of data from AMI)

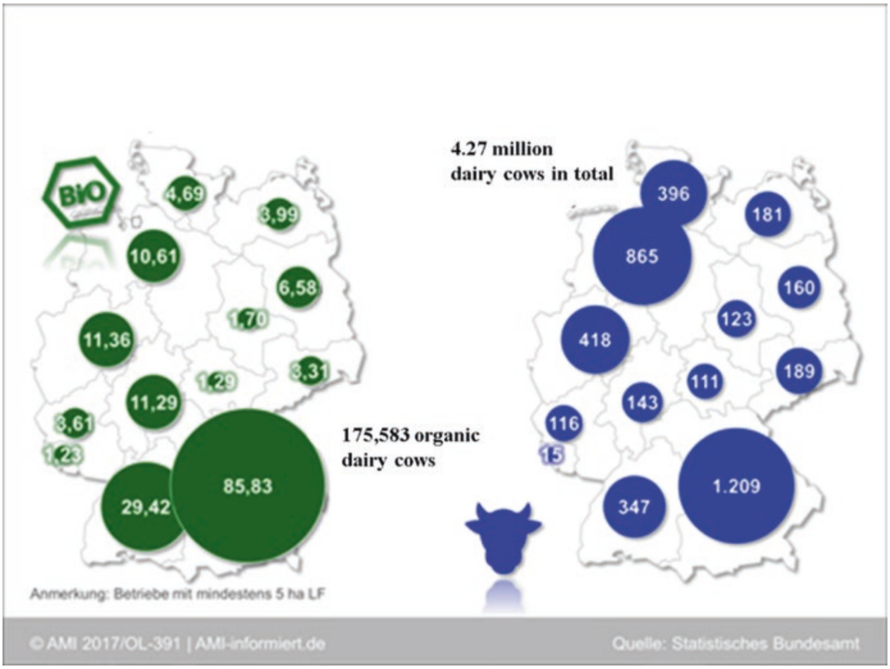

Fig. 3 Number of organic dairy cows (left side) and total number of dairy cows (right side) per federal state in Germany in 2016. (Source: AMI 2017a, b (OL-391), modified)

A total of 47,300 tons of organic yoghurt was produced in Germany in 2016 (AMI 2017a, b), and at consumer level, a total of 54,000 tons of organic yoghurt were sold on the German market. The discrepancy is accounted for by imports. About two thirds (63.6%) of the total quantity of yoghurt was sold as natural yoghurt, 38.7% as fruit yoghurt and the remaining quantity as tzatziki (AMI 2018a). This is the opposite of conventional yoghurt, where only 34% is sold as natural yoghurt. The average per capita consumption of yoghurt in Germany was 16.7 kg per head in 2015, of which 5.6 kg was natural yoghurt (MIV 2017a, b).

The recent growth in German organic milk production is mainly due to the conversion of conventional farms. In addition, existing organic farms have expanded milk production (AMI 2018a). This growth can be mainly explained by stable and high producer prices for organic milk. In recent years, the conventional milk sector has been subject to strong price fluctuations. The average producer price for organic cow milk with 4.0% fat and 3.4% protein was 48.19€ cent per kg (farm gate) in 2016, which compares to 26.70€ cent per kg for conventional milk (Bioland 2017). At the end of 2017 however, the gap between conventional and organic milk producer prices had narrowed to around 20% (AMI 2018a).

Quality Attributes of Organic Milk

In general, health, environmental protection and the abandonment of chemicals and pesticides are the main reasons for buying organic food (Hemmerling et al. 2015). The most important purchasing motives for organic products among German consumers are animal welfare, regional origin/support for regional farms, less use of additives and processing aids and lower pollution (BMEL 2017).

Research on comparison between organic and conventional milk products shows differences in quality with measurable factors such as higher Omega-3-content (Alfödi & Nowack 2015) Conjugated Linoleic Acid (CLA) (Bloksma et al. 2008; MRI 2018) ruminant fatty acids, and iron content as well as a higher level of vitamin E (alpha tocopherol), beta-carotene (vitamin A precursor) and other antioxidants like lutein and zeaxanthin (Bloksma et al. 2008; European Parliament 2016). Moreover, organic milk was considered to be creamier and tastier than conventional milk and had a higher lymphocyte stimulation index (Bloksma, et al. 2008).

Ninety per cent of German milk production occurs under private organic production standards, which apply stricter rules than those laid down in EU Regulations 834/2007 and 889/2008. However, organic production is a quality system based on special production and processing methods, rather than on final product specifications. Many advantages of organic milk products are therefore more or less directly related to the special requirements of organic animal husbandry (Table 1).

Description of the Value Chain

The value chain as described above covers all important steps from feed production to the retail stage (Fig. 4). It is important to stress that not all of the final products are required to follow this scheme. The typical value chain for organic milk in Germany is similar to the conventional one. Major differences are that in the conventional value chain, the wholesale stage is more developed and brokerage is more important due to the spot market upstream. (Expert interviews and Sanders et al. 2016).

Inputs from other areas which are not presented in the value chain above (Fig. 4) are:

- Agrarian technology, stable equipment, animal health and reproduction products (veterinary). Reproduction methods are similar to the ones employed in the conventional chain, i.e., mostly artificial insemination, but transfer of embryos is not permitted in organic production.
- packaging materials
- skimmed milk (powder and liquid), lactic acid bacteria (lactobacilli) for yoghurt processing; Sugar, which can be added in rare cases.

Table 1 Rearing conditions, processing standards and quality attributes of organic yoghurt production in Germany

Influence factors	Requirements in organic production/quality attributes
Feed	It is compulsory to have 100% organic certified feed for dairy animals. Moreover, at least 60% of the dry matter in daily rations of herbivores consists of roughage, fresh or dried fodder, or silage (§20 of EU regulation 889/2008). Private standards also require that feed be produced in Germany. The quality of the milk produced, in terms of fatty acid composition, depends on the feeding regime of dairy cows. A high proportion of roughage, especially grass in the feed, results in a comparatively high content of omega-3 fatty acids in the milk (Steinberger 2018). In order to improve nitrogen fixation, organic farms usually have clover in their grassland cultivations. Grass and clover both have a high omega-3 fatty acids content. Another group of fatty acids – ruminant fatty acids – are found in higher concentrations in organic compared to conventional milk (European Parliament 2016).
Health and treatments/ keeping	Since the preventive use of antibiotics is forbidden and the curative use is heavily restricted (with double the waiting period than in conventional production), there is a lower risk of having antibiotics in the final product or of development of antibiotic resistance (European Parliament 2016; Smith-Spangler, et al. 2012). Animals reared under organic conditions are not confined and can thus express their natural behaviors. They have access to exercise in the barn as well as to outdoor activities such as grazing, and might therefore have lower risks of illnesses (Sautereau and Benoit 2016).
Taste and ingredients	According to Smith-Spangler (2012), organic dairy products have a higher nutritive value in terms of omega 3 (56%) and a higher vitamin E and iron content as well as a lower level of iodine and selenium (Sautereau and Benoit 2016). On average, replacing conventional with organic dairy products while keeping the diet constant will increase the intake of omega-3 Poly unsaturated Fatty Acids (PUFA) by approximately 4% (European Parliament 2016). It has also been found that organic milk might contain a higher content of vaccenic acid or conjugated linoleic acid, reducing risk of eczema (KOALA study conducted in the Netherlands).
Environmental and resource protection	The main benefits of organic milk production from an environmental point of view are higher part of grassland/pasture in feed (Thünen 2017; Steinberger 2018), which improves carbon sequestrations (Sautereau and Benoit 2016). In a Dutch study, it has also been found that the energy use per unit milk in organic dairy is approximately 25% lower than in conventional dairy, while GHG emissions are 5–10% lower. (F.F.P. Bos, et al. 2014).
Transport	EU regulation on organic production does not limit transports in a special way. But most of the private certification organizations limit the transports to the slaughterhouse to four hours or 200 kilometers, in order to limit animal stress. Tranquilizers are not permitted for organic animals. Straw is required during the transport and in some areas of the slaughterhouse. Some certifiers define the maximum animal number in the vehicle or the space over the heads of the animals. Moreover, by growing most of the feed on the dairy farms themselves, organic production seeks to minimise the environmental impact of feed transport over long distances (Feeding + Dairy Co 2012).

(continued)

Table 1 (continued)

Influence factors	Requirements in organic production/quality attributes
Processing	Organic milks contain a higher content of Conjugated Linoleic Acid (CLA), which is a polyunsaturated fatty acid, and a higher content of antioxidants than conventional milk. Even after processing, these advantages are preserved (Butler et al. 2011). Although processing methods are the same in organic and conventional milk, the use of processing aids, additives and other substances is very limited in organic processing. In organic processing, only 54 additives are permitted, whereas in conventional processing more than 320 additives are permitted (BMEL 2018). For example, in organic yoghurt processing, processing aids reducing breeding time of yoghurt are not allowed, nor are artificial flavors or preservatives. Some organic processors also avoid using milk powder, which prevents the whey-water separation, though it is permitted in organic processing.

Source: Elaboration of Ecozept information from sources cited, EU Regulations 834/2007 and 889/2008 and guidelines of private certification standards (Naturland, Bioland, Biokreis, etc.)

Milk Producer and Milk Producer Associations (U3 and U4)

U1-U2 A major difference between conventional and organic milk production is the origin and the composition of feedstuff. In general, organic farms produce their own feed or produce it in cooperation with neighboring organic farms. Organic feed is procured to a lower extent than in conventional farming. Moreover, organic dairy cows are mainly fed with roughage from pasture, at least in summer. Producers of crop inputs (U1) thus play a minor role in the organic dairy supply chain. Organic

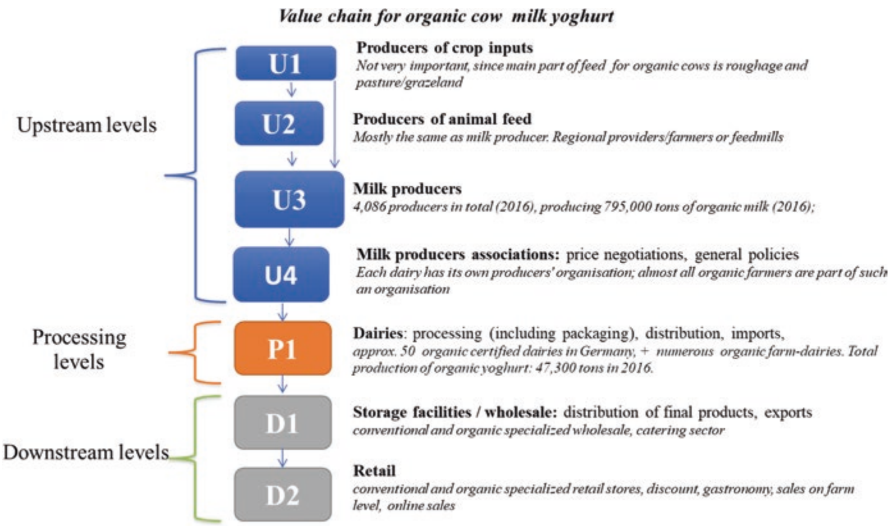

Fig. 4 The different steps of value chain for organic cow yoghurt Germany and types of companies involved in. (Source and elaboration: Ecozept)

dairy cows are fed less with concentrate (<14% of the total daily ration), than conventional ones (24% average) (Warnecke et al. 2014).

U3 The dairy cow feeding system is mainly based on roughage (grazing, hay, and others) from the same farm. The proportion of roughage varies according to season (summer/winter) and region (north/south Germany), but it is never below 60% of the daily ration. There are two main feeding systems in organic cow rearing depending on the season: in summer, 70–90% grazing, and in winter mostly grass- or maize-silage and grains (Blanc 2017, Hörtenhuber 2013). According to the experts interviewed (Ofenbeck 2018; Steinberger 2018), pasture periods are becoming longer as vegetation periods lengthen because of climate change. This trend to a "pasture based rearing system" leads to a significant higher performance in carbon sequestration as well as biodiversity preservation (Hörtenhuber 2013).

In Germany, the average organic dairy farm rears 40 cows (57 in conventional) and uses 57.2 ha of utilized agricultural area (59 ha in conventional), but these values vary depending on the region (Thünen 2017). These figures clearly indicate the lower animal density in organic farming (1 organic dairy cow every 1.43 ha on average) compared to conventional farming (1.03 ha/cow).

The dairy cow breeds used in organic farming are similar to those in conventional farming and can be classified into three main groups: Simmental (Fleckvieh), Brown Swiss (Braunvieh) and Holstein Frisian (Schwarz/Rotbunte) (LKV 2016; KTBL 2017). In Southern Germany (especially in Bavaria), nearly 75% of the dairy cattle is Fleckvieh (LKV 2016), whereas in the northern parts, Schwarzbunte (Holstein) are dominant. The proportion of Braunvieh is slightly higher in organic farming than in conventional dairy farms (LKV 2016). The share of crossbreeds (meat/milk) is more or less the same in both value chains (Schumacher 2018).

Looking at breeding objectives, there is concern in the organic farming value chain that conventional breeders (and some organic breeders as well) are trying to obtain hornless breeds, mainly for safety reasons. Organic farmers (Demeter) fear that horned dairy cattle will die out in a couple of years if the ongoing genetic selection is not halted.

Organic cows produce approximately 10–20% less milk than conventional cows. Results from 2017 show that organic reared cows give on average 6348 litres/year, whereas the average of conventionally reared cows is 7037 liters (Thünen 2017). All organic cull cows are generally sold in the organic value chain with high added value, whereas male calves generally end up in the conventional sector for fattening. The average lifespan of organic milk cows (5.7 years) is not much higher than that of conventional cows (5.5 years; LKV 2014, 2016). In both production systems, young calves are separated from their mothers at an early stage.

A key difference between conventional and organic rearing conditions lies in the reproduction methods: transfer of embryos is forbidden in organic farming.

U4 Each organic milk producer is part of a producer association, which is not always the case in the conventional value chain. These associations, called "MEG" (Milch-Erzeuger-Gemeinschaften) are cooperatives or other forms of organization.

Each dairy belongs to its own producer organization, which is responsible, *inter alia*, for price negotiations, general policies and quality patterns. Compared to the conventional sector, the price of organic milk is higher and less volatile (See price development below). This is for three reasons. First, the organic market is less export oriented and therefore less dependent on global price fluctuations. Second, price setting is completely disconnected from price setting in the conventional supply chain and separate negotiations are carried out, mainly by specialized associations. Thirdly, production aims at delivering smaller quantities of intermediate or bulk-products (like powder) but more of final consumer products, for which the contract periods in general are longer (AMI 2017c, expert interviews).

Dairies (P1)

In Germany, there were approximately 50 organic certified dairies in 2016 (Sanders et al. 2016), half of which process organic certified milk only, while the other half is composed of "mixed dairies". At least 17 of these produce organic yoghurt, most of them in southern Germany. Six organic certified dairies produce more than 85% of the total volume of organic yogurt (Fig. 5).

This number is high, since according to MIV (2017a) the total number of all milk processing companies was 124 in 2016. It appears that the organic value chain is not so affected by the concentration process of mergers ongoing in the conventional dairy sector (MIV 2017b). Approximately 2/3 of the total milk production is collected by cooperatives, and only 1/3 by privately run dairies or companies (MIV 2017b, page 11). In the organic value chain, half of the organic certified dairies are cooperatives and the other half is composed of private companies (Blanc 2017, Brügmann 2018a, b).

Nevertheless, the organic value chain also faces problems in collecting milk on a regional level, since the dairies need to expand their collecting area in order to achieve economies of scale at the facility level (Runge 2015). Experts state that the spot market has no relevance for organic yoghurt production (Szezinski 2018; Scheitz 2018; Brügmann 2018b). Almost all organic yoghurt processing dairies use their own collected milk for production.

Organic processing methods are mostly the same as the conventional ones. Standardized milk and milk powder can be used, although use of processing aids and other inputs is very limited in organic processing. At processing level, if storage as organic milk powder is not viable, organic milk can be exceptionally downgraded into the conventional value chain, but very small amounts are concerned.

There is no reliable data on the importance of on-farm (or farm-based) dairies in organic production. This is partly because the term "Hofmolkerei" or "Hofkäserei" (farm dairy) is not legally protected in Germany. The national "association for crafted milk processing" (Verband für handwerkliche Milchverarbeitung – VHM) has its own definition of what farm dairies are (at least 51% of the processed milk is

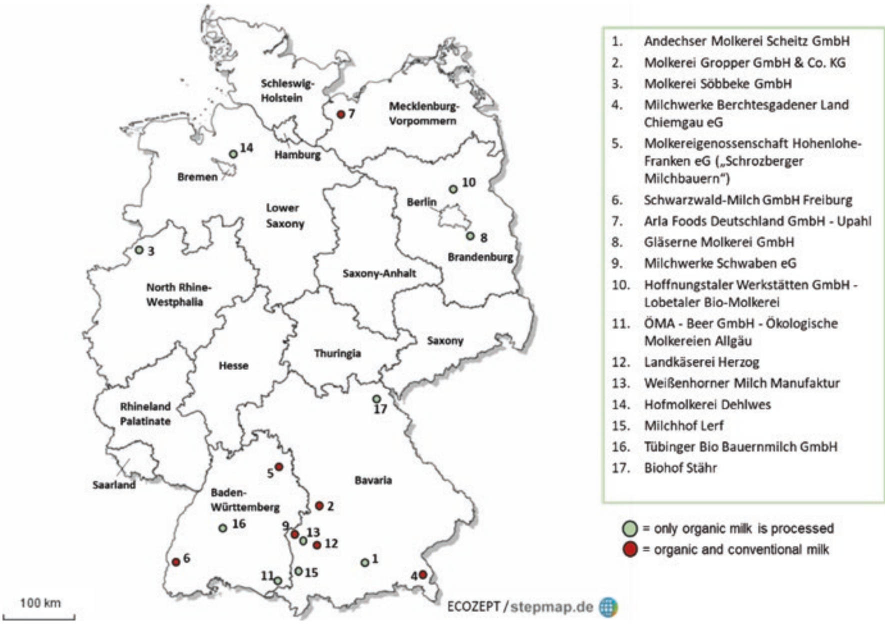

Fig. 5 Location of the main organic yoghurt producing dairies in Germany. (Source: Ecozept elaboration on the basis of expert interviews; farm websites and secondary data)

produced on farm) and delivers a product with its own brand. But no statistics are available on yoghurt processing volumes of these farm dairies (Albrecht-Seidel 2018; Mack 2018).

Storage Facilities, Wholesale and Retail (D1, D2)

The degree of self-sufficiency for organic milk products in Germany in 2016 was around 67%, expressed in milk-equivalent and at the consumption level (AMI 2017b). Austria as well as Denmark, and to a lower extent the Netherlands, Switzerland and France are the main countries supplying organic milk products (AMI 2017a, b). According to market experts, there is no consolidated data available on volumes dealt on the spot market, but the volumes are very small, and there are also other countries involved, like the Czech Republic (Mack 2018).

Concerning organic yoghurt, in 2015/2016, around 6700 tons of organic yoghurt (flavored and natural) were imported, mainly from Austria, which corresponds to 13% of the total organic yoghurt consumption (AMI 2017a, b). The import rate for organic natural yoghurt is only 9%. The main exporting countries are Austria (covering nearly all imports) and, to a very small extent, Poland and the Czech Republic (AMI 2017b).

In addition, a few German organic milk products are exported to other European countries and China (AMI 2017a). This export mainly concerns milk products such as whole milk powder, skimmed milk powder, cheese and whey powder. There is no official information on export of organic yoghurt. But according to market experts, export of organic natural yoghurt is undertaken by very few market players, is lower than 4% of the total production volume (Rampold 2018; Brügmann 2018a, b) and is exclusively to European countries, France being one of the destinations.

Regarding the distribution channels, organic yoghurt is supplied to consumers through four main channels:

1. Conventional retailers like supermarkets (e.g., Rewe and Edeka) and discounters (e.g., Aldi and Lidl)
2. Organic specialized retailers: organic supermarkets and other organic stores
3. Direct sale from organic dairy farms to consumers
4. Other channels: mainly restaurants, canteens and the catering sector

In 2016, nearly 75% of organic natural yoghurt was sold in conventional supermarkets (38.3%) and discounters (34.9%). Only 21% of the organic natural cow yoghurt was sold in organic specialized retail stores via organic specialized wholesalers like Weiling, Dennree, Bodan, Terra, Willmann, Naturkost West, Naturkost Nord, Epos or Ökoring.

The number of brands of organic milk products in Germany is continuously rising. Some examples are: *Andechser Natur*, *Söbbeke Pauls Biomolkerei*, *Schrozberger Milchbauern*, *Lobetaler Bio*, *TüBio*, *Alpenzwerg (Berchtesgadener Land)* etc. Beside these brands of organic processors, the main German conventional retailers like Edeka, Rewe, tegut, Real, Feneberg, Lidl and Aldi also offer organic yoghurt through their own organic (retail) brands. Specialized organic wholesalers and retailers also sell their own brands of yoghurt. Examples are "alnatura", "bioladen∗" (Weiling) or "dennree". At retail level, the share of 1 kg packages and 500gr cups (both available in glass and plastic) is lower than for conventional yoghurt. More than 90% of the natural yoghurt sold in Germany is packed in cups with contents of 475gr or higher, whereas this kind of packaging has a market share of only 66% in the case of organic yoghurt (AMI 2018b).

Despite the slight price fluctuations for organic milk at producer level and the growing supply, the price of organic yoghurt at consumer level remains relatively constant, even in the discount channel. Organic natural yoghurt with 3.5% fat content is sold on average for €0.36 per 150 g pack in German retail stores. The prices for organic yoghurt were lowest at discounters for all types of yoghurt in Germany in 2016 (AMI 2018a).

Governance of the FQS

The description of governance is based on Porter's Five Forces model. In general, the value chain of organic yoghurt is not marked by industry rivalry, although there is competition between the two main distribution channels, "conventional retail" (supermarkets and discounters) and “organic specialized retail” (organic food stores and organic supermarkets).

Another type of rivalry occurs within the organic value chain: the competition between organic retail brands and dairy brands. There are in fact a few dairies specialized in processing on behalf of organic retail brands like “alnatura”, “dennree” or “bioladen∗” (Meier 2016), as well as on behalf of conventional retailers like Rewe, Lidl or Aldi. This runs the risk of losing transparency, which is increasingly demanded by German consumers, since names of dairies are often not shown on the packaging of retail brands.

Nowadays, all German organic dairy farmers can sell their milk as organic, since all production regions are covered by the collecting systems of organic certified dairies. There is no decertification mechanism. Contracts are generally negotiated by producer associations (MEG and dairy associations) and agreed on a long-term basis, for more than two years. Farmers’ bargaining power can therefore be considered high. The threat of new entrants exists in the form of actors from other countries, especially given that German self-sufficiency in organic milk was only around 70% in 2016.

The threat of substitute products is serious, since other labelling schemes exist and are gaining market share. Concerning Germany and Austria, experts say that the most important competition for organic milk is “hay milk” (Heumilch). In 2017, approximately 1000 farmers were producing this product in Germany, mainly in the south, under the TSG[2] European certification scheme. In terms of volume, this kind of quality milk accounts for less than 1% of the total German milk production volume (TopAgrar 2018). Unlike in Austria, German Heumilch farmers and dairies tend to obtain the organic certification in order to compete on the market. German consumer expectations of Heumilch seem to differ from Austrian ones.

Other competing products are labels like “GVO-frei” (GMO-free) “Weidemilch” (pasture milk), “Alpenmilch” (milk from the Alps) and “Berg(bauern-)milch” (“mountain farmers’ milk”), but these concern mainly the fluid milk sector and not so much yoghurt, so are less relevant for this study. There is also competition from alternative non-dairy vegan products (e.g., soybeans, oat, almond, rice, hemp, lupine, pea and coconut). Consumption of organic soy yoghurt and soybean cream products is increasing in Germany and reached a 7% market share of the entire organic milk market in 2015 (BÖLW 2016). Not all of these types of milk are made into yoghurt, but the variety of products is increasing.

[2] “REGULATION (EU) 2016/304 of 2 March 2016 entering a name in the register of traditional specialties guaranteed (Heumilch/Haymilk/Latte fieno/Lait de foin/Leche de heno (TSG))”

Private Certification Standards – A German Specificity

In Germany, two organic markets exist in parallel: the market for organic products, certified under EU organic regulation and the market for Verbandsware, which covers products certified according to one of the private organic standards[3]. For cow milk, private certification covers 90% of the whole organic milk market.

In principle, these markets can be considered as separate, since products certified according to private standards do not allow organic raw materials, certified according to EU standards. Furthermore, they generally operate with different prices, at least for raw materials, but not always for intermediate or final products, and with special labelling. Sometimes, there are even different distribution channels because certain organic retailers only allow privately certified products.

But in reality, these markets are no longer completely separate: there is no significant price difference between them. A Demeter farmer may get the same price for Demeter milk as another farmer producing according to EU standards elsewhere. At dairy level, EU-certified milk is never mixed with milk certified to higher private standards; but the opposite may sometimes occur.

Organic dairy farmers in Germany choose among the private certifiers for market access reasons. It is a peculiarity that on the German organic retail market, organic milk products have rarely been sold at low prices even in the discount channel in recent years (Brügmann 2018a).

Price Negotiations

Sanders et al. (2016) state that organic supply chains create a higher value compared to the conventional supply chains. Indeed, the highest proportion of added value of organic drinking milk is generated at farm level, and a comparatively low share at processor level. This can be explained by the operation of powerful producer groups of organic milk farmers in Germany. These producer groups pool milk production and carry out negotiations with the dairies, which results in a stronger market position of each individual producer (Sanders et al. 2016).

This situation may also foster the development of organic dairy products through private certification organizations[4] (e.g. Bioland and Demeter) (Sanders et al. 2016).

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[3] A private certification organization is a union of organic farmers and manufacturers set up for the joint marketing and control of products. The first organization, founded in 1924, was Demeter. Demeter requirements are higher than those laid down in the EU regulation on organic farming. The most important organic certification organizations in Germany for milk are Bioland (which certifies 50% of the organic milk produced in Germany), Demeter, Naturland, Biokreis, Biopark and Gäa. These certifiers have their own standards ("EU+") which are checked by the yearly mandatory controls by German control bodies. Most of the 50 organic certified dairies in Germany are certified "EU+".

[4] In Germany, organic farmers associations like Bioland or Naturland are at the same time (a) (pri-

This has actually been the case in Germany: there are several farmer associations especially for organic milk, the "Bio-MEG's" – Bio-Milcherzeugergemeinschaften. These were set up with support from farmer associations like Bioland and operate independently from conventional producer associations. The MEG Milch Board was established in 2007[5].

In order to control the growing production volumes of organic milk in the coming years, organic dairies have developed different systems. Dairies often provide information about the state of market demand in regular newsletters, and new organic farmers can register on a waiting list and become members only if market demand increases. Farmers already contracted must apply for permission to expand production (AMI 2017a, b). There are regular meetings within the sector to discuss market developments.

To sum up, cooperatives and retailers appear to be the most powerful market actors in the organic milk sector. It is important to note that there no longer seems to be any difference between organic and conventional retailers when it comes to price negotiations and contracting. According to the experts interviewed, price negotiations can sometimes even be easier and more favorable for organic dairies with conventional retailers than with organic wholesalers.

Furthermore, there are many associations and institutions in Germany that support and develop the production and marketing of organic food products in general, but not specifically organic yoghurt. The most important ones are BÖLW ("Bund Ökologische Lebensmittelwirtschaft e.V.") – the umbrella organization of producers, manufacturers and traders, founded in 2002. There is also AÖL (organic processors organization) and BNN (association of organic wholesalers and retailers). There are, moreover, lobbying and umbrella organizations at the level of federal states, for example skills centers like the KÖN in Niedersachsen, and regional associations for organic farming.

Sustainability Assessment

Sustainability assessment of organic yoghurt in Germany was implemented (Fig. 6) through the specific methodology of Strength2Food (Bellassen et al. 2016). Some of the indicators were elaborated using values for the whole German organic sector, when values for the milk production sector were not available.

In the case of yoghurt, it was not possible to calculate indicators of gender equality, generational change, educational attainment or the local multiplier. The main reason for this was the absence or non-accessibility of statistical data. In some cases,

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vate) certification bodies, mandating inspections bodies to carry out controls on farms (b) lobbying organizations (communication via own labels) and (c) market actors through (outsourced) entities buying and reselling crops, animals, etc.

[5] www.milch-board.de/ueber-uns/organisationsstruktur.html and regional MEG's e.g.: www.bayern-meg.de/konzept/

we were able to generate empirical data from our own surveys, but not for all levels of the value chain, since this case study concerns approximately 4000 organic farms and 130 dairies over the whole of Germany. Empirical data on generational change and educational attainment was not available and expert interviewees did not feel confident to provide an estimate.

Price premium is positive and substantial all along the value chain. The farm level has the highest price premium, with 81%, followed by retail level (21%) and processing level (8%). The price premium appears to be lower downstream, especially at the processing level, but the quantitative flow of product needs to be taken into account. Processing and retail are more concentrated in the FQS and accumulate a significate premium.

Profitability is also higher for organic at farm level. Intermediate consumption and wages are very high in both organic and conventional sectors, but it is important to note that conventional production is not economically viable by itself, i.e. without subsidies. Moreover, organic farms are both more profitable in terms of cost/bene-

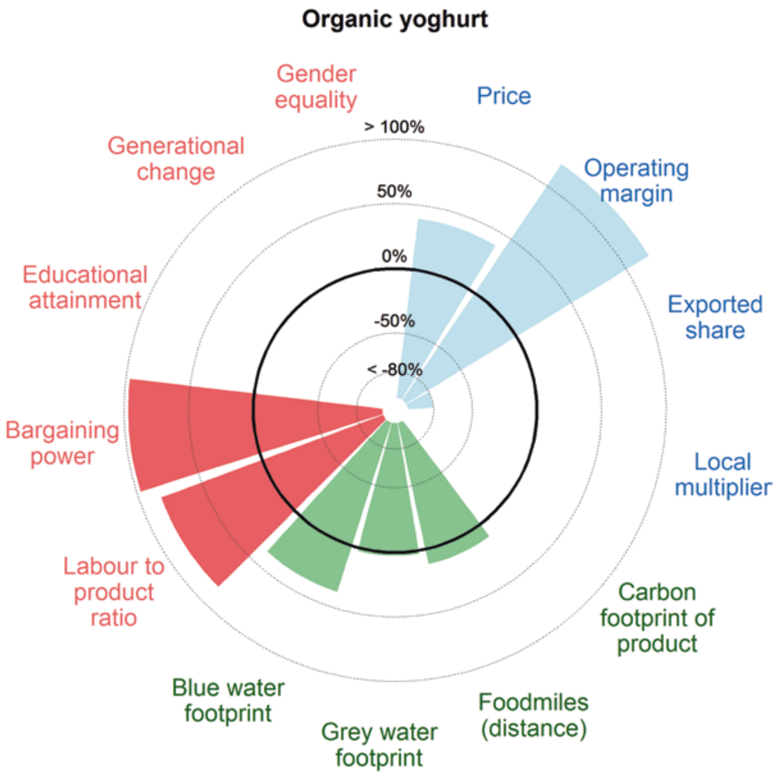

Fig. 6 Sustainability performance of organic yoghurt (supply chain averages). (Each indicator is expressed as the difference between organic yoghurt and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

fits relations and because they receive a higher level of subsidies. It should also be considered that organic farms are less productive and more labor-intensive, while conventional milk farms follow a strategy of higher volumes at lower prices. There is no data available at processing level on costs, but we can make the hypothesis that costs are similar, at least for similar production scales. Yields at processing level are also the same. The cost of collection can be higher for organic, as production units are smaller and more frequently located in mountain areas. Moreover, organic farms are less densely concentrated than conventional ones.

Finally, while 21% of conventional milk is sold in Europe at a higher price than on the national market, the share of exported organic milk is low, and the valorisation seems to be the same in domestic and export market. This could be explained by a higher ratio demand/supply for organic milk compared with conventional milk. Sales prices on export markets are not automatically higher than those for domestic markets; we assume that they are the same for natural yoghurt, which is a "basic product" in comparison with other high value-added milk products exported. Furthermore, export is sometimes simply a way of disposing of surplus volume without getting significantly higher prices.

Regarding the carbon footprint of organic yoghurt at farm level, the method used does not make firm conclusions possible. On the one hand, a higher output of greenhouse gases can be observed, as the milk-to-feed-conversion is lower in organic. But on the other hand, there is higher carbon sequestration in organic fields. The extant literature provides wide ranges of values of the estimated carbon footprint. Methods are not sound enough to draw conclusions on the carbon footprint of organic yoghurt production at farm level.

Over the entire supply chain, from farms to distribution (U3-D2), organic yoghurt travels 12% shorter distances (4500 vs 4400 t.km) and releases 30% less emissions (125 vs 175 kg CO2 eq) than conventional yoghurt. The shorter distance embedded in organic yoghurt is mainly due to a lower share of exports compared to conventional yoghurt (3.8% vs 21.5%), and to a more Europe-oriented export market. Moreover, the reference product is exported outside Europe, which drives the distance up, and by air freight, which drives emissions up since air transport is a far more carbon intensive mode than the road transport used for exports to Europe. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated along the value chain (i.e., more than 75%).

The green water footprint (rainwater use) has the greatest share of the water footprint indicator. But because there is generally no shortage of rainwater in Germany, this is not very important. Given that all feed is irrigated, differences in blue water footprint (surface and ground water use) are small, and higher for conventional yoghurt due to the manufacturing of nutrients and pesticides. Breeding, stable cleaning, animal beverage and processing also require some groundwater use, and this amount is a little higher for organic farms. Milk processing to make yoghurt however uses same amount of water in the two production schemes. However, the share of these uses in the overall water footprint is negligible.

The grey water footprint (water pollution by nitrates) is slightly higher for conventional yoghurt production. Crops used for conventional yoghurt in fact consume more nitrogen. But due to the substantial use of organic nitrogen in the organic value chain and the lower feed-to-milk conversion efficiency, the difference is not very high when grey water footprint is expressed on a per ton basis.

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is higher for organic yoghurt than for the reference product (German dairy farms). At farm level, it takes 17 hours of work to produce a ton of milk whereas the reference product requires nine hours. The difference (84%) indicates that the organic product generates more jobs than the reference system. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is higher in organic farm than in reference ones, with a relative difference of 6%. These differences are mostly due to higher sales prices at U3 level as well as higher financial support (subsidies to organic farms). We further assume, that staff costs (payment/remuneration) is similar in both value chains.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator,** which refers to the highest level of education that an individual has completed, makes it possible measuring certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The lack of specific data for the organic sector means no specific observations can be made. On German dairy farms (conventional and organic), the very large majority of employees have above secondary level educational attainment, with one-third holding a three-year first cycle degree.

Bargaining power in the organic supply chain is very evenly distributed between farmers and processors (value of 0.002), although processors show a small advantage. This can partly be explained by the fact that there are far fewer processors than farmers (although this is also the case in the conventional supply chain), but mainly by the following factors:

- strong consumer demand, which makes processors compete for raw matterials
- vertical long-lasting contracts between farmers and processors
- better relations between farmers and processors and shared values along the supply chain.

This advantage is partially offset by the fact that the contribution of farmers, producing organic milk, is key for the differentiation of the end product. In other words, the downstream level of processing enjoys a bargaining power advantage related to a more favorable competition landscape, i.e. fewer competitors, but this advantage is partially offset by the key contribution of farmers to the unique characteristics of the end product. This is because their milk is organic and producing organic milk requires specific agricultural practices and a specific organization of the farm.

Finally, bargaining power positions in the organic chain can be considered as average, as evidenced by the average bargaining power scores obtained at each level, the weakest level being that of milk production. This means that the whole supply chain can be considered as moderately vulnerable against any major changes, for example, entry of new competitors, or a change in market structure.

Our results show that bargaining power is well distributed along the conventional chain, although processors have a slight advantage (P1), at the expense of farmers (U3), which is probably because they are fewer in number. However, both U3 and P1 levels achieve very low bargaining power scores (0.19 and 0.33 respectively). These low scores also suggest that the supply chain would be vulnerable to significant change: entry of new competitors, changes in the market structure.

All in all, our results suggest that the organic supply chain enjoys a strong sustainability advantage over the reference product, as our calculations show that bargaining power is far more evenly distributed along the supply chain for the FQS than for the reference (index ratio is of 0.03). This finding is also supported by several characteristics of the supply chain which are not captured by our variables. The organic yoghourt supply chain is characterized by more stable relations between farmers and processors and by the fact that milk prices are more stable and higher.

Conclusion

Regarding sustainability parameters, the main differences between the organic and conventional cow milk value chain mainly concern production, and to a smaller extent processing and distribution. First of all, rearing conditions are not the same, and concern mainly aspects such as feed composition and feed origin, use of veterinary products as well as animal welfare aspects (i.e., density of animals, access to pasture). One major issue is the use of pasture and grassland, where opposing tendencies have been observed in recent years. Unlike conventional milk production, feeding systems in organic dairy farms are becoming increasingly "pasture based", whereas conventional rearing systems are moving towards "intensive" stable based productions systems with a large share of external feed inputs coming from arable farming. This leads to significant performance differences in biodiversity and carbon sequestration, although it is not possible to say today whether this carbon sequestration leads to a better carbon footprint for organic yoghurt production as a whole.

Differences in governance are found in the value chain. Farmers' bargaining power is higher in the organic value chain than in the conventional one. First of all, nearly all organic farmers are part of an organic milk producer association, which is not the case in the conventional sector. Secondly, private organic certification organizations (e.g., Bioland, Naturland) play an important role in the organic milk value chain. These organic farmer associations are certifiers, with higher production and processing standards. On top of this, they are also lobbying organizations for organic production as well as market players, and they also buy and sell organic products and participate in price negotiations. This also leads to the unique situation that more than 90% of German organic milk is certified according to higher production rules than those laid down in EU Organic Regulation 834/2007. Note that private certifiers are not so important in other organic value chains like meat or plant production.

Thanks to steadily growing demand, the bargaining power of organic producer associations and the planning of dairy output volumes, German producers of organic milk can rely on stable prices at a high level, compared to the fluctuating and often low prices seen for conventional milk. For this reason, German organic milk production has grown in recent years. Most of the experts interviewed for this study find no signs that this situation will change in the future, and that especially organic natural yoghurt can rely on steady growth rates. This rising demand may partly be related to the health benefits of organic milk products, which have been widely identified in scientific studies disseminated to consumers. Another reason for the steadiness of the organic milk market is the lower dependency on international markets. Compared to the conventional value chain, there are very few imports or exports in the organic value chain and the spot market has very little importance.

But the organic value chain is also threatened by changes in general market patterns. First of all, there is rising demand for organic "retail/distributor brands" in conventional as well as in organic distribution channels, which may lead to less transparency and disrupted links to the origin of the products. A second threat the organic value chain will potentially face is the ongoing concentration of dairies. This is taking place through mergers, but also through takeovers by bigger companies. There have been cases of organic dairies lacking financial resources for the necessary investments which have joined groups from other sectors. In a way, however, this risk is offset by a growing number of new processors, since ever more conventional dairies enter the organic market and obtain the organic certification. This may help to keep pace with consumer demand for "regional milk products". Only medium scale dairies operating on regional levels can meet this kind of consumer preference in the future.

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PGI Sjenica Cheese in Serbia

Jelena Filipović, Žaklina Stojanović, and Bojan Ristić

Introduction

This chapter examines sheep cheese production in Sjenica, the south-western municipality of Serbia, in the area of Pester. Sjenica sheep cheese is one of the best Serbian white cheeses in brine. Popović-Vranješ et al. (2011) state that production originates mostly in individual farms of the Sjenica-Pester plateau. Approximately 35,000 to 40,000 sheep are bred in this geographical area. Cheese is produced from fresh sheep milk without thermal treatment. White cheeses in souse are found round the world and comprise a range of types. Characteristics are increased sourness, sharp-salty taste, as well as compact but fragile consistency (Jovanović et al. 2004).

After production, the cheese is stored in wooden vats containing 20–50 kg of the product and there is no standard commercial packaging (Arandarenko et al. 2008). Manufacturers refuse to pack cheese in smaller quantities because they think it would lower quality, and say that best quality cheese is obtained when it is preserved in the wooden vats[1]. This is the main limitation on distributing the product. For retail, Sjenica sheep cheese is ordinarily packed in 1/2 kg or 1 kg vacuum packages[2]. All packages must bear the registered trademark prepared for the official registration of this product as PGI, which is an ongoing process. It represents the stylized heads of ewes and rams of the typical Sjenica breed, recognizable from the streaks on the snout, eyes and ears (Fig. 1).

This chapter comprises four sections. The first section describes the distinguishing features of Serbian sheep cheese from Sjenica, with a particular focus on facts and statistics related to sheep cheese production, the geographical area and main techno-

[1] Data obtained in in-depth interviews.

[2] Popović-Vranješ et al. (2011) and interviews in Belgrade supermarkets.

J. Filipović (✉) · Ž. Stojanović · B. Ristić
Faculty of Economics – University of Belgrade, Belgrade, Serbia
e-mail: jfilipovic@ekof.bg.ac.rs

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Fig. 1 Logo of Sjenica sheep cheese. (Source: Popović-Vranješ et al. (2011) p. 48)

logical characteristics of production. The second section describes the stakeholders of the supply chain, their connections, performance and interrelated functioning. The third section assesses the sustainability performance of Sjenica cheese compared with average cow cheese in Serbia, and the last section is a conclusion.

Overview of the Sheep Milk Sector

Average production of sheep milk in Sjenica amounts to 15,000 hectolitres. In 2016, 14,977 hectolitres of sheep milk were produced.[3] Jovanović et al. (2004) note that technological production requirements prescribe that 4 litres of milk on average are needed for the production of 1 kg of cheese. A quantity of nearly 374,44 tonnes of sheep cheese was made in 2016. Sheep milk is rarely destined for consumption in liquid form, and the calculations appear to tally.

Cheese is predominantly made in small households. Around 70% of households in Sjenica produce sheep milk and cheese. Given the social context, this kind of production is vital for the prevention of depopulation in the hilly mountainous region in the South of Serbia, especially in Sjenica.[4] That is why there are significant agricultural subsidies to households active in sheep production.

On average, a small household producing sheep milk has one fully employed person. Beside small households, which dominate in the milk processing sector, there are also 15 registered small dairy factories in the area. These companies employ 8–10 persons each, but their output is an insignificant share of total sheep cheese production in Sjenica[5]. However, registered export of sheep cheese is performed solely by these factories, given that households do not meet export requirements.

[3] Facts and data related to performance CS and its reference were collected from 4 main sources; (1) Statistical Office of the Republic of Serbia – SORS (www.stat.gov.rs), (2) Farm Accountancy Data Network for Serbia – FADN Serbia, (3) primary sources based on the interviews with farmers and processors, (4) previously conducted studies of the dairy sector in Serbia.

[4] For details of Sjenica municipality employment policy, see Arandarenko et al. (2008).

[5] In-depth interviews conducted for the purpose of this case study within Strength2Food.

All farms participating in the project "Optimization and standardization of the autochthonous technology of the Sjenica cheese with protected organic origin" were privately owned and carried out livestock breeding traditionally. Most were sized from 15 to 40 ha, with 75% of these surfaces owned by the household, and 25% rented (Bogdanović et al. 2004). Two groups of producers can be distinguished – traditional, originating from Pester and neighbouring mountains, and modern, who are mainly migrants from urban areas. The first group consists of producers who run the family business of the production of Sjenica cheese, in which all family members have their clearly distinguished roles and tasks. Their herds are big, usually about 300 sheep and 100 cows. The second "modern" group has much smaller herds and includes people who are unemployed or in low-paid work in the town of Sjenica, and opt to produce cheese because of the opportunity for fast and significant earnings. They usually produce several dairy products and not only cheese.

Geographical Area of Production

The municipality of Sjenica is shown as the dark red area in Fig. 2. It is part of Zlatibor County, the largest county in terms of land surface in the region and in Serbia. Agricultural land, in general, covers 80,818 ha of the territory of the Sjenica municipality, and almost 90% of that area is composed of meadows and pastures, which makes the area suitable for sheep production (Arandarenko et al. 2008).

Sheep cheese production in the Sjenica municipality takes place on the Sjenica-Pester plateau, the largest plateau in the Balkans and one of the largest in Europe. With an altitude of 1150 meters and an area of 63 km^2, it represents a unique oasis for sheep cheese production. The Pester plateau is unspoilt pasture, dotted with forests, agricultural fields and small villages. The Sjenica plateau is low-lying, while the Pester field is karstic and about 150–200 m higher than the Sjenica plateau.

Technological Characteristics

It is generally considered that grazing provides the best and cheapest sheep food, given that it can take place 8 months per year on average in Sjenica. Clearly, the higher the share of pasture, the lower the cost of feeding the sheep. Moreover, sheep are useful to maintain pastures, given the floristic characteristics in this region (Radivojević et al. 2004; Jovanović et al. 2004).

Sheep grazing on crop areas after harvest also allows for an efficient use of crop residues. Surfaces used for grazing would be otherwise difficult to exploit, and the use of plant or fruit residues in the fields is only possible through sheep farming.

Fig. 2 Geographical area of PGI-applicant Sjenica cheese

The yield of grain or grass expressed in nutrients is the most crucial determinant of the number of sheep per hectare. The total annual yield varies significantly. One hectare of pasture or meadow can host up to 20 sheep and their lambs (1.3 lamb per sheep on average). It appears however that the average number of sheep per ha is below optimal capacities, usually at around 10.

The use of feed in pastures is adapted to the growth of grass during the year. The most significant growth occurs during May, and then in June. During April, and later in July and August, growth is significantly reduced, while in September it falls to barely 40% compared to May. In October it is not more than 20%. Sheep pasture contributes to the fertilization of grazing area, which certainly adds up to the increase in grass yield (Poljosfera). The use of fields depends to a great extent on the skills of the keeper of the flock (herdsmen). Overnight, the herds are kept free in groups or in sheepfolds. The sheepfolds can be fixed, or in constant movement. If they are in constant movement, significant areas can be covered with manure, in amounts of 25–30 tons per hectare.

The simplicity of manufacture characterizes the production of sheep cheese. Immediately after dairying, sheep milk is filtered through gauze, then the rennet is added, which curdles milk to cheese. The milk is then blended and left to stand until coagulation is complete. This process forms a sufficiently solid mass, which is placed in the special linen for the process of squeezing, which is based solely on gravity. Cheese formation lasts until there is no remaining curd in the cheese bundle. This part of the process is crucial to the quality of the cheese. It is also essential that the temperature of the room where the boiling and pressing takes place is not below 20° Celsius. After squeezing, the cheese is cross-cut into slices and salted with kitchen salt, and then put in the 20–50 kg vats (Arandarenko et al. 2008). The cheese inside the linen is then loaded with weights between 5 and 10 kg (Fig. 3). Since cheese is made of raw milk, the maturation must be at least 60 days (Gavrilović and Đorđević (2016)). This relatively simple traditional production has remained authentic to this day.

Production usually takes place in the rural households or in the mountains in summer huts. Exceptions are small dairy plants that process sheep milk traditionally, of which there are few in the municipality of Sjenica. Cheese production is the output of a simple labour-intensive process which requires materials such as rennet, salt, strainers and packaging materials as well as milk. In the processing stage in the value chain, the product is stored in 20–50 kg wooden vats. As noted above, manufacturers have refused to pack cheese in smaller packages, either wood or plastic. They believe that different packaging would lower cheese quality. However, in retail stores, Sjenica sheep cheese is usually repacked in a vacuum pack of 1/2 or 1 kg or similar packaging.

There are few opportunities for distribution for this kind of product in Serbia. A proper and adequate distribution system is extremely complex. Specific aspects of Sjenica sheep cheese production make transport and storage problems very complicated. When output is sold to large retail chains a significant number of intermediaries are involved. Table 1 summarizes the technical specifications of the applicant-PGI.

Fig. 3 Typical packaging and storage of sheep cheese

Table 1 Technical specifications

Territory	
Geographical area	Sjenica (see Fig. 2).
Varieties/breeds	No specific breed constraint. The most common breed for Sjenica is "Sjenicka pramenka", recognizable by the expressive streaks on the snout, eyes and ears and shown on the logo for Sjenica sheep cheese.
Arable farming practices	
Fertilization	There are no particular constraints regarding mineral fertilization or feed. Sheep pasture contributes to the fertilization of grazing area. The rest of the animal diet is based on the fodder roots (carrots and fodder beat) and maize, conventionally produced.
Plant health	No specific requirements.
Field operations	No specific requirements. Farmers mostly use small diesel tractors (up to the 40 hp on average) for meadow grass mowing, collection and storage, usually taking place during summer months. Meadow grass is stored drying? chambers close to the sheepfolds.
Animal management	
Fodder self-sufficiency	No specific requirements. Up to 90% of fodder (on average) comes from farms or nearby pastures (2.5 km on average from farms). The rest of supplies originate outside the farms from more distant locations.
Grass and pasture	No specific requirements. Grass and hay account for an average of 88.5% in sheep diet.
Other animal feed constraints	GMOs are not permitted and supplements are produced conventionally.
Animal health and welfare	There are no particular limits or norms regarding animal health, medication or sanitary products. Animal welfare issues are not codified either. Strict rules do not appear to be required: the dominance of free grazing means there is little concern associated with animal confinement.
Process	
First stage	Main ingredients are: raw sheep milk, salt, wooden vats and time. The temperature of the room where the boiling and pressing of cheese is carried out should not be below 20 °C. The period of maturation of the cheese is 60 days.
Transportation	No specific requirement. However, transport and storage problems can be complicated. When production is sold to large retail chains, numerous intermediaries are required. Heavy Goods Vehicles, usually refrigerated trucks, are used for transportation from farms (processing stage) to retailers.
Conditioning	Optimal transport and storage temperature ranges from 4 to 6 °C. Product lifetime when adequately stored is up to 6 months. The final product must be stored in 20–50 kg wooden vats (see Fig. 3).

Sjenica Sheep Cheese Value Chain

Upstream Levels (U1, U2, U3)

U1 level refers to *animal feed production* (Fig. 4). Actors in this part of the value chain are mostly the same as *sheep breeders* or as *milk producers*, respectively U2 and U3 level of the value chain. In this way there is a difference with cheese production at national level, as input for milk production is not usually an integral part of cow farms. Moreover, grazing is a rare option in cow nutrition in milk farms in Serbia. Animal feed is not important because sheep grazing is dominant in sheep diet. Unlike cows, sheep are not "choosy" or particular in grazing (Grubić 2012). As a supplementary food, clover plays a minor part in animal diet during the grazing season and an essential part in the winter period.

Farms prepare animal feed for the offseason period, which is mostly stored in dry chambers close to the sheepfolds. Manure management in the offseason period is based on dry lots.

In the region of the Sjenica-Pester plateau, there are 35,000–40,000 sheep. Only 10% are dairying sheep, while rest are for meat production. Total milk production at the U3 level is 15,000 hectolitres on average. Given that 4 litres of sheep milk are needed for 1 kg of cheese, this amount of milk yielded nearly 370 tonnes of cheese in 2016.

The most recent agricultural census in Sjenica counted 5500 registered households. Approximately 70% of these are involved in sheep farming, which makes this

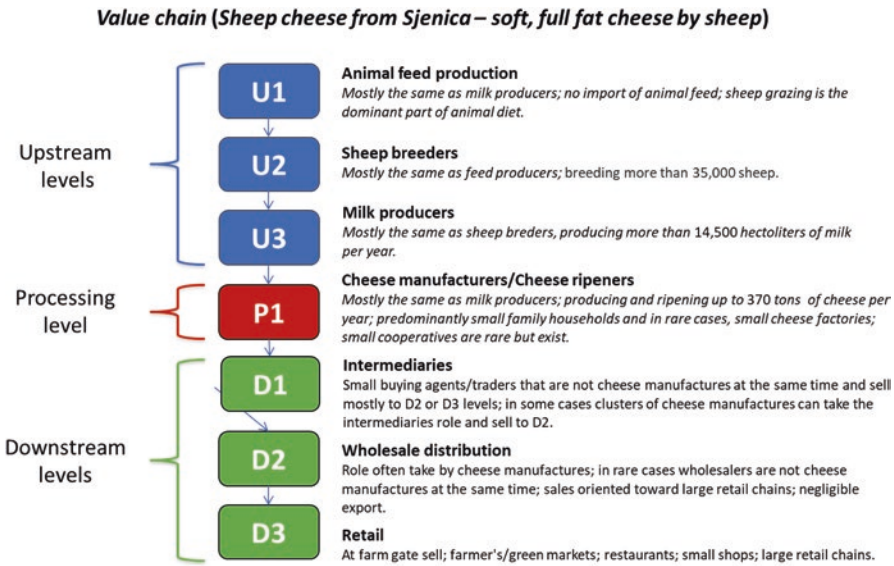

Fig. 4 Sjenica sheep cheese value chain

region valuable for sheep milk and cheese production. Natural characteristics of the terrain and climate are the main reasons for the importance of sheep farming. Employment of the rural areas of Sjenica municipality is largely based on farming activity. The majority of sheep farms are small (40–50 sheep), and need just one full-time employee to run them.

Registered wages are a negligible portion of total turnover at U3 level, because almost all turnover is for household consumption. There is no need for regular wages, which is why sheep farming is a "grey area" from the viewpoint of the state. This is perhaps understandable given the underdeveloped economy of the Sjenica municipality.

Processing Level (P1)

Processing level, P1, applies to *Cheese manufacturers/Cheese ripeners*. Leading actors at this level of the value chain are mostly the same as milk producers. They are predominantly small, family households and in rare cases, small cheese factories. Small cooperatives are rare in the rural regions of Sjenica. There are maximum of 15 small dairy factories, which account for a negligible portion of total sheep cheese production.

Downstream Levels (U1, U2, U3)

Downstream, the value chain consists of *intermediaries*, *wholesale distribution* and *retail*, respectively D1, D2 and D3 levels. Intermediaries are small buying agents or traders who are not also cheese manufactures. At most, they sell directly to D2 or D3 level. In a few cases, clusters of cheese manufacturers play the role of intermediary and sell to D2 or D3 levels directly.

Wholesale distribution is often carried out by small dairy factories or advanced intermediaries. Sales at wholesale level are oriented towards large retail chains. The regular export of sheep cheese is linked to D2 level, but it is negligible in relation to total output. Export is to neighboring countries, Montenegro, Macedonia, and Bosnia and Herzegovina. Because of the strict regulations in EU, which do not permit cheese products from unpasteurized milk, Sjenica sheep cheese is not officially present on the EU market. Manufacturers believe that boiling milk would conflict with the centuries-old tradition of production and affect the quality of cheese. However if EU standards were met, it is estimated that PGI labelled cheese of this quality could fetch up to 4 times the current price at retail level.[6] Export of cow

[6] Note that in 2016 the average retail price of Sjenica sheep cheese was EUR 4.85 per kilo. See at http://moja-pijaca-kucna-dostava.mojsajt.rs/Cenovnik1

cheese at national level is also low relative to domestic consumption, but it is higher than for Sjenica sheep cheese.

At retail level, the product is sold to final consumers mostly at the farm gate or at farmer's/green markets, restaurants and small shops. A smaller proportion goes onto the shelves of large retail chains at national level. Looking at the possible endpoints of the value chain, it is clear that farmers themselves can play U3-P1-D3 sequence for some of them, but communication with large retail chains requires mediation. Intermediaries are used at D1 or D2 levels, and sometimes even P1 level in the case of small dairy factories.

Sustainability Assessment of Sjenica Sheep Cheese

The methodology of the "Strength2Food" project (Bellassen et al. 2016) was applied to estimating the sustainability of sheep cheese from Sjenica. Sjenica cheese can be considered as a classic PGI product.[7] The most appropriate reference product appears to be cow cheese in general in the whole of Serbia. It should be noted that necessary data for S2F methodology were collected from *primary sources* (interviews with farmers and experts, and calculations based on available secondary sources) and from *secondary sources* (SORS n.d.; FADN n.d).

In ***economic indicators***, the PGI outperforms its reference product in both price and net results (Fig. 5). Those results are strongly driven by the higher price premium of sheep cheese, and lower production costs of sheep milk production (predominant grazing in animal diet, traditional labour-intensive milk processing, cheap labour, and above all, enormous subsidies at farm level). This results in a very high net result, much higher than the reference product (expressed as a percentage of turnover).

Export of PGI cheese is similar in percentages, but is lower in absolute volume. In 2016, Serbia recorded nearly 17 million hectoliters of milk production (predominantly cow milk). Around 60% of that volume was processed by 123 active (small, medium and large) dairy factories and 40% was processed by households. Percentages of export on total production do not provide much information about the relative performance of the FQS product.

In ***environmental indicators,*** we look at the carbon footprint, food miles and water footprint. The carbon footprint of the PGI sheep cheese is 83% higher than the reference cow cheese (21.3 vs 11.6 tCO2e ton-1 of cheese). The large difference reflects the greater efficiency of cow herds in transforming fodder into milk. Although the carbon footprint of each ton of fodder is similar for the PGI and reference product, ewes need three times more fodder to produce the same amount of milk as cows. While the diet of PGI ewes contains a higher share of grass and a lower share of maize than the reference product, the associated carbon benefits are offset by the yields of the dominant forage in both diets – grass – which is twice as

[7] Protected Geographical Indication (PGI).

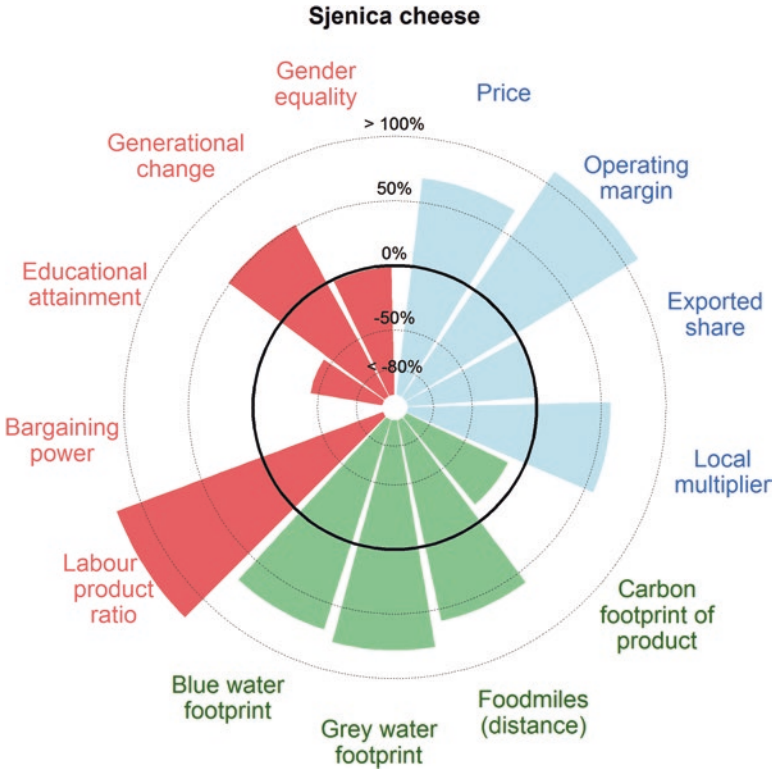

Fig. 5 Sustainability performance of Sjenica cheese (supply chain averages). (Each indicator is expressed as the difference between Sjenica cheese and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

high for the reference product without there being much more fertilizer use. This is because the plateau land of the Sjenica region is much less productive than the reference national average, and because of the combination of alfalfa with grass in the reference product.

The PGI Sjenica cheese supply chain was compared to the conventional cow cheese in Serbia for food miles. Over the entire supply chain, from milk to distribution units (U3-D1), there is a 40–55% difference in favour of the PGI. It travels up to half the distance (200 km instead of 450 km) and releases up to half the emissions (25 kgCO2e ton-1 instead of 55 kgCO2e ton-1) of the reference product. The shorter distances embedded in Sjenica cheese are mainly explained by the shorter distances travelled by exported cheese, although a small share of output is exported. The higher transformation product ratio implies fewer raw products to obtain a unit of Sjenica cheese, and therefore fewer kilometres and emissions embedded in the product at processing level. Finally, the difference stems to a smaller extent from shorter distances travelled at the processing level, given that technical standards for the PGI cheese lay down that it be processed locally in the Sjenica area. The distribution level (P1-D1) concentrates most of the kilometres embedded in the product, and more than 75% of emissions generated for transport along the value chain.

Comparison of sheep cheese and its reference product relating to water footprint are made for all three components of water footprint –blue (surface and ground water use), green (rainwater use) and grey (water pollution by nitrates). In all three cases, there is a substantial difference between the two products at farm level. For the green water footprint, the PGI records about 52% lower net consumption of water than its reference (2.01 vs 4.25 m3 kg^{-1}), and for the blue water footprint this percentage is even higher (around 73% in favour of the PGI, 0.055 vs 0.21 m3 kg^{-1}). Water pollution measured by the grey water footprint is 72% lower for the PGI than for the reference product (0.12 vs 0.55 m3 kg^{-1}). The PGI substantially outperforms its reference product in all three components of the water footprint at farm level.

Using S2F methodology, the sphere of the ***social indicators*** consists of four complementary components as follows: (1) employment, (2) bargaining power distribution, (3) educational attainment and (4) generational change and gender equality.

Thelabour use ratio indicator, calculated by output, reflects labour requirements for a unit of physical output. The allocation of labour to production is higher for Sjenica cheese than for its non-PGI reference product. At farm level, it takes 4.6 hours of work to produce one ton of sheep milk, whereas the reference product requires only 0.16 hours. The difference (1654%) indicates that the PGI product, as more labour intensive, generates more jobs than the reference system. This is also connected to the fact that sheep milk production is less efficient then cow milk production. The relative difference is of the same order as for the process level, since it takes 18.993 hours of work to prepare a ton of Sjenica cheese against 1.174 hours for the non-PGI cheese. The turnover-to-labour ratio indicator provides insight into labour productivity. The average turnover per employee is 85% lower on PGI farms. Productivity levels are much higher at the processing level, but the relative difference between PGI and non-PGI product is of the same order as at the farm level. As noted above, these differences are mostly driven by the structure of farms/firms, the technical specifications of the product, and in part, by geographical conditions.

Low or negligible bargaining power of actors along the different parts of the value chain is characteristic of sheep cheese production in Sjenica. For example, there is just one association of Sjenica cheese producers – "Sjenica cheese", which was founded in 2011. This association incorporates small dairy factories, while the majority of households are not members of any association or union, which would be able to strengthen their bargaining power and advocate in their interests. Clusters of cheese producers exist, but they are informal and rare. It seems that U3 or P1 levels are price takers, in most cases integrated, so there is no bargaining between the two levels. On the other hand, downstream, wholesale distribution and retail especially have greater bargaining power in relation to the U3-P1. The situation of milk producers in the rest of the country is similar to individual milk producers; they tend to be atomized the same way as in sheep farming. However, at P1 level, the situation is different, because 60% of total raw milk production in Serbia is sold to

123 active dairy factories, some of which are large enterprises. For example, the largest processes up to 21% of total raw milk production in Serbia (Lončar and Ristić 2011). Comparing the U3 level of the PGI and its reference product, bargaining power appears much stronger for the reference product and non-existent for the PGI. It is predictable that the P1 level will be similar.

The education attainment indicator, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches one as the level of education increases. The level of education is slightly lower for Sjenica cheese producers than for conventional Serbian cheese sector producers. In Sjenica there is a majority of primary school certificate holders (58–59%) while across Serbia there is a majority of secondary school certificate holders (55–56%).

To track generational handover for the two distinct products, the generational change index was calculated as follows: percentage ratio of the number of employees in the 15–35 age range and the number of employees in the 45–65 age range. Gender inequality in employment is shown by one single indicator which expresses the extent of the difference in the male and female participation in the labour market.

The sheep farming stage for the Sjenica Cheese is more sustainable than its reference in terms of the generational change indicator. It is higher than 100%, which shows that the sheep farming stage employs more young workers than older ones. This should help the transmission of knowledge necessary to keep or increase the levels of production of the PGI product. The same holds for the same indicator in the cheese processing stage. And looking at the gender inequality index, sheep farming for the reference cheese appears slightly more sustainable than sheep farming for Sjenica Cheese due to a lower level of the indicator, which shows that there is less gender inequality. This result reflects that there are more equal percentages of secondary (and higher) education individuals – across genders –employed in farming for the reference cheese than for the Sjenica cheese. The values of the indicators are very consistent across the stages of the two supply chains.

So there are several elements which could affect the sustainability of the production and sales of Sjenica sheep cheese in the future (Table 2 and Filipović 2019).

Concluding Remarks

Sjenica sheep cheese is a branded product from the area of Pester, Serbia. The local community have been very keen to protect the product, and in favour of including on the national list of items with intangible heritage. In general, it can be considered as a classic PGI product with huge market potential in Serbia and the rest of the Western Balkan Countries (WBC) region. However, manufacturers in Pester have refused to pack the cheese in smaller quantities, as they fear this would lower

Table 2 SWOT analysis of the Sjenica sheep cheese

Strengths	Weaknesses
Product authenticity	Lack of associations or cooperatives –low bargaining power
High quality	Inflexible packaging
Methods of animal feed – Grazing	Unstandardized production
Low price comparative to the competitors	Inability to export to EU countries without changing production method
Artisan (traditional) product	Absence of promotion
Ecologically clean area of production	Low availability on markets
Opportunities	Threats
PGI label popularization	The low number of sheep
Rising consumer interest for traditional products	Inconsistent national agricultural policy
Regional branding	Competition from established brands of cheese
Export to non-EU countries	Low level of producer education
Better organisation of packaging and delivery	Non-compliance with regulations on foreign markets

product quality, and the traditional packing means that there are limited opportunities for distribution outside WBC region.

Our analysis shows that the PGI outperforms its reference product (fresh cow cheese) in terms of price and net results (due to significantly higher price premiums and low-cost input technology). It also appears to be underrepresented in overall export potential because of the significantly lower volume of production. Given that cow herds are more efficient in transforming fodder into milk, the carbon footprint of the PGI is higher than for the reference product. In terms of food miles, the PGI is more sustainable in terms of distance travelled, and in terms of emissions released at the transport stage, which reflects the strong regional orientation of FQS sales and the dominant use of local resources in its production. All three components of the water foot print (blue, green and gray) show that PGI substantially outperforms its reference product, calculated at farm level. The upstream sequence U1-U2-U3 in the Sjenica cheese value chain is carried out by the farms themselves.

The allocation of labour to production is higher for the PGI than for its reference product, indicating higher labour intensity and generation of more jobs for the local community, but the average turnover per employee is significantly lower because of the structure of farms/firms, the technical specifications of the product and geographical conditions for agricultural production in the Pester region. Sheep farming employs more young workers than older ones, which is positive for overall capacity for innovation and longterm survival of the FQS Supply Chain. However, educational attainment is close to 0, which is a strong barrier for further FQS development. Additionally, more people with a secondary and higher level of education, across genders, are employed in farming for the reference product cheese.

Finally, P1 levels of the PGI value chain are price takers in both value chains, but comparing U3 levels, bargaining power is stronger for the reference product. On the other hand, wholesalers and retailers hold bargaining power in relation to the U3-P1. Cooperatives are rare as a result of previous practice during the socialist era, where this form of organization was often misused "to make peasants into workers". In this case, the PGI product provides more opportunities for higher farmer price premiums and income. Sjenica cheese is still nationally and regionally well recognized. It also gives more opportunities for job creation at local level. The FQS is thus heavily supported by government, at both national and local level. On the other hand, the export potential of Sjenica cheese appears to be slightly lower than that could be presumed ~~by wider public in Serbia~~; there is significantly lower average turnover per employee and a significantly larger carbon footprint.

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Part VI
Fish and Seafood Sector

PDO Saint-Michel's Bay Bouchot Mussels in France

Lisa Gauvrit and Burkhard Schaer

Historical Background

Description of the Bouchot Cultivation Specificities

The term « Bouchot » refers to a mussel cultivation system: bouchots are wooden pilings sung deep into the sandy ground in the foreshore area. This mussel production system is implemented in different regions in France, in Brittany and Normandy, on the Atlantic Ocean and the Northern Sea coast.

In the bay of Mont Saint Michel, as in many other bays of the Northern coast, mussel seeds are unable to attach themselves spontaneously to the pilings. Mussel seeds are therefore captured on ropes in other locations, mainly in French Atlantic coast seed hotspots. These ropes are imported to the bay and are rolled onto the pilings, in order for young mussels to grow in the tidal area. Exposure to the sun and variations in sea level give mussels strong shells and well-developed colorful flesh.

Bouchots are place lines, and different parameters drive the density of mussel populations; these include the number of bouchot lines, the number of bouchots per line, and the number of bouchot that are effectively seeded per line (seeding rate).

The main species of bouchot mussels is Mytilus edulis and there is also more marginally Mytilus galloprovincialis.

L. Gauvrit (✉) · B. Schaer, Dr
Ecozept, Montpellier, France
e-mail: gauvrit@ecozept.com; schaer@ecozept.com

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Start and Development of Mussel Production in the Bay of Mont Saint Michel

It was only in the late 1950s that mussel culture was introduced into the bay of Mont Saint Michel on a commercial scale (Secula 2011). After a few years of experimenting mussel cultivation on bouchots by local farmers in the early 1950s, a group of mussel growers from the Aiguillon (Atlantic coast) set up mussel farms and processing plants in the bay at Le Vivier-sur-Mer (INAO 2011; PDO Committee Interview led by authors in 2017; Secula 2011).

As in other basins, the rapid expansion of mussel production led to regular overproduction crises. After first significant crisis in the 1960, caused by the parasite *Mytilicola*, mussel growers in the bay of Mont Saint Michel took steps to prevent such crises and consequences on the quality of mussels and other products of the bay. Possible consequences include degradation of trophic conditions, parasites on farmed and natural shellfish, and silting etc.

To that end, producers followed a genuinely collaborative policy of rapid adaptation to the trophic capacity of the environment in order to limit the number of bouchots (density control) and for the management of the bouchot location and implantation.

From the 1970s onwards, the policy has involved continuous decrease in the number of pilings, including a maximum limit for the length of bouchot lines since1980. This limitation was decided and implemented by the Syndicate of producers of the bay of Mont Saint Michel, created in the 1970s (Secula 2011; INAO 2011).

Since the installation of the first mussel growers in the bay of Mont Saint Michel, the bouchots have been moved and restructured five times to adapt the number of pilings, the density, the location and the seeding rate of the bouchots (number of bouchots seeded per line) to the biological resources available.

The last restructuring of mussel production in the bay of Mont Saint Michel occurred in 2003–2004. It involved the removal of many bouchots and limiting the seeding rate to 55–65% of the existing bouchots for each farm. While the number of lines and bouchots have been regulated everywhere in France by official Ministry shellfish aquaculture structural plans since 1987, the bay is the only mussel production site where the density control is set at seeding rate level. Here, the number of seeded bouchot per line is fixed, as well as the number of lines and bouchots as in other area.

Despite the limitations collectively imposed by farmers in the bay of Mont Saint Michel, the average annual volume of mussel production has remained stable over the years. Mussel producers report that what was lost in bouchot density was compensated for by individual mussel growth rate.

The bay of Mont Saint Michel is also the only production area with collective regulation of harvest dates, and there is a procedure for fixing dates of harvest opening and closing. The calendar takes account of analytical and organoleptic tests and follows the seasonality of *Mytilus edulis*, to prevent in particular premature harvesting of mussels which have not reached a sufficient size. Harvest usually opens in mid-July and ends in January.

This collective production collaboration was accompanied by the implementation of tools to protect quality of watersheds. In addition, in 1998, the construction of a seawater reservoir made possible the supply of sea water for all mussel preparation plants in Le Vivier-sur-Mer.

Steps to the Creation of the PDO Scheme

The constraints on production, including low density, harvest dates etc. limit short term profit prospects for mussel producers in the bay of Mont Saint Michel, but also guarantee a high quality level that has long been recognized on the market.

Before the creation of an official origin and quality sign, a commercial brand "Moules du Mont Saint Michel" had been registered by a collective of producers. Fraudulent practices however affected the development of this commercial brand and threatened quality reputation. The volume of mussels sold under the brand was in fact regularly nearly twice the real volume produced in the bay. Some wholesalers and market/shop vendors would mix bay mussels with other mussels.

Thus, mussel growers in the bay decided collectively to protect the origin and quality of their production. In 2006 the *Appellation d'Origine Contrôlée* (AOC) was created, in the preliminary step in France towards European Protected Designation of Origin (PDO) recognition – "Bouchot mussels from the bay of Mont-Saint Michel", which was the first AOC for a seafood product. The creation of this AOC at first brought conflict. At the beginning of the AOC process, many producers in the bay feared that the technical restrictions on the product (minimum size, etc.), would lead to a significant part of their harvest being downgraded, so that they wouldn't be able to use the term "Mont Saint Michel" on their products and would lose market share. An intense cycle of negotiations finally led to the approval of the AOC specifications, and now almost 100% of bouchots in the bay are used for production under designation. Since 2011, the production has also been protected by a European PDO.

Quality Attributes of the PDO Bouchot Mussels from the Bay of Mont-Saint Michel

Claimed and Controlled Intrinsic Quality Attributes of the PDO Bouchot Mussels from the Bay of Mont-Saint Michel

Mussels benefiting from the designation of origin "Moules de bouchot de la baie du Mont-Saint-Michel" are fresh whole mussels, mainly of the species Mytilus edulis, which present specific physico-chemical and organoleptic characteristics (Table 1). Briefly, mussels from the bay of Mont Saint Michel have a more homogeneous size (bigger than 4 cm) than other bouchots mussels and are longer than 4 cm; the flesh is colorful, yellow to orange, and fills the shell.

These quality characteristics are determined at different stages.

- Setting the official opening and closing dates of the harvest season:

A tasting committee conducts tests in several production sites around 20 June. The Committee represents three groups or colleges: the first, farm owners and employees, in activity or retired; the second, technicians and experts (from administration services or analysis laboratories); the third, consumers and chefs/caterers. At least two colleges need to be present and approve decisions for the commission to be valid.

If the flesh rate and the organoleptic test are positive, a General Assembly meeting chooses the starting date of the harvest season. The choice of date is submitted to the INAO authority (National Institute for Designations of Origin), which finalizes it.

- Quality controls during harvest season:

Mussels from each producer are tested by the tasting committee 2–3 times a year during the season. Certipaq, the independent body in charge of the control and certification of the PDO mussel producers and enterprises also makes quality checks as part of their supervision activity.

A Product Quality Linked to the Originality of Its Terroir…

The eight municipalities involved in the designation of origin Bouchot Mussels from the bay of Mont-Saint-Michel are located along the shore of the bay, at the bottom of the Norman-Breton gulf. The PDO Mussel Breeding Zone is precisely defined (Fig. 1).

Table 1 Main specifications of the PDO Bouchot Mussels from the bay of Mont-Saint-Michel

Territory	
Geographical area	Farming zone: Two thirds of the Bay of Mont-Saint-Michel (Fig. 1). Preparation and packing zone: Eight municipalities, all in *Ille-et-Vilaine* département (Fig. 1).
Varieties/breeds	Minimum 95% of *Mytilis Edulis*
Mussel farming practices	
Distribution and density of bouchots	Distribution and density of the bouchots are limited to: 110 bouchots per line of 100 linear meters in the eastern zone of the Vivier-sur-Mer reach at Cherrueix; 140 pilings per 100 linear meters line in the north-western area of Hermelles Bank, the northeastern area of Hermelles Bank and the rest of the breeding area.
Sowing on bouchots	The seeding rate of the bouchots is limited to: 65%[a] by line of 100 linear meters in the eastern zone from the Vivier-sur-Mer to Cherrueix, in the north-western zone of the Hermelles bank and the 99 southernmost lines of the northeast Bench of Hermelles; 55% by line of 100 linear meters in the rest of the production area.
Minimum and maximum duration of farming	Minimum period of rearing: eleven consecutive months, of which at least eight months from the seeding of the bouchot. Maximum period of rearing: 24 months.
Harvesting period duration, opening and closing time	Harvest periods are fixed according to the age of the mussels: one date to start the harvest (opening date) and one date to stop the harvest (closing date). The harvest opening and closing dates are fixed each year by the INAO services after consulting the PDO group (Tasting Committee, see part 2.1). Flesh rates are analysed on representative samples, (Lawrence and Scott index[b]); carbohydrate content of the cooked flesh and organoleptic characteristics are tested by a tasting commission.
Maximum quantity per bouchot	Maximum of 60 kg of mussels marketed per piling on average
Duration of basin storage	Maximum 7 days of reserve, 8 days of basin, 10 days for reserve + basin[c]
Quality requirements for the product	
Physico-chemical characteristics	Size: an average length equal to or greater than 4 cm Shell filling: flesh rate of 120 or more (Lawrence and Scott Index) Chemical composition: carbohydrate content greater than 4% of flesh cooked
Organoleptic properties	Smooth, dark, regular shaped shell Yellow to orange flesh Flesh free of crab and grains of sand Flesh with an unctuous and melting texture Predominantly sweet flavor.
Mussel preparation and packing practices	

(continued)

Table 1 (continued)

Washing, sifting and eligibility of lots	Grading size: minimum 12 mm Maximum weight of mussels that measure less than 4 cm in length: 20% Zero non AOP mussels handled and stored with AOP molds during washing, sifting and packaging.
Final packing	No mix between operators (one commercial bag/pack contains the product from a single farm) 18 hours maximum between washing, grading and packing Containers with a maximum capacity of 15 kg.
Governance	
PDO Committee	PDO Committee that include all the mussel producers of the bay. Mussel packing firms in the PDO supply chain are also members but do not have decision power in the PDO Committee (consultative role).
Tasting Committee	Tasting Committee and General assembly for the determination of the harvest season, with final decision made by INAO.

[a]65% of the existing bouchots are seeded
[b]Lawrence and Scott Index = Flesh dry weight∗1000/(total weight − shell weight)
[c]Reserve is the term designating a stocking area located on the foreshore and accessible at each flood tide, where mussels can be placed after harvest. Basin designates a pool of seawater located in the preparation/packing facilities, usually at port

The bay of Mont-Saint-Michel is an original geographical and ecological entity in many respects, and offers outstanding conditions for mussel farming. It is characterized by:

- an immense estuary with very slight slope, which has strong implications particularly on the temperature of the waters and its variation;
- the presence of fine and medium sediments and exceptional hydrodynamics: the flow of the rivers flowing into the bay interacts with the biggest tidal marches on French coasts;
- a mosaic of ecosystems characterized by the interaction of terrestrial environments (hedgerows, polders), transitional environments between land and sea (marine marshes, freshwater marshes, rivers and estuaries) and marine environments (mud flats).

All these conditions influence the flows and migrations of organic matter, nutrients and microorganisms, and impact on mussel breeding conditions in terms of presence or elimination of diseases and parasites, feeding conditions, filtration and growth.

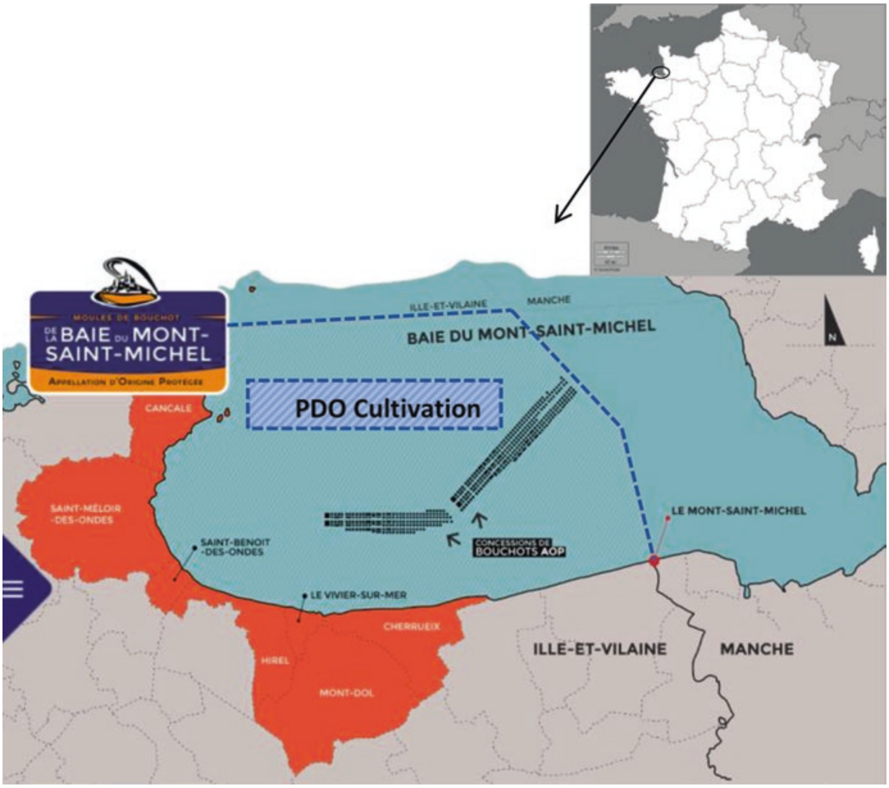

Fig. 1 Production area of the PDO. (Source: www.moules-aop.com/). The broken line limits the farming area and the municipalities in orange are those where processing is authorized

… and to Strict Production Specifications

As detailed in the historical background (Chap. 1), mussel production in the bay is regulated by production rules which are unique in the French mussel production sector. The following table describes the main specifications required by the PDO scheme.

Links with Other Quality Labels

In the same area, another important GI product is based on the image and the terroir of the bay of Mont Saint Michel: the PDO Prés-Salés du Mont-Saint-Michel (lamb raised on salt marsh grasses). The coordination of the two PDO organizations is carried out by the same person, so there can be synergy, in particular in guarding against the fraudulent use of the image of Mont Saint Michel.

The creation of the PDO raised concerns regarding its links with other types of regional and national quality schemes in the mussel production sector. French mussel production in fact faces intense competition from low-price imported mussels. France produces around 75,000 tons of mussels per year, and imports around 55,000 tons per year. The national sectorial organization (CNC) has long tried to distinguish mussel production from French western coasts (Atlantic, British Channel and Northern Sea) on the markets by promoting the originality of the bouchot production practice. After a lengthy process, the Traditional Specialty Guaranteed “Moules de bouchot” (TSG) was created in 2013.

TSG producers are affected by the existence of the PDO designation because it highlights differences in quality. Effects of quality differences are sometimes debated in producer networks, but the market signals are clear: the PDO mussel is priced higher and is so widely recognized that some French and overseas buyers are systematically supplied with PDO mussels when the season is opened.

On the other hand, PDO producers fear that the graphic similarity between PDO and TSG logos may create confusion for consumers and unfairly lower price differences on the market, given that PDO requirements are higher and more costly. But this impression requires further investigation in order to be confirmed.

Sector experts also suggest however that the PDO has helped to raise the prices of the whole labeled mussel market, including TSG. Discussion on the complementarity of the two schemes in terms of both communication and technical specifications is ongoing.

Relations with Local Activities and Community

Mussel production is an important provider of employment for the local municipalities of the coast, second to tourism. Generating more than 20 million euros of turnover, firms in the mussel sector employ more than 315 people directly (CRC 2013), in the equivalent of over150 full time contracts, and 88% are long-term contracts.

The economic effects on the port of Le Vivier sur Mer have encouraged other activities such as shipyards, as well as a tourist center on shellfish: the “*Maison de la baie*” (Bay house). This is a tourist and learning center providing information about the bay of Mont Saint Michel and its productive activities. Co-financed by local authorities and producer organizations, it disseminates knowledge about the natural features and human activities linked to shellfish cultivation. Exhibitions, excursions to visit oyster and mussel parks as well as hikes round the bay are held for visitors and groups of pupils, and the centre receives about 10,000 visits per year.

Nevertheless, links with tourism, in particular catering and hotels, are considered too loose by some mussel producer representatives. In fact, producers believe that many restaurants offer mussels from other regions or countries and do not do enough to publicize the seasonality, quality attributes etc. of the local product. Producers state that apart from the *Maison de la Baie*, no significant coordinated action is currently being undertaken to build stronger relationships or integrate local development dynamics.

Description of the Value Chain

Description of the Value Chain

The operators of the PDO Bouchots mussels from the bay of Mont-Saint Michel are as follows (Fig. 2):

- 84 *concessionaires* (holders of a contract with the State which gives the right to use a parcel of the maritime public domain for mussel cultivation for a certain amount of time), who own the mussel production park of bouchots;

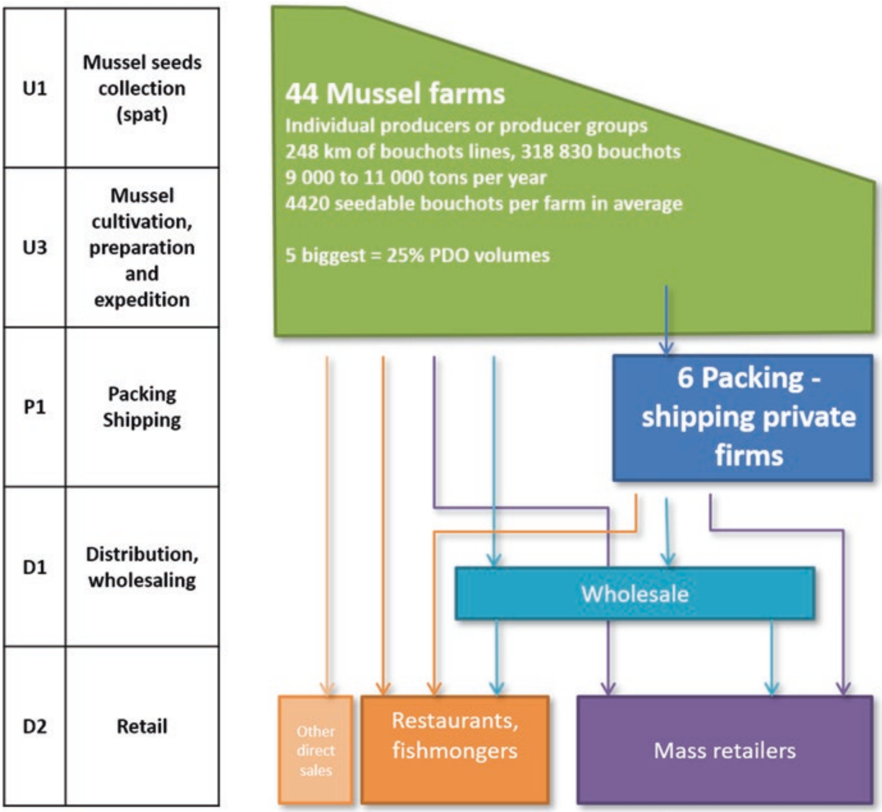

Fig. 2 Supply chain technical diagram. NELLA GRAFICA seedable non seadable, 6 PACKING/SHIPPING private firms

- 44 mussel farms. The activity of a PDO producer mandatorily includes cultivation as well as harvest, grading and washing of mussels. Most producers are also concessionaires;
- 6 centers for packing and shipping which are firms with no involvement in mussel production activities.

U1: Seed Collectors

Seed collection is not possible in the bay of Mont Saint Michel, mainly because the ecosystem entails a low seawater temperature. Some producers have their own hatchery on the Atlantic coast, where seeds are collected on ropes in the natural environment (offshore) and transferred to the bay of Mont Saint Michel. These producers provide seeds for the other producers in the bay, and no other operator is involved in seed supply to the bay.

U3: Mussel Producers

The 44 producers under PDO have different profiles (Daniel 2010; PDO Committee Interview 2017):

- producer only: no other activity than mussel cultivation, harvest, cleaning, screening/grading. Only two producers in the PDO organization.
- producer-shipper (almost all producers under PDO): have their own facilities for grading, cleaning, purifying (mussels are purified after harvest in basins where filtered and oxygenated water circulates during minimum 12 hours), and packing. They have an agreement for shipping exclusively their own mussels. Some ship only part of their output and sell the rest to private shipping agents.
- producer-traders: have their own facilities and agreements for preparing, packing and shipping their own mussels, and also buy mussels from other producers (two or three producers in the bay).

The history of mussel production in the bay in the bay is complex and it has seen waves of immigration from other regions as well as the involvement of local people. This has led to various farm structures and sizes (Secula 2011), with production capacities ranging from under 100 tons to more than 500 tons per year (Fig. 3).

P1: Packers-Shippers

Packing and shipping is done by producer-shippers for 67% of PDO volumes. Producers themselves handle the basic packing of mussels into polypropylene bags. Each container has to be sealed with a PDO label, with specific colors according to the package weight (black for 2 kg bags, blue for 5 kg, green for 10 kg, red for 15 kg).

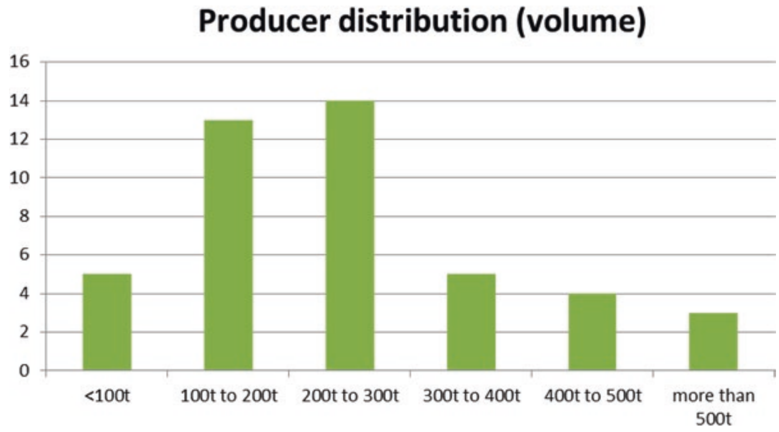

Fig. 3 Distribution of producers according to their production volumes in tons

The 33% remaining volume is packed and shipped by six private shipping firms which do not produce in the bay of Mont Saint Michel and one producer-trader (see definition in part U2 Mussel producers above).

These shipping companies buy already purified mussels from producers. They handle the final washing (cleaning of shells) and/or removing of byssus) and vacuum packing within hours of receiving them. They belong either to bigger groups operating in Bretagne-Nord or the whole of France (including import and export), or they are small and medium sized enterprises created by regional/local groups of producers. The proportion of PDO mussels in their activity is variable, and depends on their size and links with the area.

The most important shipper covering more or less a fifth of PDO volumes marketed for PDO mussels is *Mytilimer Production*, the leading mussel distributor in France. The next most important shippers are *Mytilea* (specialized in PDO mussels and partially owned by a local producer) and *Cultimer* (owned by 25 producers in Normandie, Bretagne and Charente, selling products from 200 producers).

Producers cannot individually invest in vacuum packing equipment (Fig. 4). Initially, producers in the bay of Mont Saint Michel sold out only part of their output requiring special packaging: packet or tray vacuum packed, rather than the simple bags that producers can supply directly. But since the demand for vacuum packaging has grown, especially for big retailers, volumes packed by packing firms are increasing.

Unlike other mussels sold in France, PDO mussels cannot be sold in bulk. They are sold in traceable containers: in bags (65% of PDO mussels, maximum 15 kg per bag) and in vacuum packaging.

Fig. 4 5 kg bag (left) and vacuum packed (right) PDO fresh mussels. (Sources: http://lalydo.com, https://www.mytilea.com/)

D1 and D2: Wholesale and Distribution

More than 80% of mussels sold transit through intermediaries such as wholesalers, traders, central purchasing bodies (LEMNA University of Nantes 2016). In terms of market destination, 70% of mussels from the "Nord-Bretagne" basin, where the bay of Mont Saint Michel is located, are for conventional retail, and are sold to purchasing centers directly by shippers or through wholesalers including shellfish and fish traders. According to the "Nord-Bretagne" Regional Shellfish Committee (CRC), this proportion is the same for PDO mussels. PDO mussels are not more distributed through short supply chains than other mussels or shellfish.

The total volume of mussel production in the bay of Mont Saint Michel was 12,500 tons in the 2016 season, including 11,400 tons sold under PDO. Approximately 90% of the bay's mussel production is under PDO annually. The other 10% mainly consists of smaller mussels discarded in the grading process and mussels collected out of the official PDO harvest season.

The turnover associated with PDO mussels at shipping stage can be estimated at approximately 25 million euros (Author's estimation made on average price data supplied by experts).

PDO Mussels: A Significant Place on the French Mussel Market

Total French mussel production was estimated at 74,140 tons in 2013, with a value of 132 million euros (FranceAgriMer 2016a). Bouchot mussels cultivated on the Atlantic, Channel and Northern Sea coasts account for approximately 75% of French mussel production. With a production of around 10,000 tons per year, the

PDO bouchot mussels of the bay of Mont-Saint-Michel account for almost 15% of national mussel production, and 25% of national bouchot mussel production.

Demand for mussels in France is to a large extent met by imports, which account for approximately 55,000 tons per year. This is especially true for processed products (17,182 tons of frozen and canned products imported in 2015), as French mussels are mainly sold fresh (95% according to FranceAgriMer). The main importing countries are Spain (fresh mussels), the Netherlands (fresh and frozen), Chile (mainly canned) and Italy (mainly fresh) (FranceAgriMer 2016b).

On the other hand, French mussels are not well positioned on the export market because of low price competitiveness and insufficient output. In 2015 total exports were only 2291 tons 2015 (€ 8717), mainly to European countries. Exports of PDO mussels are also marginal: approximately 260 tons in 2015.

Governance of the PDO

The PDO Committee, Reference Body for the Regulation of the Quality Scheme and Representation of Producers

The PDO Committee is the organization responsible for the management, representation and protection of the designation. Its role is first to coordinate the designation, with statutory events, working meetings, and tasting committees. It also coordinates the application of the rules included in the PDO specification and ongoing supervision together with the independent control body and INAO. It is also responsible for management of PDO labelling of containers shipped (purchase, distribution, verification, monitoring).

The PDO Committee is also responsible for communications, which account for two thirds of its budget. This includes public relations, publications, management of the website, point of sale advertising etc. The President and the secretary are particularly involved in media relations, and press and TV interviews, etc.

Finally, the PDO Committee supervises constantly the use of the designation made by operators, in terms of wording and the image of Mont Saint-Michel, in order to prevent fraud. It initiates any legal proceedings taken against fraudulent practice.

PDO Committee financial resources come from a licence fee amounting to 3 eurocents per kilo on mussel sales. There is a part-time coordinator employed 2 days a week for the PDO Committee. The Board of the PDO Committee is composed of 12 producers, including 5 members of the Bureau. Only producers have the right to vote at the General assembly. The six companies which only do shipping are represented in the General Assembly, but have no voting rights.

The PDO Committee has recently been recognized as professional syndicate which allows its representatives to be included in regional professional bodies and assemblies. Producers are also members of historical unions, of which three are present in the bay.

Commercial Activity and Bargaining Power along the Chain

As described in previous chapters, the level of collective coordination is high in the management of production in the bay of Mont Saint Michel, but producers have to date retained a higher degree of independence in trade.

Information about PDO volumes, production progress and quality is supplied to the PDO organization in a transparent manner. But information on prices, turnover and commercial strategies is not shared.

Since the early 2000s in the bay, and more generally in the French bouchot mussel sector, an increasing number of producers have collectively invested in enterprises specialized in packing and/or shipping output. In the bay of Mont Saint Michel, Mytilimer was created by 14 producers in the bay, and now works in partnership with more than 50 producers in different regions. Other producers in the bay collaborate as partners with similar entities set up in other basins, like Cultimer for instance.

This evolution has been driven by several external factors. First, the increasing concentration of the conventional retail sector: nowadays mussel producers deal with only six or seven buyers in purchasing centers in order to reach the entire French retail sector. Retail accounts for approximately 70% of mussel sales in France, including PDO mussels. It has therefore become essential to aggregate volumes in order to gain bargaining power. Secondly, there is increasing demand for small vacuum-packed units (approximately 35%), which require costly facilities which individual producers cannot afford. Lastly, producers often delegate export to these entities, in order to save time and reduce costs.

Other Important Issues

Another important issue noted by PDO producers is the great need for control and legal assistance in order to prevent fraud. Producer representatives say that legal inspections are insufficient, and find that they are left alone to handle complex and time consuming procedures. The image of Mont Saint Michel is extremely coveted, and there is constant pressure on its use.

Producers also highlight the close link between quality of water in the bay and activities on land. Sustainability of mussel production depends on stakeholder land and rivers being non-polluteds.

Another concern is the management of waste shells. Undersized mussels are usually crushed and deposited in a specific area in the bay, which is smaller than 5000 m^2. Shoreline residents have shared their concern that this waste has negative effects on the ecosystem of the bay. No recycling has to date been set up to use this waste as a coproduct, but research programs are currently examing solutions such as methanization, ecodigestion, and potential uses in animal feed etc.

Sustainability Assessment

Sustainability assessment of PDO mussels from the bay of Mont Saint Michel was implemented through the specific methodology of Strength2Food (Bellassen et al. 2016). The indicators were elaborated by using the whole French bouchot mussel production as a reference for economic indicators. Social and environmental indicators were compared with the whole French shellfish sector as a reference (Fig. 5).

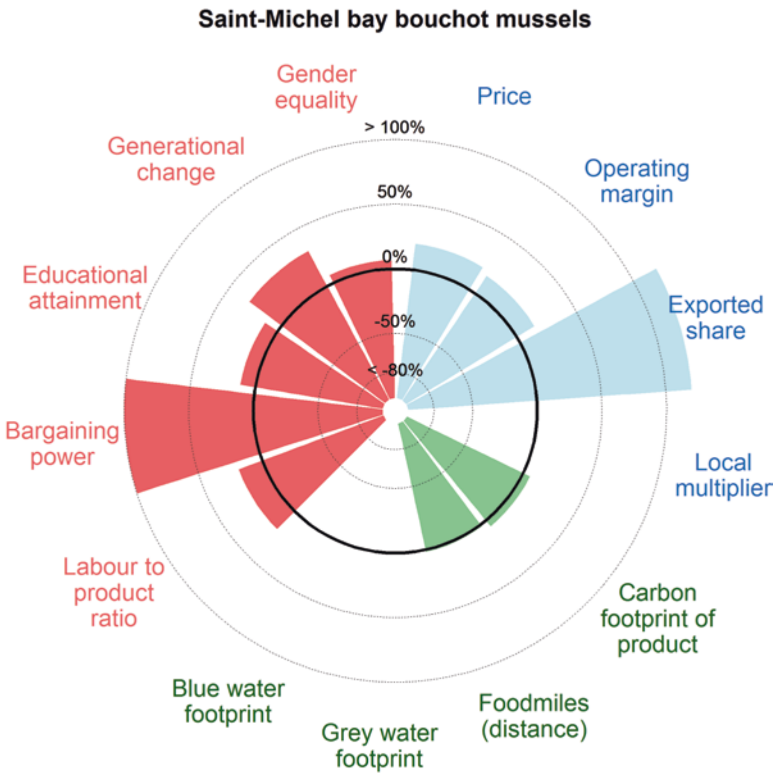

Fig. 5 Sustainability performance of PDO Saint-Michel bay bouchots mussels (supply chain averages). (Each indicator is expressed as the difference between PDO Saint-Michel bay bouchots mussels and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower)). Data sources for each variable are transparently documented in the data repository (https://www2.dijon.inra.fr/cesaer/informations/sustainability-indicators/).

Economic Indicators

Performance on economic indicators reflects the price premium of PDO mussels, which is around 20% all along the supply chain from producers to consumers. Calculation on the net result indicator was not possible but comparison on the gross operating margin at producer level shows a difference of approximately 15% in favor of the PDO mussels compared to reference supply chain. Price difference (20%) is not totally transferred into margin difference as intermediate costs per unit of product are slightly higher for the PDO producers.

There was an increase in production of about 17% between 2013 and 2016 and at the same time a slowdown in production of non PDO mussels. Volume exports are not high for either type of mussels: 3% for the FQS product and 5.3% for the standard product. The latter is exported almost exclusively to Europe, whereas the FQS product targets the external market.

Environmental Indicators

The carbon footprint indicator calculated here takes into account the production stage and is based on energy consumption at farm level in the PDO and the reference product. There is very little difference between the PDO and the reference product (184 and 195 kgCO2e ton^{-1} of fresh mussel respectively), which is not surprising as the energy inputs are similar, and because nothing in the technical specifications seems likely to have an impact on the carbon footprint. Higher fuel use in the PDO due to the higher use of amphibious boats in the Mont Saint Michel bay, where there is a long large foreshore, and longer distances to the bouchots, could perhaps have been predicted, but does materialize in the accounts of mussels farms. The results are towards the lower end of the literature: SARF (2012) reports 252 kgCO2e/ton of fresh suspended mussels, and Winther et al. (2009) report 165 kgCO2e/ton of fresh mussels (shell included). This makes sense as we do not account for the carbon footprint of materials (ropes, etc.) and because the French electricity mix is much less carbon intensive than average. Aubin et al. (2018) reports 9.5 kgCO2e/ton of fresh mussels when including carbon sequestration in shell and in wooden bouchots. The high values reported by Iribarren et al. (2010) were disregarded because the extremely high energy consumption involved is deemed unrealistic.

Concerning food miles, the PDO supply chain was compared to conventional bouchots mussel chain from U1 to P1, and to the national mussel sector from P1 to D1. Over the entire supply chain, from baby mussels to distribution units (U1-D1), there is little difference between the PDO and its reference product. PDO mussels travel slightly shorter distances (1230 km instead of 1250 km) but release slightly more emissions than the reference (155 kg CO2 eq instead of 150 kg CO2 eq). The shorter distance embedded in the PDO Bouchot mussels can be explained by the shorter distance traveled by mussels from farms to packing units, as PDO specifications require packers to be located in the bay of Mont St Michel. Similarly, the higher emissions embedded in the PDO can be explained by the higher emissions released per ton of product exported, due to a higher share of long distance air transport for the PDO than for its reference (export to non EU countries). The distribution level (P1-D1) concentrates more than 95% of the kilometers embedded in the product and most of the emissions generated along the value chain.

Social Indicators

The **labour use ratio indicator**, calculated on the basis of output, reflects labour requirements for a unit of physical output (Just and Pope 2001). The allocation of labour to production is slightly higher for Saint-Michel bay bouchot mussels than for its non-PDO reference (bouchot mussel sector in France). At the farm level, it takes 38 hours of work to produce 1 tonne of mussels, and the reference product requires 32 hours. The difference (19%) indicates that the PDO product generates more jobs than the reference system. The **turnover-to-labour ratio indicator** provides an insight into labour productivity. The average turnover per employee is 11% lower in the PDO than in the non-PDO sector, which means that labour is more productive in the reference value chain. It must however be taken into account that PDO farms also produce oysters, which employ low qualified seasonal labor intensively. For the reference product, the sample is composed of specialized mussel farms only.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The **education attainment indicator**, which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The level of education is slightly higher for the PDO mussel producers (who are mussel farm owners) than non-PDO bouchot mussel producers. Qualitative interviews with processors and farmers in the bay also highlight the high rate of young and low educated employees, at both production and processing level.

The generational change indicator provides weak evidence that the PDO value chain is slightly more sustainable at the mussel breeding stage than its non-PDO reference. However, both supply chains are somewhat endangered in their sustainability prospects because there is a low proportion of young farmers (15–35-yearsold).

The gender equality indicator is also better for the PDO than the reference product at breeding stage. Data shows a very low representation of women, approximately 10% in farm leaders in both PDO and French shellfish national. But female employment is twice as high in the PDO sector.

The analysis of Bargaining power (BP) shows that BP is evenly distributed between levels U3 and P1 of the PDO supply chain, as both levels reach identical scores for all variables. Mussel growers are still very present at the processing level (purification, cleaning) and packaging level, although the tendency to pack mussels for the conventional retail market is increasing. At retail level, the mussel market is much more concentrated, but unfortunately data collected for this research was insufficient to calculate bargaining power distribution at this level.

Conclusions

Sustainability of this food quality scheme is closely related to the high level of coordination established at production level. Producers were in fact able to translate what historically constituted an adaptation to the specific characteristics of their environment – and their acute awareness of its fragility – into a supply chain organization and marketing force.

Sustainability assessment shows that supply chain performs well in social and economic areas. The organization in the bay of Mont Saint Michel and the valorization of the PDO was highlighted by producers and packers as providing greater stability in production, quality and incomes and greater resistance to hazards in the bay of Mont Saint Michel than other basins. It was however not possible to test these hypotheses during this research, and they require further investigation.

The close link of the PDO to its territory is based on the strong link with natural resources and on the economic and social impact of employment and economic revenues along the supply chain.

Producers themselves believe that integration with economic activities other than shellfish production could be strenghtened, and that the potential conflict with other uses of the marine and coastal area such as shore fishing, leisure, tourism and housing could be managed. Building stronger relationships with the variety of players in the territory appears to be a key development for sustainability by PDO producers.

Assessment of environmental impact requires closer investigation using indicators refined for the specificities of shellfish production. Recent LCA analysis led by Aubin et al. (2018) concludes that Bouchot mussel culture has low environmental impacts compared to livestock systems. It also highlights the impact of the management of discarded mussels and household waste on carbon sink potential of this production. Waste management is therefore an area to be strengthened for environmental reasons and to improve surroundings for residents and tourists.

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PGI Lofoten Stockfish in Norway

Virginie Amilien, Gunnar Vittersø, and Torvald Tangeland

Introduction

The Lofoten region is a group of islands in Nordland county, in the northern regions of Norway, made up by the six municipalities of Flakstad, Moskenes, Røst, Vestvågøy, Værøy and Vågan. The archipelago had a population of around 25,000 people in 2017,[1] and is well known for its wonderful scenery combining high mountains and unspoilt beaches. Tourism has grown the last 10 years, and natural fish drying is a local landscape and tourist attraction.

The Lofoten islands offer excellent fishing areas. The particular climate and natural conditions have for centuries encouraged the fishing of "skrei"[2] in wintertime and the natural wind drying of the fish during spring. The specifications contain the following note[3]:

> *The long fish migration in water of low temperature gives a lengthy fish with a firm and muscular flesh. This gives the fish a quality that is essential to withstand the drying process.*

"Tørrfisk" (the Norwegian term for dried fish, i.e. stockfish,) is important for Northern Norway and especially the Lofoten islands, while "klippfisk" (clipfish, the Norwegian term for salted and dried fish) is mostly produced in the Møre region on the west coast of Norway. Although the Protected Geographical Indication is quite recent in both Norway and the European Union, dried stockfish from Lofoten (SfL)

[1] http://www.ssb.no/a/fob2001/kommunehefte/

[2] The cod come from the Barents Sea to the Lofoten islands to spawn, as the area is perfectly adapted to their needs and the development of their eggs. Cod eggs first float on the surface, and develop on the Lofoten sandbanks before they grow up in the depths of the sea.

[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:361:0010:0012:EN:PDF

V. Amilien (✉) · G. Vittersø · T. Tangeland
Consumption Research Norway SIFO – Oslo Metropolitan University, Oslo, Norway
e-mail: viram@oslomet.no

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is traditional element in the Norwegian cultural heritage. Documented since the early Middle Ages, SfL has been recognised as an export product to several continents for centuries as well as a local food product.

Historical Background

A Diachronic Overview of Stockfish from Lofoten

Stockfish in Lofoten

> *Now I have to turn to the Norwegian cod*
> *that the fishermen call "skrei" in Norwegian*
> *He is called the Norwegian crown.*[4]
> Petter Dass

The Vikings traded stockfish for other foods and products in the early Middle Ages. *Egil's Saga*, a saga telling the life of the Icelandic farmer and Viking Egil Skallagrimsson and his family clan,[5] tells us that dried fish from Lofoten was being sent to England for trade as far back as around 875. Various sources also show that stockfish was a key source of income in northen Norway even though King Håkon Håkonsson conferred the monopoly of trade to the north on Bergen[6] on the western coast. Foreigners went to Bergen at least until 1715 to buy stockfish, and the Hanseatic League played a central role in the development of stockfish as a trade product. But Petter Dass, Norwegian priest, poet and tradesman called *stockfish 'the crown of Lofoten',* and different studies have shown that the value of some of the dried fish cargoes could be higher than the national budget.

Stockfish is produced in northern Norway, and today three quarters of the total volume of dried fish comes from the archipelago. Italy and West Africa have long been the two main export destinations, already accounting for almost 70–80% of the market after the second world war (Konow 1945, p. 16).

Stockfish from Lofoten: The Central Role of Europe (Especially Italy) and West Africa

In his 1801 book about traveling in Norway, Jacques Louis de la Tocnaye wrote: "The most important export product in Bergen is the fish coming from the North. Exactly as in Trondheim, traders from Christiansund send the fish to Spain or to St.

[4] Our simple translation from *Svemmende Dyr i det Nordlandske Hav*- Peter Dass, Nordlands trompet – Lofoten- source: https://kalliope.org/da/text/dass2001081407

[5] Translation into English by W. C. Green 1893 from the original Icelandic 'Egils saga Skallagrímssonar'. *Egil's Saga* manuscript is from 1240 AD. Online at http://www.sagadb.org/files/pdf/egils_saga.en.pdf

[6] Today Norway's second-largest city, but at that time the largest, thanks to the tons of dried fish that passed through the northern part of Norway

Martin's du Ré where the boats then fill up with wine, salt and strong alcohol." (Tocnaye de la 1980, p. 58). In stockfish trade today, Italy and West Africa both play a leading role in the development and continuation of the tradition of dried fish. West Africa also buys a large amount of stockfish from other sources, while especially Nigeria imported increasing amounts in the 1980s as part of Norwegian humanitarian aid. Both destinations were well established a century ago, and are sometimes compared. There are however big dissimilarities; product prices on the African export market are closely linked to the palm oil trade and regulated by governments, at least since the Second World War.[7] Until recently, West African countries imported types or parts of stockfish not in demand on the Italian market. Fish heads, for example, were used with red pepper in Nigerian stew recipes. Today however Nigeria too is showing new interest in better quality products.

SfL has a higher quality reputation than standard stockfish from Norway, especially in Italy.[8] For many years, the Italian market was covered by a few well-organized export businesses in Bergen,[9] but direct access to the Italian market increased considerably from the beginning of the twentieth century. Once a direct line from Norway to Italy was established, tradesmen gained in mutual trust and reciprocal cultural knowledge. The Italian market cannot however be considered as a single entity, as there are big differences in stockfish quality, knowledge and demand according to geographical area. The highest quality stockfish is sold in northern Italy, while the southern regions prefer a cheaper product. For example, stockfish is highly praised in Liguria, especially in Badalucco, a small mountain village near San Remo, where there is a Stoccafisso festival every year. Sandrigo in the Veneto regions also has its own annual festival, and in 2017, 40,000 portions of stockfish were served there.[10]

Tørrfisk fra Lofoten: The PGI

From Local Product to PGI

At the dawn of the twenty-first century, when the PGI application was started, quality labels and PGI and PDO were new on the Norwegian market and in the Norwegian food mentality[11] Legislation on quality labels was passed in 2002. When fishery products were integrated into EU food quality schemes, the Norwegian Fisheries Department wished to promote a Norwegian product through this quality system, and SfL was clearly one of the best candidates. After 1994 study commissioned by

[7] Ibid, p. 22–24.

[8] Ibid., p. 17.

[9] Ibid., p. 68.

[10] Personal communication from Anne Karine Statle, secretary of Tørrfisk fra Lofoten and project leader of "LofotenMat".

[11] Discussion with Rune Stockvold, Chairman of the Stockfish from Lofoten PGI consortium.

the regional council of Lofoten on stockfish export to Italy, Dreyer and colleagues noted that it would be interesting for Norwegian stockfish production to develop *"a form for labeling identity that could, in the long term, protect against competition (like Icelandic stockfish).*"(Martinussen et al. 2000, p. 207). This was realised twenty years ago when SfL producers agreed to set up the Beskyttet Geografisk Betegnelse consortium (BGB, or PGI consortium). Although it may not initially have been clear why producers opted to collaborate in a common organization, there were two important elements in the decision. First, there was no official means of coordinating the market at that time (Martinussen et al. 2000). Second, marketing research on Italian consumers commissioned by the Norwegian Seafood Export Council a few years later, showed that there was a willingness to pay higher prices for BGB labelled products in Italy (Mangseth and Teigland 1998).

Although the Norwegian Food Branding Foundation provided information to farmer and fish producers, most actors involved had difficulty in understanding the difference between PGI and PDO labels. Aiming at increasing the added value of their product the consortium opted to apply for the more straightforward PGI.[12] The first Norwegian application was drawn up by Frank Jakobsen on behalf of the Forum for stockfish (Tørrfiskforum). The application appears to have been largely led from above, and involved both Innovation Norway and the FHF (Fishery and Ocean Research Fund). The aim of the consortium was to raise added value, fight potential fraud on the market and to promote the unique quality of the Lofoten product.

The SfL PGI covers only fish from Lofoten, traditionally defined in several levels of quality. Martinussen et al. (2000, p. 199) report two main categories (Prima and Secunda), with twelve sub-categories based on the weight of the fish. This classification was first developed for trading in the Hanseatic League centuries ago. "Ragno" for example is a very thin round fish which is the best for the Italian market, as leanness is in Northern Italy a mark of delicacy. Eventually the SfL obtained the European PGI in 2014 under the name: Tørrfisk fra Lofoten. The designation had been registered at national level in 2007.

The Consortium and the Label

There are 18 members - 80% of all stockfish producers in Lofoten - in the Stockfish from Lofoten PGI consortium.[13] The stockfish from Lofoten processing consists of several phases all requiring specific knowledge and skills. The phases comprise hanging, drying, grading, packing and selling, while fishing is not directly handled by the consortium. Here, "stockfish producers" refers to processors who are often but not necessarily combined with exporters and wholesalers. In the PGI consortium there are mainly fish processors and a few exporters. The fish processors buy fish and most of them process it as part of their business. There are sixteen processors in the PGI consortium. There are also two companies which do not process themselves,

[12] Discussion with Rune Stockvold.

[13] https://www.torrfiskfralofoten.no/

but buy stockfish from other producers and trade with national and overseas clients. Fishermen are not members of the consortium.

Collaboration in the PGI entails not only member collaboration but also working with external actors, such as new foreign intermediaries or importers. One idea currently being explored by the consortium and its partners is to further process the fish, from dried stockfish to "ready to eat" products which should be attractive to several markets. The dry fish sold today needs to be soaked for eight – twenty days before consumption.

The PGI label and PGI as a marketing tool still appear to have a low profile. On the Norwegian market only a few products are labelled BGB, and the most visible product is implicitly linked to "export" as it is on sale at Oslo airport. Our interviews confirm that the label is not common, although Glea (one of the PGI members, producer and processor) uses it.[14] Most producers fail to fully exploit the potential added value of the labelling system and continue to use their traditional network. Surprisingly, the PGI label is not observed on the Italian market either. However, the PGI consortium is working with the Norwegian Seafood Export Council to improve the utilization of products with the PGI label on the Norwegian and Italian markets. A further project aiming at the recognition of Lofoten as a UNESCO "gastronomic area" is also ongoing, underlining the relationship between local production and food quality.[15]

Product Specifications

> *Stockfish as a product is unique. The hanging process gives a concentration of fish which is such that the protein content is around 75%. A dry and airy storage will make it possible to conserve the product for several years. It is difficult to find a product which is more sustainable.* (Martinussen et al., p. 199[16])

The Winter Cod and Lofoten Fishery

The raw material is Atlantic cod, caught around Lofoten and Vesterålen from January through April. During this period, mature cod from the cold polar waters of the Barents Sea travel to the Vesterålen and Lofoten areas to spawn. This raw material is considered to be of high quality and is very well suited for Tørrfisk fra Lofoten."[17]

[14] They have an excellent webpage on: http://glea.no

[15] Information from Anne Karine Statle secretary of Tørrfisk fra Lofoten PGI – Interview 29.11.17.

[16] Our translation.

[17] Sources: PGI Tørrfisk fra Lofoten official specifications.

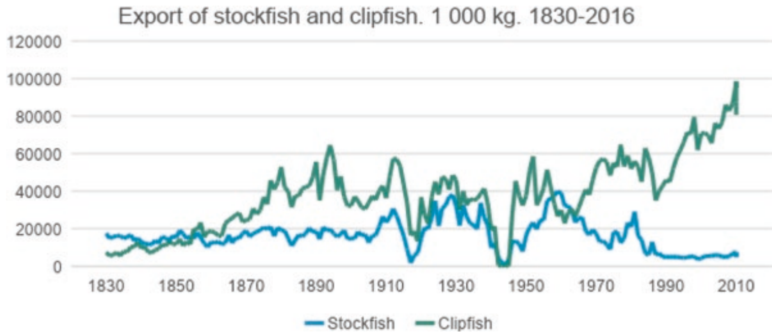

Fig. 1 Export of stockfish and clipfish 1830–2016. 1000 kg. (Source: http://www.ssb.no/296323/utforsel-av-torrfisk-og-klippfisk.1-000-kg.1830-2016)

The Lofoten fishery[18] does not only depend on the quantity of fish but also on the amount of men. Every year between January and April fishermen from all over Norway come to work in Lofoten. Today the boats are manned by smaller crews, but in the past, the population would increase substantially during the fishing season. In record breaking year 1895, 37,200 fishermen worked on 7700 boats and caught 123,520 tons of fish (Pedersen 2013, p. 143). It is worth noting the current decrease in stockfish export. Norway exported 17,548 tons in 1830, and around 40,000 tons in 1929 and 1969, but the figure fell to 4832 in 2016 (Fig. 1).

Natural resources are not infinite. Marine researchers warned against depleting cod stocks, and a very strict regulation of fishing with quotas was decided by the government in compliance with international fishery policies at the end of the 1970s.[19] Local fishermen protested against decisions they considered unfair, and Norwegian media reported a "fishing crisis" until the big strike of January 1990. According to researchers, however, the regulations have been effective. In 2013, 150,000 tons of cod were caught in the winter fisheries, which is a new record in quantity of available fish. In 2018 the total quota for fresh cod north of 62°N was set at 349,932 tons.

Stockfish is still today a big source of income for the Lofoten islands. Most of the production is exported. In 2017 Norway exported 4687 tons stockfish (Table 1) or approximately 30,000 tons of corresponding fresh fish.[20,21] Stockfish is also produced outside Lofoten, but the PGI Stockfish from Lofoten makes up the biggest

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[18] Pedersen B.T. 2013 *Lofotfisket*. Pax forlag AS.

[19] For example, in 1980 the number of authorized vessels was approximately 27,000 and only 3600 participated (Pedersen 2013, p.154).

[20] Conversion factor: 6,41 Final product ratio: G48: 1/6,41 = 0,156 (approx. 15%) per kg fresh fish-source: https://www.fiskeridir.no/English/Fisheries/Norwegian-conversion-factors

[21] http://seafood.no/markedsinnsikt/apne-rapporter/manedsstatistikk/. For the calculations of the sustainability diagrams we used figures for 2016, which do not however differ significantly from 2017.

Table 1 Export of stockfish and clipfish in 2016 and 2017. 1000 kg

Type	Clipfish total		Clipfish of cod total		Stockfish PGI		Stockfish other		Stockfish total
Year	Tons	Euros	Tons	Euros	Tons	Euros	Tons	Euros	Tons
2017	89,158	406,954	38,156	244,402	3049	52,000	1638	15,600	4687
2016	80,729	372,540	38,145	227,505	3381	57,000	1517	12,700	4898

Source: Data from Norges sjømatråd AS, Norsk eskport av fisk, Månedstatistikk p. 84, 86, 91 and 92

share of export with 3049 tons. Italy is the main export market with 2144 tons in 2017 followed by other EU countries (613 tons), USA (242 tons) and Nigeria (252 tons).

Although most of the production is traditionally exported, Norwegian consumption has also recently increased in recent years and approximately 15%[22] stays on the Norwegian market. This is mainly used to make "lutefisk" (lye fish[23]) a traditional Christmastime dish.

Technical Specifications

Jacques Louis de la Tocnaye noticed that *"fishermen cut the fish's heads and as amazing as it sounds, they use them to feed their animals*." (Tocnaye de la 1980). The production methods have changed little the last centuries and bear witness to handing down of traditional know how. The PGI technical specifications are summarized in Table 2 (Fig. 2).

Following the specifications, drying takes place outdoors with no requirements for energy (electricity) or other material resources other than the racks to hang the fish on. The fish is then stored for "after drying" indoors, still with no use of electricity. The quality control and packaging is done manually. However, some producers are now testing a "climate" storage to better control the moist and the quality of the air.[24]

[22] It is difficult to obtain exact numbers, as official figures focus on export. The figures are based on discussions with two experts: Lorena Gallart Jornet, researcher at FHF (fishery research) and Rune Stockvold, chair of the Stockfish from Lofoten consortium.

[23] Lutefisk is a delicacy in Norway, made from stockfish soaked in cold water first, then in lye, and then cooked. It is the most common way to eat stockfish in Norway.

[24] Information from PGI consortium.

Table 2 Summary of technical specifications

Supply chain for Tørrfisk fra Lofoten	
Geographical area	Fishing area: Fish for production of Tørrfisk fra Lofoten is to be caught around Lofoten and Vesterålen (see Fig. 3). Area of landing, processing (drying) and preparation (sorting): Lofoten, consisting of the municipalities Flakstad, Moskenes, Røst, Vestvågøy, Værøy and Vågan
Varieties/ breeds	Atlantic cod (Gadus morhua)
Fishing practices	
Raw material	The fish is captured from January through April. It is to be bled as it is being taken on board. In order to ensure thorough bleeding, the fish is to be put in water. The fish is then to be gutted. The incision shall start between the pectoral fins and go down to the anus. Liver, roe and other entrails are to be removed. The flesh must not be damaged. The fish shall be beheaded according to regulations. Then the fish shall be washed in clean water.
Fish landings	Fish that have been sorted for hanging are to be rinsed thoroughly in clean water. Fish of equal size are then bound together two by two above the tails (Fig. 2). One fish is to be rotated so that the ropes are tightened firmly around both fishes. Then the fish is to be rinsed again in fresh, running water. The fish is not to be iced.
Hanging and drying	Hanging as soon as possible after the fish is caught, then dried on racks. Depending on the weather conditions, the drying process takes from 2–4 months until May/June.
Quality requirements for the product	
Nutritional content	Tørrfisk fra Lofoten shall have a water content of 16–27%, a protein content of 68–78% and a fat content of approximately 1%. Tørrfisk fra Lofoten has a concentrated taste and aroma of fish, a golden colour on the skin and a size between 40–90 cm.
Grading	"Tørrfisk fra Lofoten is to be sorted into various quality groups according to the Norwegian Industry standard for classification of stockfish. Important criteria for further grading are the size/weight and thickness of the fish. Tørrfisk fra Lofoten of the Prima category shall be virtually flawless with a natural shape and open belly, clean neck and belly, no trace of slick formation, without hanging spots or frost damage." Note: Information from the PGI consortium underlines that they are working for a third category, which could be "other", but that only the PGI product could use.
Preparation, packaging and labelling practices	
Post drying	When the fish has been dried on a rack, it is to be taken in and post-dried in a warehouse. The fish is to be stacked on pallets, with enough space between the pallets for air to circulate and for inspection.
Packing	Tørrfisk fra Lofoten is to be packed in jute or cardboard.
Labelling	Proof that the product originated in Lofoten is ensured by labelling both the wholesale packaging and consumer packaging with lot number and the manufacturer's company number (plant code).
Consortium	

(continued)

Table 2 (continued)

Supply chain for Tørrfisk fra Lofoten	
PGI consortium	PGI consortium including 18 members, including 16 producers and two wholesalers/exporters. The consortium covers about 80% of the producers and most of the production of stockfish in Lofoten. To date, the PGI label has been infrequently used on consumer products.

Source: Official specification for PGI tørrfisk fra Lofoten and data for this study

Fig. 2 Illustration of hanging and drying (left) and post drying and packing (right). (Source: Official specification for PGI tørrfisk fra Lofoten)

Geographical Area

As noted above, the area is defined as follows in the specifications: "Fish for production of Tørrfisk fra Lofoten is to be caught around Lofoten and Vesterålen between Ø 010°00` to Ø 016°08` and N 67°00` to N 69°30` […]., delivered to a landing facility in Lofoten and naturally dried and sorted in Lofoten. Lofoten consists of the municipalities Flakstad, Moskenes, Røst, Vestvågøy, Værøy and Vågan" (Fig. 3).

Description and Governance of the Value Chain

The SfL value chain is based mainly on three central types of operator (Fig. 4): fishermen, producers and sellers. Fishermen are not members of the PGI consortium.

PGI stockfish producers are often family-owned, traditional businesses which work in buying and processing fish as well as sales and sometimes export. It is therefore often difficult to separate the processing from the trading phase.

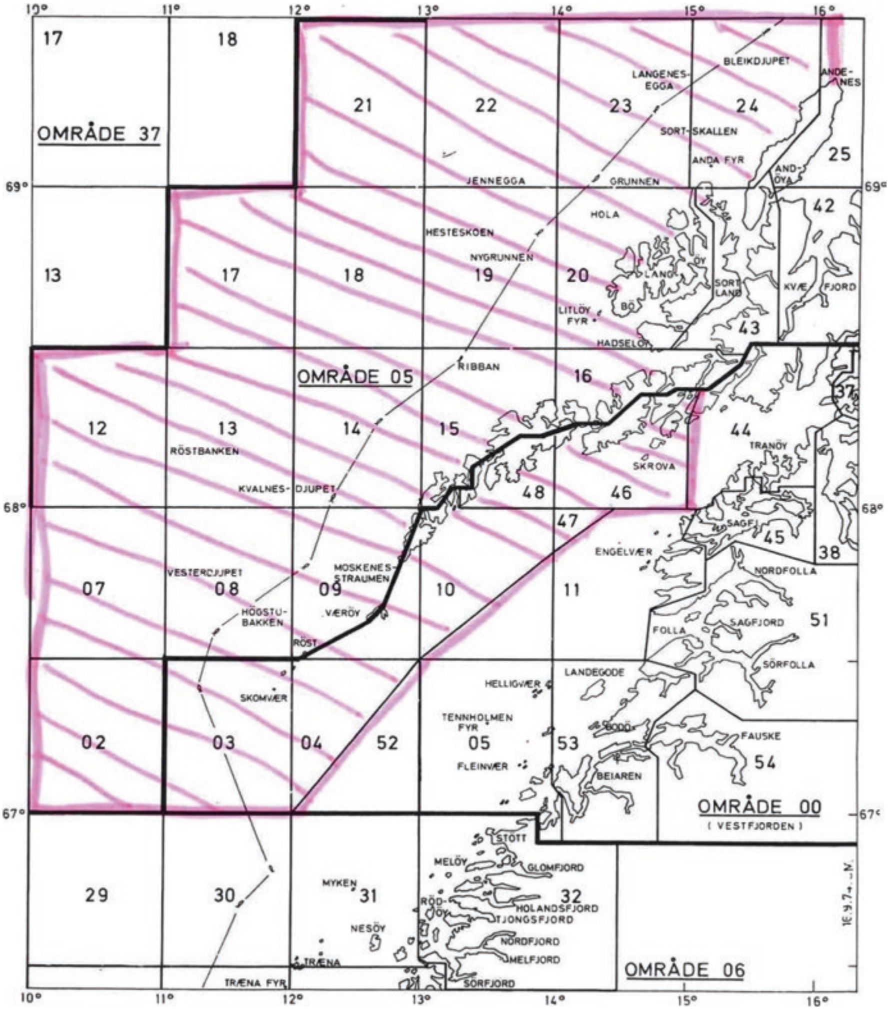

Fig. 3 Fishing area (coloured squares). (Source: Official specification for PGI Stockfish from Lofoten)

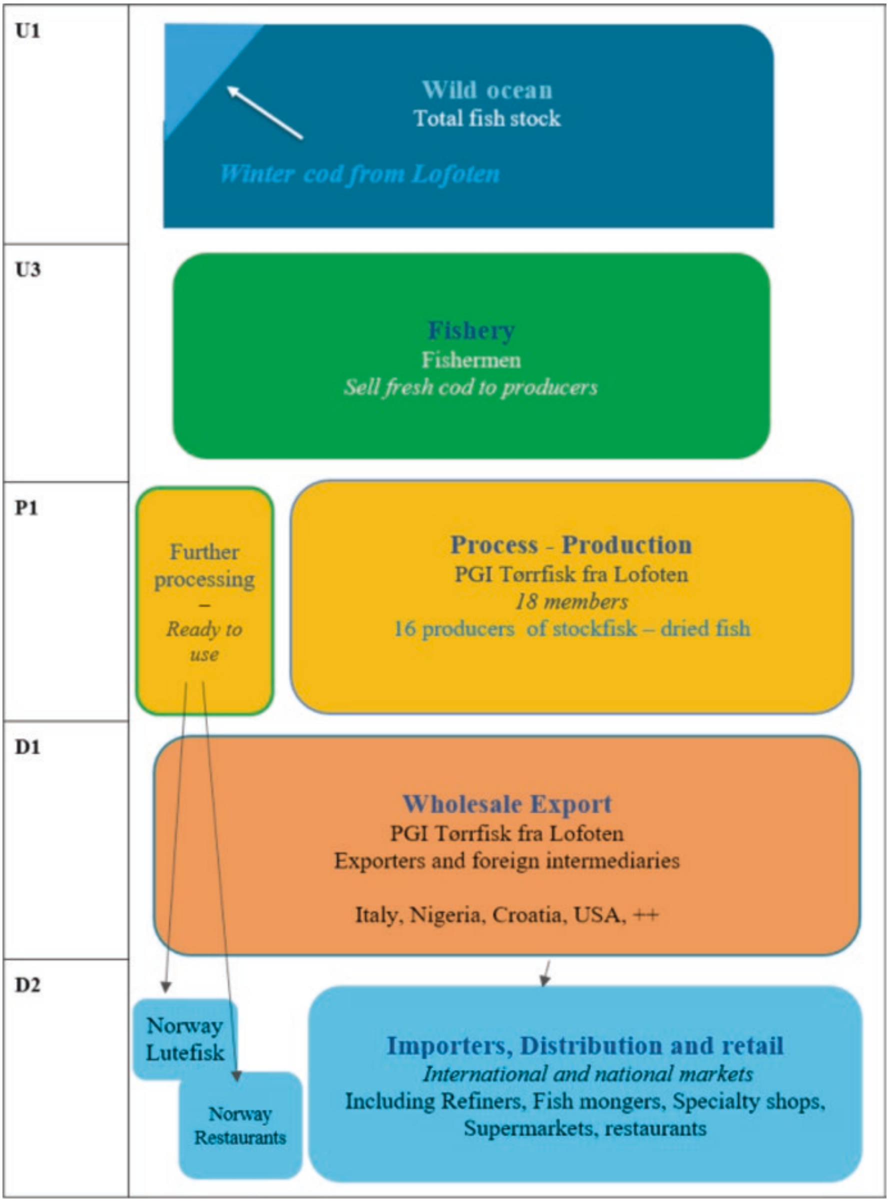

Fig. 4 Simplified representation of the value chain

Furthermore, Norwegian fisheries are stringently regulated in order to safeguard environmental, social and economic sustainability. Three important laws underpin the governance of the primary fishing, landing and distribution of fish as a raw material. They are:

- "Law on the right to participate in fishing and catching (The Participant Act)"[25]
- "Law on the management of wild living marine resources (Marine Resources Act)"[26]
- "Law on firsthand distribution of wild marine resources ("The first hand sales and distribution Act")"[27]

Ocean: Wild Fish (U1)

"Skrei" (winter cod) is a natural resource with availability fluctuating according to season, climate and fishery. The cod population near Lofoten and Troms has been estimated around 1,500,000 tons by ocean researchers. *The Marine Resources Act* has as its main aim to: "Ensure a sustainable and socio-economically profitable management of the wild marine resources and associated genetic material and to contribute to securing employment and settlement in coastal communities." It also states that the wildlife resources belong to the Norwegian community. The law is enforced by the Ministry of Trade, Industry and Fisheries, which also aims to prevent overfishing by individual fish stocks. Quota regulation can be made either for specific vessel groups or types of fishing equipment.[28]

Fishermen (U3)

Around 2000 fishermen catch about 60,000 tons of winter cod every year. Around 25–30% is used for stockfish.[29] The fishermen are not involved in the processing or sale of stockfish. This is partly due to the special regulation of the fisheries in Norway.

The Participant Act regulates admission to the fisheries on the basis of links with place (place of residence, nationality) and size of the fishing vessel etc. The Marine Resource Act applies to the management of the marine resources in matters such as determination and allocation of fishing quotas. The first-hand sales and distribution

[25] https://lovdata.no/dokument/NL/lov/1999-03-26-15

[26] https://lovdata.no/dokument/NL/lov/2008-06-06-37

[27] https://lovdata.no/dokument/NL/lov/2013-06-21-75?q=r%C3%A5fiskloven

[28] https://lovdata.no/dokument/NL/lov/2008-06-06-37

[29] Source: Rune Stockvold, chairman of the Tørrfisk fra Lofoten consortium.

act states that only government-approved fishing sales organizations can engage in the primary sale of fish. The purpose of The Participant Act (§1) is:

a. To adapt the fishing fleet's catch capacity to the resource base to ensure the rational and sustainable utilization of marine resources,
b. to increase profitability and value creation in the industry and through this safe settlement and workplaces in the coastal districts, and
c. to facilitate the harvesting of marine resources to benefit the coastal population.

The Fish Sale Distribution Act states that first-hand sales of wild live marine resources take place through or with the approval of a fish sales association. A fish sales association is a sales co-operative owned by the fishermen through their professional organizations.[30] These are organized on a regional basis and each co-operative has the duty to receive the fish landed within the region and the right to firsthand sale. The law allows sales cooperatives to set minimum prices for first-hand sales of wild marine resources. The purpose of the minimum price is to obtain a fair distribution between fishermen and industry of income from the market. There is little room for individual negotiations on prices, and fishermen usually receive the minimum price centrally negotiated by the sale co-operative.

The Fish Sale Distribution Act also states that when it is necessary for catches to be traded in the most efficient way, the sales cooperative can co-direct catches to certain buyers and to certain use.[31] In the municipalities where the producers within "Tørrfisk fra Lofoten" are located there are a total of 47 landing facilities for fish. The facilities are often run by those who buy fresh fish, who in some cases are also the producers of the dry fish (level P1).

Producers of Dried Fish and Further Processing (P1)

The consortium consists of 18 members. Within the consortium there are mainly fish processors who buy fresh fish and produce stockfish, and potentially process it to "ready to use products" as a part of their business. There are also two companies which do not produce themselves, but buy stockfish from other producers and trade with national and foreign actors.

Stockfish is produced by transforming the fresh winter cod into dried fish through the phases of hanging and drying etc. as described above. Most of the trade is based on dried round fish, but a few actors also make a further transformation of the dried products, such as pre-soaked fish ("Gryteklar tørrfisk"), ready for cooking, which

[30] https://no.wikipedia.org/wiki/Norges_R%C3%A5fisklag; For Lofoten it is Norges Råfisklag who organizes the firsthand sales of fish. The co-operative is owned by the following fishermen's organizations: Norges Fiskarlag, Norsk Sjømannsforbund, Fiskebåtredernes Forbund og Norges Kystfiskarlag.

[31] https://lovdata.no/dokument/NL/lov/2013-06-21-75?q=r%C3%A5fiskloven

can be found in markets and shops[32] **"**Lutefisk"/lye fish for the Norwegian and potentially American markets, and snacks, mostly in Iceland or out of Lofoten.

Although the fisheries are highly seasonal, stockfish production provides employment all year round in processing and preparing fish for export. Stockfish production is important for employment in the region. The industry employs local workers as well as, increasingly, overseas workers, mainly from Eastern Europe, on both a regular and temporary basis.[33]

Wholesale (Export) Including Middlemen (D1)

Most of the SfL is exported. The export trade is traditional, and negotiations between Norwegian producers who sell directly to merchants from Italy is the most usual channel. This trade however has changed in recent years, and today tends to be carried out by intermediate traders rather than producers themselves. All producers in the consortium trade with foreign buyers themselves, which means that P1 and D1 levels are often merged within a single firm.

D1 also includes wholesalers who are not in the PGI consortium, and specifically Italian agents and middlemen who buy directly from producers in Lofoten and sell to distributors in their own country (D2). Middlemen from Italy and Nigeria are regularly to be seen at the Tørrrfisk festival in Røst. Those agents play a central role linking producers, exporters and retailers from foreign countries, and they are paid a percentage of the value of trade, which Martinussen and his colleagues (2000, p. 205) identify as about two per cent.

Import, Distribution and Retail Including Refiners (D2)

This last part of the value chain includes distribution and retail. This is not necessarily carried out by PGI members, but concerns PGI products and actors such as overseas importers, intermediaries and distributors at national level play a key role. More concretely, it covers importers, retail and distribution, as well at the local sales of stockfish from retailers to end- consumers, either households or catering outlets. Stockfish is exported as dry fish and, thus, not ready for use. D2 also includes the *refining* phase, a process consisting of preparing the fish for consumption by soaking it, here called *refining*, in parallel with the world of cheese.

[32] Stockfish from Lofoten consortium plan to have a «ready to use» product for the Norwegian market by 2018. (Example *Halvors tradisjonsfisk*) Source: Personal communication from Anne Karine Statle secretary of Tørrfisk fra Lofoten and project leader of "LofotenMat".

[33] Information from Rune Stockvold, chairman of the Tørrfisk fra Lofoten consortium and Anne Karine Statle secretary of Tørrfisk fra Lofoten and project leader of "LofotenMat".

The stockfish is mostly retailed by fishmongers or supermarkets, or specialty shops focusing on quality products, selling both refined fish and half / whole round dried fish. Even in Norway, processed lutefisk from Lofoten, prepared by local refiners, is a novelty at retail level. Glea, one of the PGI members and traditional manufacturers of high-quality lye fish presents this new product:

"In April 2013, lye fish from Glea became the first lutefisk in Norway to be labeled "Specialty" […] In the past, it was only possible to buy Glea lutefisk directly from us, but as demand has risen, it has become available in stores. Outlets can be found a little further down on this page.[34]"

Refined products can also be found on the overseas market, including the "ready to use vacuum-packed stockfish" on sale in Italy, which is already softened and cooked and can be eaten without further preparation. One interesting issue for the PGI product is the fact that the "softened" fish is processed and differentiated for special markets by refiners who sell directly to retailers or special shops. Note that the refined products are much more difficult to label, as it is almost impossible to ascertain the provenance of the original dried fish. But under the current product specification, it is not "round fish" and cannot not be labeled as a PGI.

Sustainability Assessment of the PGI SfL

The value chain of SfL was compared with the value chain for clipfish along several indicators, based on the three dimensions of sustainability using the Strength2Food method (Bellassen et al. 2016) (Fig. 5).

Economic Sustainability Indicators

PGI SfL attracts a price premium. Compared to clipfish, it has a premium of 288% at processing and 88% at retail level. However, there is no significant difference at fishing level, mainly because regulations assign fishermen a minimum price regardless of fish destination. Costs are similar, so profitability is similar for fishing in both cases. At processing level, the relative gross added value is slightly higher for the PGI (10% of the turnover) compared to the reference product (9%). But in absolute terms, higher costs (wages and intermediate consumption) for PGI are offset by the price premium.

Both products, the PGI SfL and the reference clipfish, are mainly exported, although the national market accounts for a higher share of the PGI (12% of total volume sold in Norway, compared to under 1% for the reference product). While export shares of clipfish are almost equally distributed between Europe and non-European countries, 72% of the PGI SfL is sold in Europe. Italy is the main

[34] On the webpage glea.no.

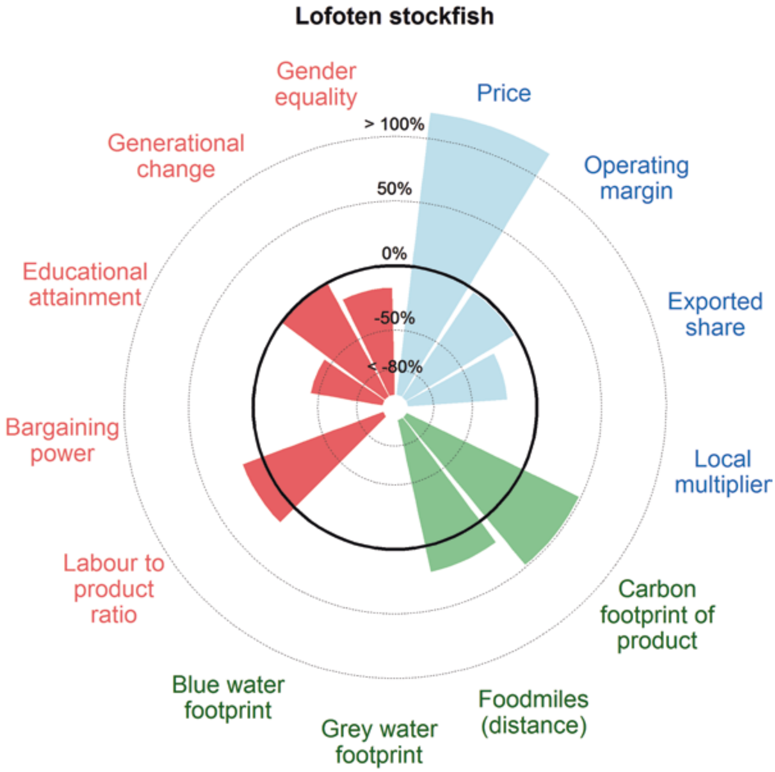

Fig. 5 Sustainability performance of PGI Lofoten Stockfish (supply chain averages). (Each indicator is expressed as the difference between PGI Lofoten Stockfish and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

traditional destination for stockfish, and in some regions, it has been part of the gastronomic heritage for a long time. However, the PGI label is not frequently used on the Italian retail market. Both the PGI and the reference product obtain higher prices in Europe than in other export destinations, and the ratio exported value/ exported volume is above 1 for European countries and below 1 for other destinations.

Environmental Sustainability Indicators

The carbon footprint of the PGI is 48% lower than its reference – 0.68 and 1.31 tCO_2e ton edible (rehydrated) fish^{-1} respectively. PGI fishing uses 33% less fuel to catch the fish because of the shorter distance to the fishing area. The technical specifications require that they fish "around Lofoten and Vesterålen". Moreover, thanks to the shorter fishing distances, they do not refrigerate the fish, either on board or when it is landed, whereas for the reference product, it is estimated that half the fish is cooled on boats. This results in an additional 0.31 tCO_2e ton edible (rehydrated) fish^{-1} from the production of refrigerant liquid for the reference product. Sun and wind drying of the PGI does not substantially lessen its carbon footprint, as drying is only a minor component of the footprint and because the Norwegian electricity mix is dominated by hydropower. Both values are close to the carbon footprint obtained by Winther et al. (2009) for Norwegian clipfish (2.06 t CO_2e ton edible (rehydrated) fish^{-1} without transport but with all fish refrigerated).

On food miles, the PGI SfL supply chain was compared to the Norwegian clipfish chain from processing to distribution (P1-D1). Over the entire supply chain, the FQS performs 20% better than its reference product as regards distances traveled, but 35% worse as regards emissions released at the transportation stage. PGI stockfish travels shorter distances (7000 km *vs* 9000 km) but releases more emissions (650 *vs* 470 kg CO2 eq) than clipfish. This difference is entirely driven by export destinations (Europe *vs* outside Europe), and by the transportation mode used for exports (road *vs* sea transport). The long distances and high emissions embedded in both value chains can be explained by the large share of exports (85% for the FQS *vs* 99% for its reference). Export always involves long distances due to the northerly location of Norway, and export to European countries largely relies on carbon intensive transportation modes, particularly road. The location of Norway, combined with the importance of road transport on domestic and international markets, reinforces the large CO2 emissions allocated to the FQS. Regarding foodmiles indicators, the PGI SfL is more sustainable than clipfish in terms of distance traveled but less sustainable in terms of emissions released at the transportation stage.

Social Sustainability Indicators

The "labour use ratio indicator", calculated based on output, reflects labour requirements for a unit of physical output (Just and Pope 2001). In this case, the allocation of labour to production is lower for SfL than for its non-PGI reference (Clipfish from Norway). At fishing level, it takes 10 hours of work to harvest a ton of fish when the reference product requires 36 hours. This difference might be explained by the fact that the season for "skrei", in other words conditions for fishing the specific winter cod used in the PGI product, is limited to four months a year. This also influences the quantity of fish: a high amount of "skrei" is caught in this period although the vessels are small. This factor might offset the higher labour requirement for fast on-boat bleeding and gutting on the smaller vessels (Table 2). The relative difference is however to the advantage of PGI-product at the process level, since it takes 90 hours of work to prepare a ton of fish against 44 hours for the non-PGI product. This probably reflects the manual work required for sun drying and packaging the stockfish.

The "*turnover-to-labour ratio indicator"* provides an insight into labour productivity. The average turnover per employee is 261% higher in the PGI than in non-PGI sector. Productivity levels are much higher at the processing level, as the high price premium more than offsets the higher labour use ratio. The relative difference between the PGI SfL product and the non-PGI one is smaller at fishing level. This slightly higher turnover-to-labour ratio for the PGI at the fishing level is mostly due to the fact that Lofoten vessels on average catch a larger quantity of fish within a shorter period but at a similar price.

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital, and greater educational achievement as an important outcome. The "*educational attainment indicator",* which refers to the highest level of education that an individual has completed, makes it possible to measure certain components of social capital indirectly. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. The level of education for the PGI product is lower than that observed for the reference product. The majority of employees in the PGI sector (60%) have only a primary level of education compared to the employees of the reference sector who have a secondary level (54%)[35].

Bargaining power is to the benefit of the upstream levels for both the PGI SfL and the reference product clipfish. This is due to the fact that the fishermen's cooperative holds regulatory power over the price of fish. By way of contrast, the supply chain for the reference product sees a much more balanced distribution of bargaining power, thanks to its use of less specific resources and the absence of any dominant actor at this level.

Without considering the impact of the monopoly position held by the fishermen's cooperative, individual bargaining power scores obtained at each level of the FQS supply chain indicate that each level holds strong bargaining power. The weakest score is 0.62 for the U3 level of fishing, and the highest is 0.93 for the P1 level of processing. This indicates that a breach in the monopoly and regulatory position of the fishermen's cooperative would significantly benefit processors. The bargaining power scores obtained by individual levels of the reference supply chain are much weaker, thus indicating that decreases in the bargaining power of the dominant level (P1) would not significantly affect the distribution of bargaining power along the supply chain.

Finally, a comparison of the bargaining power distribution scores of the FQS and of the reference supply chain indicates a clear advantage for the FQS over the reference. Bargaining power is in fact much more evenly distributed in the FQS than in the reference supply chain (ratio FQS/ref <<1).

The whole supply chain of the SfL is, on average, slightly more sustainable than the supply chain of the reference product, as shown by the generational change indicator. This is due to the very high value of the generational change indicator for

[35] For this indicator, the reference used at the P1 level is the educational attainment of workers in the processing industry (in Lofoten vs Norway in total), as specific data for the fishing industry was unavailable.

the processing level of the SfL supply chain, which drives the average result for the supply chain(s). In fact, at fishing level, the reference product attracts younger workers than SfL. However, the processing stage of the supply chain employs roughly as many younger people as older ones. This is positive with respect to the transmission of knowledge from the older to the younger generations.

Both the SfL and of the clipfish are characterized by high levels of gender inequality. Although at fishing stage, the SfL is slightly more sustainable than its reference product, differences are almost negligible. The high values of gender inequality arise from the very limited female share in the workforce and among entrepreneurs. Fisheries have traditionally been dominated by men, and it is physically demanding, with heavy lifting involved, to be a boat crew member or owner, and this probably creates a cultural barrier against women entering these fields. The processing stage of the supply chain of the SfL is also marked by a very high value of the gender inequality indicator, largely due to the absence of female entrepreneurs. The processing stage of the reference supply chain seems to provide more entrepreneurial opportunities to females. Note however that for the 18% share of female entrepreneurship in leading positions, the reference is the average Norwegian fishing and aquaculture industry rather than the specific clipfish value chain. On average, the SfL is less sustainable than its reference in terms of gender inequality.

Conclusion

Dried SfL was the first Norwegian product to obtain a European Protected Geographical Indication. This chapter describes the historical background and the technical specifications for the PGI product. The product would clearly have been eligible for a PDO, as wind, sun, the special fishing area combined with the traditional know-how for processing fish and the long tradition for trading with foreigners is unique. Export has always played a major role, influencing the quality of the product. In the last thirty years, Italy has been a driver for both export and production of stockfish from Lofoten.

The official requirements of the PGI reveal the traditional and exclusive technical particularities of the product. Clipfish, which is both salted and dried, and which was introduced to Norway only in the 16th and 17th centuries, was selected as the reference product for stockfish from Lofoten. For the perspective of sustainability, and based on the indicators collected for this study, the PGI product is slightly more sustainable than its counterpart, mostly because the fish is not cooled or frozen on boats and because the drying process is natural. Clearer differences between the two products appear in value chain levels of processing and retail phases.

Nevertheless, several points should be noted. From an economic perspective, the PGI product has a high price premium at both processing and retail level, while there is no difference for fishermen. In the aspects of labour and education, the average turnover per employee is 261% higher in the PGI sector than in non-PGI one, while the level of education is lower for the PGI product, clearly reflecting the use of seasonal labour. We note a potential danger in the lack of generational change which may impact negatively on traditional production techniques, and high gender inequality. Regarding foodmile indicators, PGI SfL is more sustainable than clipfish in terms of distance traveled but less sustainable in terms of emissions released at the transportation stage.

Moreover, the historical background reveals the high cultural sustainability, as SfL is a recognized food product unequivocally associated with its geographical area.

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Organic Salmon in Norway

Kamilla Knutsen Steinnes, Virginie Amilien, and Gunnar Vittersø

Introduction and Historical Background

> "*Then Loki*[1] *swam ahead of the net; but when he saw that it was but a short distance to the sea, then he jumped up over the net-rope and ran into the fall. Now the Æsir saw where he went, and went up again to the fall and divided the company into two parts, but Thor waded along in mid-stream; and so they went out toward the sea. Now Loki saw a choice of two courses: it was a mortal peril to dash out into the sea; but this was the second - to leap over the net again. And so he did: he leaped as swiftly as he could over the net-cord. Thor clutched at him and got hold of him, and he slipped in Thor's hand, so that the hand stopped at the tail; and for this reason the salmon has a tapering back.*[2]" Gylfaginning[3] p. 77

Once upon a time, in a far-away kingdom called "*The Way to the North*", the salmon was king in its native environment. The story of Loki from old Norse mythology, shows the importance of salmon in Norwegian people's everyday life by explaining that the particular shape of the salmon tail is actually due to the dexterity of Thor

Salmon, salmo salar (Linnaeus 1758), is rather unique being both a freshwater and saltwater fish, giving salmon a freedom and strength that made its reputation (and that Loki adopted when he wanted to escape). Borch described salmon as "*the fattest and best fish of our coast; it is also the most widespread because in our country there are almost no rivers at the mouth of which we cannot find salmon … In addition to the rivers and their mouths, salmon is also fished in the fjords*" (Borch 1878, p. 391).

[1] Loki is a god in Old Norse mythology. He often provokes the other gods, and he turns into a salmon when he wants to escape danger. He is also known for having made a fishing net.

[2] See: http://www.norron-mytologi.info/sgndok/sn-edda/02-gylfa-e.htm

[3] *Gylfaginning* saga tells the story of Gylfy, a Nordic king, in the first part of the *Heimskringla*, known as the *younger Edda* written by Snorri Sturluson (1179–1241)

K. K. Steinnes (✉) · V. Amilien · G. Vittersø
Consumption Research Norway SIFO – Oslo Metropolitan University, Oslo, Norway
e-mail: kamillak@oslomet.no

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Salmon has long symbolized the Kingdom of Norway: first as an image of wildness and pureness of nature, linked to the previous description by Borch, and enhanced by many tourists over the last two centuries (Borch 1878; Amilien 2000). During the last generation, the image has changed from nature and tranquility to industry and efficiency, now illustrating a successful export market. Thus, the aquaculture of salmon has exploded in the last 30 years from the production of a few thousand tons in the early 1990s to more than two million tons in 2015 (following the FAO 2018). Of this massive global production of farmed Atlantic salmon, since 2017 approximately 50% comes from Norway. and is predominantly exported to Europe, Japan, and North America (Statistisk Sentralbyrå 2018).

The Development of Norwegian Salmon Production and Consumption

> "*In the previous century [1700] salmon was such an important part of daily food, in so many places, that servants requested their masters not to serve them salmon more than twice a week.*[4] *Nowadays [1878] salmon is an important source of export and its price is so high that it can generally only appear on the table of the wealthy class. Salmon is eaten fresh or packaged in ice for export, but it is often smoked and is then called "røgelax" (smoked salmon); as such it is a favorite food of the wealthy class*" (Borch 1878, p. 294–295).

In 1850 salmon was a rare food for Norwegian people. Fresh and smoked salmon were reserved for the upper class and feasts. In 1866 salmon was eaten approximately as much as lobster (around 350,000 portions a year in the whole of Norway), while cod or herring were everyday food (respectively 15,300,000 and 10,444,000 portions) (Borch 1878, p. 69) in a population of 1,701,756 people in 1865 (Borch 1878, Annexe X, p. 29).

It was during this period that salmon produce was exported, as shown in Table 1 (from Borch 1878, p. 70).

Consequently, salmon was being overfished even during the nineteenth century. The Norwegian government decided to control salmon fishing: "*the law for the protection of salmon of May 23, 1863/supplementary law of April 29, 1866 regulates salmon fishing by banning 6 months a year (Sept. February)*", effectively making salmon the only protected species at that time and persistently during many years to come. A consequence of this regulation was that Norwegians "*tried to hatch eggs by artificial means*" (ibid, p. 392), but it did not work properly before the 1960's. Following information from the FAO,

[4] Borch is not the only author who claims that farm workers would not eat salmon more than two times a week until the Enlightenment; but this was obviously limited to a few places near lakes or rivers where anglers could get salmon. The authors could not find any official historical source confirming this view. Therefore, it should be treated with caution, especially considering the huge amount of seafood potentially in competition with the more seasonal salmon.

Table 1 Different types of fish and quantity in "tønner" (barrels) exported between 1851 and 1875

Year interval	Fresh salmon and mackerel (in ice)	Herring	Oil from cod	Cod/ stockfish/ salt fish	Hummer (per piece)
1851–1855	15	565,051	52,900	29,977	77,300
1861–1865	1900	808,962	63,151	31,772	1,464,000
1871–1875	3130	896,460	104,120	44,279	920,000

1 tønne = 139 liters

> "*Atlantic salmon culture began in the 19th century in the UK in freshwater as a means of stocking waters with parr in order to enhance wild returns for anglers. Sea cage culture was first used in the 1960s in Norway to raise Atlantic salmon to marketable size. […] The early Norwegian success reflected the excellent deep sheltered sites available, favorable hydrographic conditions (stable temperatures and salinities), natural salmon strains that mature late, and heavy governmental support and investment. […] The vast majority of Atlantic salmon currently in production is hybrid stock, derived originally from native crossed with Norwegian stock.*" (FAO 2018)

Furthermore, the section of the FAO report titled "*market and trade*", reads that

> "*because of rapid increases in production over the last 10-15 years, ex-farm prices have fallen sharply. […] Many producers in Europe are unable to sell fish into the market at the cost of production. There has been an increase in the development of quality schemes, both industry and interest-group led (e.g. organic/welfare-related schemes), in order to try and protect market prices. Political intervention (e.g. minimum import prices for Atlantic salmon imported into the EU from non-EU countries) has failed to maintain market prices in some markets*" (FAO 2018)

Although wild Norwegian salmon is still considered a premium product, it is a scarce delicacy and there is a need to reintroduce quality to the salmon market. The above FAO quotation provides an excellent description of the situation. The production of organic salmon was introduced as a quality scheme a few years ago. Meanwhile the "*label rouge*", a new French inspired (and controlled) quality label was recently introduced in the Norwegian salmon market (PNS 2018). The following text, however, will consider organic salmon.

Figures regarding the Norwegian fish market are available, but few figures for general fish consumption (including salmon) are available until the beginning of the twenty-first century. As noted by Runar Døving, in his excellent study of fish (Døving 1997, p. 268), there is a long tradition of self-caught fish in Norway. Furthermore, self-caught fish has long been a second source of income in many families, as illustrated in the previous quotations about salmon fishing. It was also commonly used as a gift, and thus not visible as a market share. Statistics Norway decided in 1993 that such figures were so indeterminate compared to agricultural products that rather than giving a general overview, they would focus on the fish market.[5] This makes the history of Norwegian salmon consumption difficult to

[5] Ibid.

distance from the overall historical background. It can roughly be described as seasonal and important early on (until 1700) and progressively exclusive and rare as salmon products became fruits of secondary occupation in several families.

While previously recognized as publicly funded and state-owned, modern salmon production is characterized by privately-owned organizations and investors (Aarset and Borgen 2015), and as such has seen a massive increase in production.[6] Consequently, the production of fish from farms exploded during the 1990s and this intensive production played a key role in demand.

Norwegian Salmon Consumption

The consumption of fresh salmon filet has steadily increased during the last 15 years. This rise is the result of two key factors. On one hand, Norwegian authorities strongly emphasized the nutritional properties of fish, particularly salmon, for their omega 3 content. On the other hand, new distribution facilities appeared on the market making fish products – including salmon – more accessible.

While Norwegian meat consumption increased steadily, fish consumption fell dramatically in Norway after the Second World War, prompting, after 2000, the launch of huge state campaigns to promote eating fish. Today, the National Nutrition Council recommends 300–450 g of pure fish per week per person, where at least 200 g should be from fatty fish such as salmon, trout or mackerel (Direktoratet for e-helse 2018).

Around 2005, a new technology through atmosphere packaging appeared on the market appealing to the urban consumer. It was then possible to find quality fresh salmon filet *sous vide* in almost any local supermarket, and it compensated for the lack of fish stores. According to the Norwegian Seafood Council in 2007, salmon consumption was – for the first time – equal to cod consumption. Thus, with about 7.5 kg per person per year, Norwegians were the top salmon eaters in the world in 2007 (Seafood Norway 2008). "Salmon consumption rose by 87% between 2003 and 2013 … there is especially increased availability of fresh pre-packaged salmon which includes, for example sushi, and packed freshly baked fillets" (von Krogh 2013).

There is currently an ongoing discussion about the health and environmental aspects of farmed salmon, where antibiotics, local pollution, and animal welfare are at the core. Despite recent studies showing a decrease in the use of antibiotics, experts disagree resulting in a complicated and confusing public debate for consumers. In a qualitative study with Norwegian consumers, we perceive increasing doubts about fish farming. Several informants have decided to limit their salmon consumption despite encouragement from the authorities to eat more fish (Døving

[6] Better fertility rates may have helped this production increase; The female salmon shows immense fecundity (Borgen and Aarset 2016) as she can produce up to 10,000 eggs during her lifetime span of 2–3 years (Hindar et al. 2007).

1997; Amilien et al. 2018). However, already in the early 1990s a number of parliamentary reports indicated that environmental quality must become part of the food quality concept, which implied environment- friendly and sustainable food production. Several reports also underlined that methods of cultivation according to ecological principles must be further developed. For example, the parliamentary report on agricultural policy 96–97 assessed objectives and instruments for ethically and environmentally respectful production, including organic agriculture.[7]

Political considerations and regulations may not have suited the large-scale, intensive salmon farm production. Salmon farm consumption is very practical and well established but a number of consumers are now concerned about the impact of aquaculture on nature and human health. Organic and quality certified salmon (label rouge) is therefore becoming more apparent on the national market and is slowly becoming more accessible for everyday consumption in Norway.

Development of Organic Control- and Labeling System in Norway

Similar to the evolution of the French PDO (Protected Designation of Origin) food labeling system, organic production in Norway has primarily been encouraged and implemented by food producers (Amilien et al. 2008). While PDO labeling was formed among wine producers, at the beginning of the twentieth century, as an alternative movement emphasizing origin and quality, Norwegian organic production can be traced back to the biodynamic agriculture of the 1930s as an alternative movement emphasizing Steiner (Waldorf) philosophy. This movement later received support from practitioners with a heavy focus on environmental aspects. These criticized conventional agriculture for its lack of environmental concern, mainly due to its reliance on artificial fertilization and pesticides (Amilien, Schjøll and Vramo 2008).

Debio is the supervision and certification body for all organic production, processing, and importion in Norway (Debio 2018). Debio certification was established in 1986 (Terragni et al. 2009) and was initiated by the farmers and producers themselves rather than politicians or consumers. This was mainly due to the farmers' perceived lack of legal protection as they had observed several non-organic farmers falsely claiming to produce organic products (Amilien et al. 2008). First, a private labelling scheme was created, which farmers could freely choose to adhere to. In 1991, the EU implemented a regulation pertaining to organic farming and the term "*organic*" with reference to plant production became protected by law. Thus, in order for either pure or processed products to be classified as organic, they had to comply with the regulations set by the EU. These EU regulations required every

[7] Governmental report nr, 13 1992–93 "Om FN-konferansen om miljø og utvikling i Rio de Janeiro", Governmental report nr. 40 1996–97 "Om matkvalitet og forbrukertrygghet", Governmental report nr. 58 1996–97 "Miljøvernpolitikk for en bærekraftig utvikling".

state within the EU or EEA to appoint at least one controlling body. This could either be the government itself or a privately-owned institution. In the latter case, the institutions had to be officially accredited. During this time, Norwegian organic agriculture was limited in scope, despite the establishment of the Debio certification. Hence, the government chose not to construct a new state-owned controlling body for organic production, but rather decided to enter into an agreement with Debio. Debio has effected control of ecological production on behalf of the government ever since.

As noted above, the term "*organic*" is protected by law, meaning that products can only be promoted as organic if the producer has been approved by Debio. The objective of organic aquaculture certification is to ensure that natural resources are managed in ways that minimize – or ideally avoid – environmental harm. This system is primarily based on local and renewable resources and the main objective is to attain a positive reciprocal interaction between the organic farm and its surroundings. The first organic salmon farm in Norway was certified by Debio in 1990 (Table 2).

Product Specifications

Geographical Production Area

There are currently two Debio certified producers of organic salmon in Norway – Salmar and Flakstadvåg Laks (see Fig. 1 for geographical location). Both producers farm, process (i.e., slaughter), and distribute the organic salmon. Conventional salmon is produced in the same areas as organic salmon as both producers run organic and conventional salmon farms.

Claimed and Controlled Intrinsic Quality Characteristics

Economic Differences

Conventionally farmed versus organically farmed salmon are different in cost structure. The production costs for organic farming are approximately 30% higher than conventional farming (Dybdal 2017). More specifically, a report issued by Oraqua (2013) show that these higher production costs are due predominantly to 35% feed costs, 40% costs for new production capacity (such as new machinery, technology, infrastructure, costs related to the change from chemical to biological methods to fight disease, etc.), 13% for smolt costs (such as conditioning), and 12% other costs (Oraqua 2013). Furthermore, export prices for organic salmon are a whopping 50% higher compared to conventional salmon (Oraqua 2013).

Table 2 The main specifications of organically farmed salmon in Norway

Territory	
Geographical area	Two producers located in North and CentralNorway; Møre og Romsdal and Senja. The production is spread across 12 locations; 4 in Northern-Norway (Senja) and 8 in Central-Norway (Møre og Romsdal).
Varieties/breeds	No difference in fish breed. Atlantic salmon (*salmo salar*) of the *Salmonidae* family is the farmed species of both organic and conventional salmon production.
Animal management	
Fodder self sufficiency	Feed and most crop inputs are imported from abroad. The marine material in organic fodder has to be derived from organic aquaculture.
Animal health and welfare	The welfare of the salmon is the number one criterium for organic certification evaluation (Åsli and Mørkøre 2011). Density of organic fish cages is reduced to 10 kg/m^3, compared to 25 kg/m^3 for conventional farming. Organic farmers are to avoid medication and vaccination as often as possible and they ought to use biological methods to fight disease whenever feasible (e.g., wrasse to control salmon lice) rather than chemical methods. Artificial oxygen and re-usage of water are prohibited as both factors affect cage space and thus animal welfare.
Other	Nets in the ocean have to be free of copper and cannot be cleaned using chemicals. While conventional salmon locations can lie fallow for only 3 months, organic salmon locations are required to stay fallow for twice as long.
Process	
Slaughter	Two organically Debio-certified slaughterhouses; one located in southwestern Norway (Aukra) and one in northwestern Norway (Senja). The actual slaughtering of the fish is identical for organic and conventional production; as of 2010, both are subject to the same rules and regulations of the slaughter and euthanasia of Atlantic salmon (Prytz 2009).
Transportation	The main mode of transportation nationally and within Europe is by road. Transportation outside the EU is primarily by air.
Distribution	Products mostly go directly from processing to export. Almost all Atlantic salmon (94%) produced in Norway (both organic and conventional) is distributed as fresh fish product (Solvoll et al. 2014) and over 90% of the product is exported abroad. The producers usually sell their products directly through partners and via in-house sales forces.
Product attributes	Organic salmon has a higher level of fat content, redder and firmer meat, than the reference product.
Governance	
	The value chain is mainly governed by organic farms – essentially functioning as producers, processors, and retailers – as well as through the Norwegian organic certification system, consumer and environmental organizations.

Nutritional Composition of Organic Versus Conventional Salmon

The nutritional value of organically and conventionally farmed salmon is very similar (von Krogh 2015). The main difference relates to the concentration of carboxylic fatty acids (Åsli and Mørkøre 2011). Results presented in a report by The Norwegian

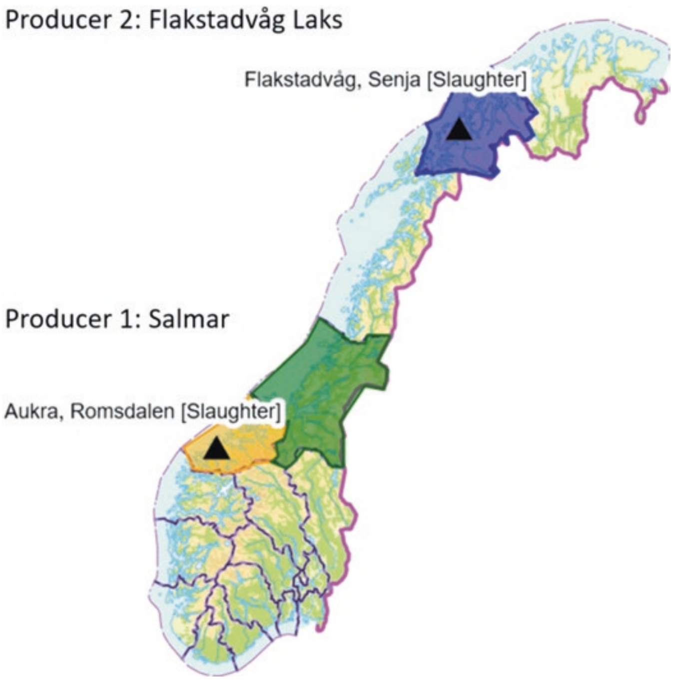

Fig. 1 Geographic location of the two producers of organic salmon in Norway

Institute of Food, Fisheries and Aquaculture Research/Nofima (Åsli and Mørkøre 2011) show that organic salmon contains significantly higher levels of marine polyunsaturated fats EPA (eicosapentaenoic acid), DPA (docosapentaenoic acid), and DHA (docosahexaenoic acid). Conventionally farmed salmon, on the other hand, has significantly higher levels of the vegetal predecessors to EPA, DPA, and DHA, namely the omega-3 fatty acid ALA (alpha-linolenic acid) and the omega-6 fatty acid LA (linoleic acid). Nofima's concluding remarks about the nutritional difference is that the meat of organic salmon is firmer and redder, the loss of liquids through storage is lower, and the concentration of the favorable polyunsaturated fatty acids EPA and DHA is higher compared to conventional salmon (Åsli and Mørkøre 2011). Indeed, not only do consumers say that wild salmon tastes better than conventional (Døving 1997), they are also more willing to pay a price premium for redder salmon products (Steine et al. 2005) and organically farmed salmon products compared to conventionally farmed products. Thus, Norwegian consumers have demonstrated that they are willing to pay if they believe it can help reduce harmful environmental effects resulting from conventional fish farming (Olesen et al. 2010).

Conditions of Production

Debio certification for organic fish farming requires the same three main criteria as other farm production methods, namely animal welfare, environmental, and health considerations (Debio 2018).

Both conventional and organic salmon in Norway are fed with a combination of marine animal and vegetal-based food. As opposed to conventionally bred salmon, the feed of organic salmon consists of a higher ratio of fish oil and meal to vegetal oils and products. Organic certification of salmon requires that fish trimmings used as feed originate from sustainable wild fish populations and naturally produced carotenoids from yeast, algae, and bacteria (von Krogh 2015). Welfare of the salmon is the main focus of the entire organic farm production, and is consequently the number one criteria for organic certification evaluation (Åsli and Mørkøre 2011). Organic salmon farming is regulated by strict requirements relating to density of the fish cages and avoidance of medication and vaccination as far as possible. Artificial oxygen and re-usage of water is not permitted within organic farming, as both factors limit cage space and consequently lower production efficiency (Dybdal 2017). More specifically, organic salmon has 2.5 times as much space within cages than conventional salmon – the mandatory limit for cage density within organic farms is 10 kg/m^3 compared to 25 kg/m^3 for conventional farming. Moreover, organic farms utilize biological methods to fight disease whenever possible (e.g., wrasse to control salmon lice) rather than chemical methods. Unlike conventional salmon farms, the nets in the ocean have to be free of copper and cannot be cleaned using chemicals within organic farms. Furthermore, compared to the 3 month-fallowing of conventional locations, organic salmon locations have to lie fallow for 6 months.

Despite these strict regulations pertaining to organic salmon production, it has faced some controversy regarding welfare aspect (due to salmon suffering from lice) and the environmental impact. The restricted use of chemicals in organic aquafarming results in increased use of wrasse fish to reduce lice accumulation on salmon, which creates other environmental issues such as increased risk of virus infections due to potentially higher levels of excrement from the wrasse fish (von Krogh 2015). A decline in the wild wrasse populations has also resulted probably caused by overfishing (Halvorsen et al. 2017). This negative information related to organic salmon might potentially influence consumer purchase behavior. Indeed, previous choice experiments have demonstrated that when consumers are presented with negative information about organically farmed fish, they are less willing to pay for an organically labelled fish product (Chen et al. 2015).

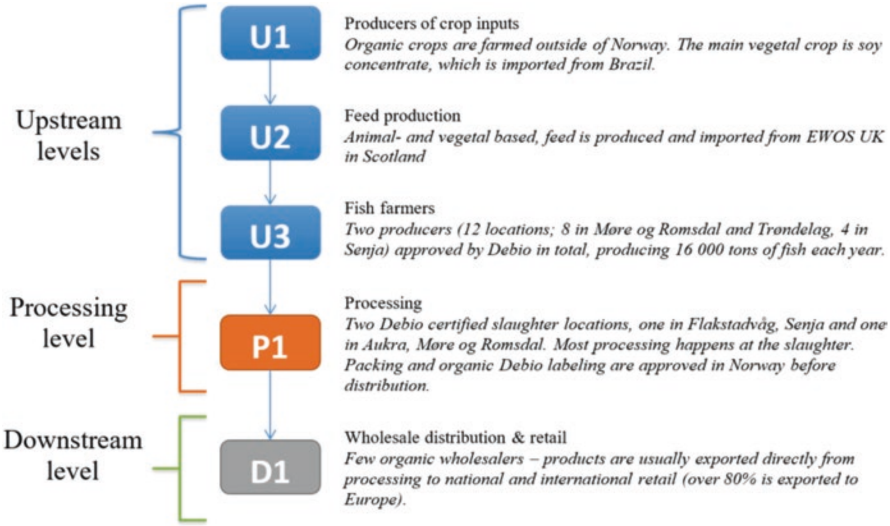

Fig. 2 Production value chain of organic salmon in Norway

Description of the Value Chain and its Components (Fig. 2)

U1: Producers of Crop Inputs

The main ingredient (approx 25%) in the vegetal material of salmon feed is soy concentrate imported from Brazil (Cargill Aqua Nutrition 2017). Fish trimmings in the marine material of feed mainly comes from Denmark, Iceland, Faroe Islands, Chile, Peru, Norway, and the UK (Cargill Aqua Nutrition 2017).

U2: Feed Production

Organic salmon are fed different fodder to conventional salmon, the main difference being the proportion of marine and vegetal material. The vegetal material consists of a mixture of plant proteins and oils, such as from soy, sunflower, rapeseed, corn, fava beans, and wheat. The marine material comprises fish oil and fishmeal from trimmings deemed inedible for human consumption. In conventional salmon feed, the ratio between marine and vegetal material is 30 to 70, respectively. In organic salmon feed, however, some of the vegetal material is replaced by marine material resulting in a slightly higher concentration of marine material (37.5%) and reduced vegetal material (62.5%).[8] The sole producer of feed to salmon farmers in Norway

[8] The increased concentration of marine material in organic salmon is believed to be a key reason behind the demonstrated stronger fish taste of organic salmon compared to conventional salmon

is EWOS UK in Scotland. EWOS UK produces feed for both organic and conventional salmon. The marine material in organic fodder has to stem from organic aquaculture, while conventional fodder can use fish trimmings from conventional farms (Cargill Aqua Nutrition 2017).

U3: Fish Farmers

There are two organic salmon producers in Norway: Salmar and Flakstadvåg Laks. In 2017, these two firms produced around a total of 16,000 tons of organic salmon. Salmar produces at eight locations spread around mid-Norway, while Flakstadvåg Laks has four locations in the North.

The farming process from egg to adult salmon is similar for both conventional and organic salmon production. The fertility rates for farmed salmon are high (Borgen and Aarset 2016) as the female salmon can produce up to 10,000 eggs or 5500–6000 eggs per litter during her lifetime span of 2–3 years (Hindar et al. 2007). Survival rates are also high as most offspring are farmed until they reach a reproductive stage.

P1: Processing

The two producers each have their own organically Debio-certified slaughterhouse, which essentially functions as a processing unit. Salmar's slaughterhouse is located in Aukra within Møre og Romsdal county, while Flakstadvåg Laks's slaughterhouse is in Senja in Troms county. The actual slaughtering of the fish is identical for organic and conventional production – as of 2010, both are subjected to the same rules and regulations for the slaughter and euthanasia of Atlantic salmon (Prytz 2009).

D1: Wholesale Distribution & Retail

Products mostly go directly from processing to export. The producers usually sell their products directly through partners and via in-house sales forces. Almost all Atlantic salmon (i.e., 94%) produced in Norway (both organic and conventional) are distributed as fresh fish products (Solvoll et al. 2014) and over 90% of the products are exported abroad. Of this, the vast majority is exported within European countries. France has traditionally been the most important export destination for

(Åsli and Mørkøre 2011).

Norwegian salmon for several years as Norwegian salmon has accounted for approximately 70% of the French market (Grimstad de Perlinghi 2017).

Governance of the Organic Product/FQS

The organic salmon value chain in Norway is mainly based on three central actors (these are typically merged into one single actor): producers, processors, and retailers. External influences, however, such as political regulations or consumer organizations are also important entities. Mixing human and non-human operators, the governance builds on four main complementary pillars (several of these may also be divided into sub-pillars). At the production level (1), we find national actors like the ocean (where salmon farming takes place) and the fish that are indirectly part of governance because of the respective regulations pertaining to them. More concrete is the role of the two organic salmon farm companies, as well as international actors such as producers of crop inputs and producers of feed. At processing levels (2) there are two organic certified slaughterhouses. Retailers (3) include both national distribution and wholesale export, for both fresh and processed fish. The governance is also affected by regulations and organizations (4). The organic certification system is highly regulated and consumer and nature organizations play a central role in its development.

Production itself is located in twelve areas and two firms. Flakstadvåg salmon has produced organic fish since the beginning of the twenty-first century with an actual volume of 50–60 tons a week. Processing takes place about twice a week and produce is essentially for export. In recent years Flakstadvåg has had competition from Salmar, with eight production locations. Organic feed and most crop inputs are currently being imported from foreign countries, depending on a global market.

At a national level, distribution is a core part of governance. In 2007, Matmerk (the Norwegian Food Branding Foundation) signed an agreement with the four food distribution channels to promote high quality food. They agreed that food products that received FQS such as European-inspired quality certificates (PDO, PGI or TSG) or a Specialty label would be sold in supermarkets. On this occasion the first organic salmon product to get a Specialty label, called Røykt Mørelaks, certified by both Debio and Matmerk, appeared on the shelves.

National regulations for organic food, related to developing production and consumption in Norway, have been part of the political programs at least since 2000 (Norwegian Ministry of Agriculture 1999). EU regulations have been inspired by Norwegian regulations (interview Debio) but reciprocally the Norwegian organic system has also been influenced by the EU.

A few years ago an issue arose when the EU did not accept the Norwegian organic certification due to disagreement at an agricultural level. At the end of 2016, some countries decided to accept Norwegian organic salmon again (i.e., France) but a final agreement was only reached in March 2017. After several years of negotiations, the regulatory framework for organic production is now incorporated into the EEA Agreement, and Norwegian breeders can again sell organic salmon to the EU. This is good news for consumers, who ask for high standards of quality, says Per Sandberg, Minister of Fisheries (Regjeringen 2017).

Sustainability Diagram of Organic Salmon

Based on data collected from both primary and secondary sources, the two value chains of organic and conventional salmon have been compared along several indicators of the three dimensions of sustainability, namely economic, social, and environmental using the Strength2Food method (Bellassen et al. 2016). Figure 3 gives an overview.

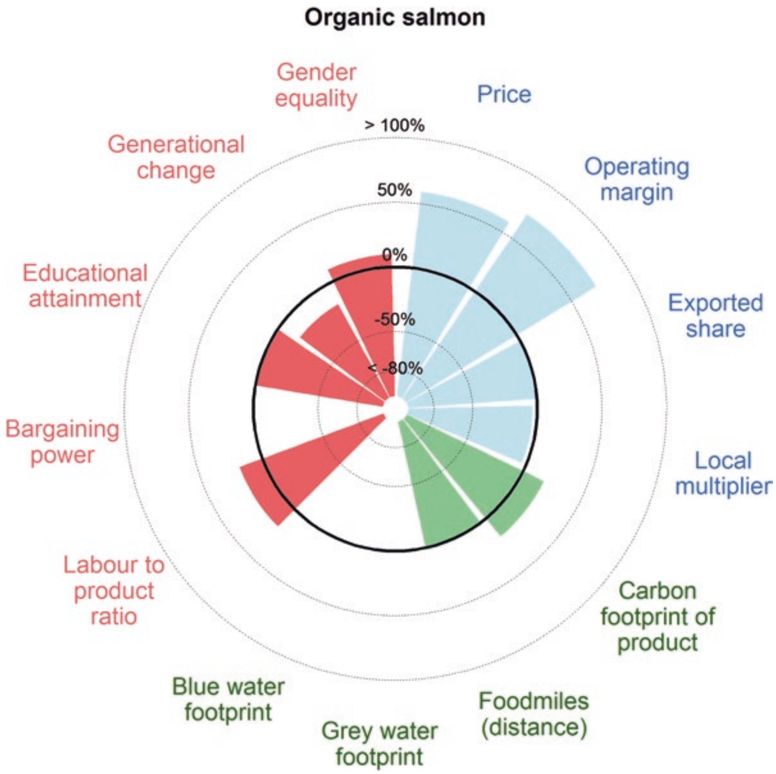

Fig. 3 Sustainability performance of organic salmon (supply chain averages). (Each indicator is expressed as the difference between organic salmon and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower))

Economic Sustainability Indicators

Profitability and Exports

The data indicates that both prices and profitability are higher for organically farmed salmon. At U3 level, intermediate consumption is higher, but represents a smaller share of turnover than conventional production. Wage costs are quite similar, but higher prices for organic product results in smaller share for wages in total turnover. Concerning exports, both organic and conventional salmon have the same share of value and volume exported.

Impact of Organic Salmon on the Local Economy

The local area used for the local multiplier calculation is the Møre og Romsdal and Senja regions considering them as a unique and contiguous region. The organic and the conventional salmon supply chains show the same or very similar local economy impact. This would imply that the organic and conventional supply chains present an organization comparable in terms of actors involved and their territorial distribution.

Social Sustainability Indicators

Two indicators have been calculated for the aquaculture/breeding and processing stage of the supply chain for both organic and conventional salmon production in Norway: a Generational Change Index and a Gender Inequality Index in Employment.

Age and Gender Composition of Staff

Index	Organic salmon	Conventional salmon
U3 stage – Aquaculture/breeding		
Generational change	66%	64%
Gender inequality	0.12	0.42
P1 stage – Salmon processing		
Generational change	66%	106%
Gender inequality	0.12	0.44
Supply chain average		
Generational change	**66%**	**85%**
Gender inequality	**0.12**	**0.43**

As a whole, the supply chain for conventional salmon is slightly more sustainable than the one for organic salmon, according to the average – across the stages – value of the Generational Change indicator. However, both products appear somewhat endangered in their opportunities to transmit the skill and knowledge associated to their production from one generation to the next. In fact, both supply chains record Generational Change indicators, which are smaller than 100%. On the other hand, the entire supply chain of organic salmon is more sustainable than that of conventional salmon, according to the average value – across the stages of the supply chain – of the Gender Inequality indicator. In fact, the value of the Gender Inequality indicator for organic is markedly lower than the one for conventional salmon. In absolute terms, both supply chains are fairly sustainable in terms of the equality of opportunities, because the value of the Gender Inequality index for both supply chains is low.

Labor and Education

Regarding labor and education, several indicators have been calculated. The labor use ratio indicator, calculated on the basis of output, reflects labor requirements for a unit of physical output (Just and Pope 2001). The allocation of labor to production is lower for organic salmon than for its non-organic reference (Norwegian Atlantic salmon). According to the indicator, it takes about 8 hours of work to harvest a ton of fish when the reference product requires 11 hours at the farm level. The difference (−23%) indicates that the organic product generates fewer jobs than the reference system. The relative difference is to the advantage of the organic product at the processing level. The indicator shows that it takes approximately 9 hours of work to prepare one ton of fish compared with 6 hours for the reference product.

The turnover-to-labor ratio indicator provides an insight into labor productivity. According to this calculated indicator, the average turnover per employee is 98% higher in organic farm than in the reference sector. The productivity level is much higher than at the processing level. Differences observed are mostly due to the farms/firms structure (as organic farming employs a far smaller workforce compared to conventional), the technical specification of the product (organic salmon farming requires more labor due to several strict regulations they must adhere to) and in part due to the geographical conditions (organic salmon farming is highly concentrated with only two national producers).

Both Putnam (2000) and Halpern (1999) identified education as key to the creation of social capital and greater educational achievement as an important outcome. The education attainment indicator, which refers to the highest level of education that an individual has completed, allows us to indirectly measure certain components of social capital. This indicator is close to 0 if the majority of workers have a primary education level and approaches 1 as the level of education increases. There is no difference in the profile of education levels between producers of organic salmon and those of the reference sector. In both, the level of education is dominated by the primary and secondary level.

Labor to product ratio	Farm	0.0046	0.0059	−23%
Labor to product ratio	Proc	0.0050	0.0031	60%
Profit to labor ratio	Farm	1,798,303.63	909,296.03	98%
Profit to labor ratio	Proc	1,982,290.41	610,272.68	225%
Educational attainment	Farm	0.36	0.37	−3%
Educational attainment	Proc	0.34	0.33	2%
Wage level	Farm	53,949.11	55,467.06	−3%
Wage level	Proc	59,468.71	37,226.63	60%

Bargaining Power

Bargaining power could not be estimated due to the structure of the organic salmon supply chain. The underlying assumption for calculating this indicator is that two consecutive levels (i.e., U3 and P1) have to be run by independent firms. The supply chain of organic salmon is characterized by vertical integration, meaning that the two organic salmon firms both produce and process the fish. Thus, the underlying assumption could not be met for this particular social sustainability indicator.

Environmental Sustainability Indicators

Carbon Footprint

One indicator has been calculated regarding carbon footprint. As previous studies have shown (Pelletier and Tyedmers 2007; Winther et al. 2009), the lion's share of the farmed salmon carbon footprint is concentrated in feed production. The carbon footprint (excluding transport) of organic salmon is 14% smaller than its conventional reference, with 0.89 vs 1.03 tCO2e ton gutted fish^{-1}. This is driven by the absence of mineral nitrogen fertilizers for feed production (12–57% lower footprint of organic feed), although the lower feed yields and, more importantly, the higher use of fishmeal largely offset this benefit. These results are at the lower end of the 1.5–6.6 tCO2e ton live fish^{-1} range in the literature (RIAS Inc. 2016), due to the use of Bouwman's equation for the estimation of N2O emissions (Carlson et al. 2016) instead of the simpler IPCC Tier 1 method. These results rely heavily on the assumption that fishmeal is composed of fish captured for the sole purpose of feeding salmon, rather than composed of trimmings from fish processing. In the latter case, the carbon footprint of organic salmon would be half that of its reference, although both footprints would be much lower than the current estimates.

Food Miles

Concerning food miles, the organic supply chain was compared to the conventional salmon chain from U3 to D1. Over the entire supply chain, from salmon farms to distribution units (U3-D1), the FQS performs slightly better than its reference. Organic salmon travels slightly shorter distances (5500 km *vs* 5600 km) and releases slightly less emissions (990 *vs* 1100 kg CO_2 eq) than conventional salmon. The difference is in support of organic salmon, in the range of 1.5% for distances and of 10% for emissions. This difference is entirely driven by the value chain organization, and more precisely by exports, since organic salmon is to a larger extent exported within Europe, implying shorter distances and more road transport, a less carbon intensive mode than air transport used for exports outside Europe. The rather long distances and large emissions embedded in both value chains can be explained by the large share of exports (98%), that implies long distances due to the fringe location of Norway, and that relies on carbon intensive transportation modes (road and air). The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated for transportation along the value chain (i.e. more than 95%). Regarding food mile indicators, we can conclude that organic salmon is slightly more sustainable than its reference in terms of distance traveled and emissions released at the transportation stage.

Conclusion

Norwegian salmon production has a rich historical tradition. Farmed salmon in Norway initially started out as a reaction to government attempts to control overfishing. Despite its humble beginning, salmon farming has witnessed a steady exponential growth, leading to an explosive increase during the last three decades. Today, the industry represents a successful global export market. While conventional salmon farming began in the 1960s, organic production did not see the light of day until 1990. Today, there are two organically certified salmon producers in Norway that are obliged to adhere to strict regulations aiming to minimize – or ideally entirely avoid – environmental harm. For instance, organic certification requires that the salmon have more space within the ocean cages and are fed with trimmings stemming from organic fish. Moreover, organic farms must adhere to other regulations relating to vaccination and water oxygen compared to conventional farms. Regarding the consumer product, the color of the meat is natural and has a slightly different fat structure than the conventional reference product. The farming, processing, and retailing of Norwegian organic salmon supply chain is highly integrated as these three levels often overlap. Moreover, the supply chain is highly regulated and is typically characterized by sound farm governance. The preceding text has presented indicators along economic, social, and environmental sustainability dimensions based on primary and secondary data. In terms of economy, organic salmon scores higher on profitability and prices despite larger intermediate costs than the conventional reference product. Both organic and conventional salmon show very a similar impact on the economy locally. Results for social sustainability are rather heterogeneous and difficult to interpret, often because the data is not easily comparable.

At farm level, organic salmon farming seems to be marginally more sustainable in terms of the age and gender composition of staff as well as female entrepreneurship. At processing level on the other hand, the conventional salmon supply chain appears to perform better than organic in terms of staff age composition (higher share of younger employees). No differences were observed between the supply chains relating to staff education levels. Findings for the environmental sustainability dimension display a pattern of higher performance for the organic supply chain compared to the conventional reference chain. The carbon footprint of organic salmon is 13% smaller (although the underlying fishmeal assumption should be noted) while its impact on food miles is lower than conventional salmon. In sum, we observe minor differences between both supply chains, although organic salmon perform slightly better on all three sustainability dimensions taken together.

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PDO Phu Quoc Fish Sauce in Vietnam

Viet Hoang and An Nguyen

Characteristics of the PDO Phu Quoc Fish Sauce

History of the Phu Quoc Fish Sauce

The waters around Phu Quoc Island are rich in seaweed and plankton which provide food for anchovies, the main input of the Phu Quoc fish sauce. This typical resource has provided the special attributes and prestige of the Phu Quoc fish sauce for over 200 years. The product has been known outside its home island since the late 1950s and became very popular between 1965 and 1975 (Vu 2017). In 2012, the Phu Quoc fish sauce was granted a European Union Protected Designation of Origin (PDO) status.

Kien Giang province started applying for geographical indication (GI) registration in 1998 to protect the reputation and increase the value of the Phu Quoc fish sauce. With the support of Mutrap Project, the application was submitted to fight against misuse and fraudulent trade as well as improving consumer awareness and product competitiveness in the EU. In 2001, GI certification was granted by the National Office of Intellectual Properties, Ministry of Science and Technology. PDO was granted to the Phu Quoc fish sauce by the EU in October 2012, marking a new step towards protection and development of the product on the world market. In general, the PDO Phu Quoc fish sauce development process can be briefly summarized in three phases as follows (Phu Quoc FSA 2016):

1. **Phase 1: Registration for GI in Vietnam : 1998–2001**

The first application for GI registration was developed and submitted with the support of the French Embassy in Vietnam and the Ministry of Fisheries. In 2001,

V. Hoang (✉) · A. Nguyen
University of Economics Ho Chi Minh City, Ho Chi Minh City, Vietnam
e-mail: viet.hoang@ueh.edu.vn

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the Phu Quoc fish sauce obtained the GI and became the first product to be registered and obtain GI certification in Vietnam.

2. **Phase 2: GI application and completing the institution and policy for GI practice**

Vietnam's Ministry of Fisheries promulgated the general rules of Phu Quoc GI management and usage in 2005. Kien Giang provincial People's Committee (PC) issued the Decision 2482/QĐ-UBND promulgating specific rules of Phu Quoc GI management and usage in 2008. The Phu Quoc fish sauce with GI has been managed and developed with the support of Program 68 under the project of "Management and Development of Phu Quoc GI for fish sauce products of Phu Quoc Island, Kien Giang province". The implementation period of the project was from 2009 to 2010. It was led by the Kien Giang Centre for Scientific and Technological Advances to formulate and promulgate the management documents and development tools of GI product promotion and marketing. In 2010, Kien Giang province PC authorized Phu Quoc district PC to recognize the Control Board of Phu Quoc fish sauce and its statutes.

3. **Phase 3: EU protected designation of origin and the institutional improvement**

With the support of Mutrap Project, Ministry of Industry and Trade, the National Office of Intellectual Property, and Ministry of Science and Technology submitted the application for GI registration in the EU in 2009. On 8 October 2012, the European Commission approved the decision on GI Phu Quoc fish sauce as an EU protected designation of origin (PDO). Phu Quoc fish sauce was the first product of Vietnam to be recognized as a PDO on EU markets. Kien Giang province PC issued Decision 1401/QĐ-UBND promulgating Rules for management and use of the PDO in 2014. Kien Giang's Department of Science and Technology organized a press campaign to promote the PDO of Phu Quoc fish sauce from 14th to 22nd July 2014 with the support of the EU – MUTRAP project.

Description of the PDO Phu Quoc Fish Sauce

Intrinsic Quality Attributes

According to the registration document of Vietnam for the PDO for Phu Quoc fish sauce to European Union (Phu Quoc FSA 2011) and the Handbook of the PDO management and use (Luong 2014), the fish sauce characteristics are as follows:

– Color: the Phu Quoc fish sauce has a dark red-brown colour since it is produced from fresh fish, and naturally fermented for 12 to 15 months.
– Taste: salty, strong sweet with natural fatty taste reflecting the content of natural protein and fish grease.

– Smell: delicate special smell, without fish and ammonia odour, because it is produced from fresh fish and naturally fermented. The prolonged natural fermentation in wooden barrels ensures that there is no unusual smell and taste.
– Nitrogen values or degree: maximum of 43 g/l for the first extract and minimum of 20 g/l for finished extract of fish in second or consecutive extract.

Taste and flavour is the most significant and special value of fish sauce in general and Phu Quoc fish sauce in particular. According to a taste test of 13 fish sauce brands to identify the fish sauce brand with the best flavours, descriptors are as follows (Hildebrant 2015):

– It should taste pure, with fish and sea salt being the only perceivable ingredients
– Fish should be the dominant flavour, with salt aftertaste
– It should taste of fish and the ocean, but not be fishy or off-putting
– It should not taste sweetened; if there is a sweet taste this should be natural and at the finish

The winning sauce was Red Boat 40°N in Phu Quoc, Vietnam. The taste of the Red Boat 40°N in Phu Quoc is fish and salt, with a slightly sweet finish. Testers remarked; "Now this is what fish sauce should taste like" (Hildebrant 2015).

Physiochemical Indications of the Phu Quoc Fish Sauce

Overall, the Phu Quoc fish sauce, both PDO and Non-PDO, includes various physiochemical ingredients such as nitrogen, proportion of nitrogen amino acid versus nitrogen, proportion of nitrogen ammoniac versus nitrogen, acetic acid, salt (NaCl), histamine, and lead surplus. Values of these indicators are dependent on the classes of the Phu Quoc fish sauce. In general, both the PDO and Non-PDO Phu Quoc fish sauces consist of different classes from Special to Standard 3 type. The PDO and Non-PDO Phu Quoc fish sauces also include the various micro-organism indications. The most significant difference between the PDO and Non-PDO Phu Quoc fish sauces is the level of nitrogen. The PDO Control Board requires the nitrogen level to be from 20 g/l (Standard 3) to more than 40 g/l (Special), but in reality, most PDO fish sauce processors produce the product with more than 35 g/l. On the other hand, Non-PDO fish sauce processors may produce the fish sauce product with any concentration of nitrogen, even lower than 20 g/l.

Extrinsic Quality Attributes (Packaging and Label)

The PDO Phu Quoc fish sauce must be preserved by natural methods and bottled and packaged in Phu Quoc district, Kien Giang province. The PDO Phu Quoc fish sauce label needs to follow the regulations of the PDO Phu Quoc fish sauce Control Board. The main extrinsic quality attributes of the Phu Quoc fish sauce include the common label and logo, private (firm) label and logo, and packaging. The common requirements for bottling, labelling and preserving the Phu Quoc fish sauce product are in compliance with TCN 230:2006.

The Logo of the PDO Phu Quoc Fish Sauce

The logo of the PDO Phu Quoc fish sauce has three main colors; dark red, sea blue, and light yellow. The main design shows fish, the outline of Phu Quoc Island, and an ocean wave. The wording is “PHÚ QUỐC”, “nước mắm” (“nước nắm” means “fish sauce” in Vietnamese) and “extract of fish” (Fig. 1).

The Label of the PDO Phu Quoc Fish Sauce

The Phu Quoc fish sauce label follows government Decree number 89/2006/ND-CP dated 30 August 2006 on the labeling and other guidelines. The label is required to show the following information: (1) Brand; (2) Logo; (3) Type (name) of product; (4) Indication (or original); (5) Name and address of company; (6) Ingredients; (7) Quality indications; (8) Extract of fish quantity; (9) Bottling date, expiration date; (10) Directions for preservation and use; (11) Package number code; and (12) Hygiene safety warning.

The use of a designation of origin for Phu Quoc entails common rules in labelling and packaging. The Association of Phu Quoc fish sauce unifies the style of the label and package and helps members to use the PDO sign by printing a special design on the labels. Only the fish sauce processors who have successfully passed the inspection and certification procedure can use the logo or label. These regulations and the labels are supplied by the PDO Phu Quoc fish sauce Control Board. Under property law, other fish sauce companies and products which are not members of the Phu Quoc Fish Sauce Association and are not qualified cannot use this label or similar labels. Moreover, the PDO Phu Quoc fish sauce processors and

Fig. 1 The compulsory common label of the PDO Phu Quoc fish sauce. (Source: Phu Quoc FSA 2011, Anh 2014; Luong 2014)

products may use the European PDO logo. The use of the European PDO logo is not mandatory for the PDO Phu Quoc fish sauce processors but it is recommended and encouraged when exporting to EU markets.

Geographical Area of the PDO Phu Quoc Fish Sauce

Phu Quoc is the biggest island of Vietnam, located in the Gulf of Thailand at 103°29′–104°09′ West longitude and 9°48′–10°26’ North latitude. Phu Quoc and nearby islands, along with distant Tho Chu Islands, are part of the Kien Giang province, as Phu Quoc district. The island has the total area of 574 square kilometres and the permanent population of approximately 103,000. Phu Quoc is located to the south of the Cambodian coast, west of Kampot, and 40 km west of Ha Tien, the nearest coastal town in Vietnam. The island is 50 km long from north to south and 25 km wide from east to west in the north at its widest, having a roughly triangular shape (Kien Giang PC 2017). The anchovies for the PDO Phu Quoc extract of fish are harvested in the territorial waters of both Kien Giang and Ca Mau provinces (The authors’ review and estimates in Fig. 2). The island is famous for the traditional fish sauce and tourism, offering plentiful sea foods and peaceful natural landscapes. Moreover, the area has relatively long and stable sunshine hours, which

Fig. 2 Geographical area of the PDO Phu Quoc fish sauce production. (Source: Google Maps, Kien Giang PC, and the authors’ review and estimation)

provide favourable conditions for fresh fish fermentation and create the special characteristics of the Phu Quoc fish sauce (Nguyen 2016).

Phu Quoc Island is surrounded by sea waters in Gulf Rach Gia-Ha Tien (Gulf of Thailand) and located at the Mekong river delta, which generates a unique and ideal environment and conditions for anchovies. The Mekong river, especially running through the Great Lake (Tonlé Sap or Biển Hồ in Vietnamese) in Cambodia, carries various alluvial and organic compounds, which makes the scad and anchovies better quality than those from other areas (Table 1).

Technical Process of Phu Quoc fish sauce Production

The process of Phu Quoc fish sauce production starts with fishing anchovies as the main raw material. Anchovies are cleaned, mixed with salt, and prepared for the next step of the natural fermentation process. After the fermentation period, fish sauce is drawn off for bottling and packaging. The PDO Control Board regulations specify that anchovies for the PDO Phu Quoc fish sauce must be harvested in the water sea areas of Kien Giang and Ca Mau provinces in the gulf of Thailand. Moreover, all steps of mixing with salt, fermenting in the barrel, extracting from the barrel, filtering and mixing, and bottling and packaging in boxes must be carried out in Phu Quoc district, Kien Giang province. Figure 3 describes the key steps in technical process of the Phu Quoc fish sauce production.

The main differences of the PDO Phu Quoc fish sauce production scheme from other fish sauce productions are that (i) anchovies are mixed with salt immediately after fishing. This may make the fermentation time longer, but it increases the quality and safety of fish sauce; (ii) the PDO Phu Quoc fish sauce is naturally ripened and fermented without boiling or ripening under the sun. Salted anchovies must be stored and fermented in the wooden barrels in roofed buildings. This helps to maintain the natural quality of the fish sauce; and (iii) there are no additives and caramel additions to the final fish sauce products (The authors 2017; Lopetcharat et al. 2001).

Raw Materials: Anchovies and Salt

The main raw material used for producing Phu Quoc extract of fish is anchovies (*Stolephorus* belonging to *Engraulidae* family). This fish has a high content of protein (36 gN/kg) and moisture with low fat, which creates the typical taste and high quality for Phu Quoc fish sauce (Nguyen 2016). The traditional fishing procedure begins during the annual rainy season when large shoals gather around Phu Quoc Island looking for shelter and food. The sediment carried down by the Mekong river currents makes the area an ideal habitat for anchovies, and the rainy season is the best time for producers to begin their new production cycle. Anchovies used for

Table 1 Summary of the technical specifications

Territory	
Geographical area	Geographical area includes: (1) Area for fishing - the territorial waters of the Vietnamese provinces of Kien Giang and Ca Mau; (2) Area for fermention, mixing and bottling - Phu Quoc Island. Phu Quoc is the biggest island in Vietnam, located in the Gulf of Thailand at 103°29′–104°09′ of West longitude and 9°48′–10°26′ of North latitude.
Varieties/breeds	There are two primary raw materials: (1) Fish material is anchovies (*Stolephorus*) belonging to *Engraulidae* family with total amount of other species not exceeding 15%; (2) Sea salt produced in Ba Ria-Vung Tau, Phan Thiet or equivalent. The salt then needs to be stocked at least 60 days from production date at a level 15 cm higher than the ground.
Animal management	
Animal health & welfare	N/A
Process	
First stage	**Fishing and preparing raw materials:** Anchovies are caught in narrow mesh tunny nets → They are shifted into boat decks and cleaned with sea water → Fresh anchovies are mixed with salt in the proportion 2.5–3 fish with 1 salt in weight, using wooden mixing instruments → Salted anchovies are stored in the boat holder and covered → The bloody liquid extracted from salted anchovies in the bottom of the holder is manually removed → Salted anchovies are stored in barrels without adding anything, not even water.
Second stage	**Naturally fermenting salted anchovies:** Salted anchovies in barrels are covered by about 3–5 cm of salt. Bloody fluid from salted anchovies comes out after 2–4 days. The pressing process starts with the use of fastening sticks, then the bloody liquid is added again to cover the lid or surface of barrels. The fermentation process takes about 12–15 months.
Third stage	**Drawing off extract of fish:** *Drawing off the first or pure fish sauce:* When the fish sauce in the barrel turns into yellow brown with a good smell, fish sauce can be drawn out and poured back into the barrel again and again until the extract of fish becomes red yellow, clear and viscous with aroma and strong taste of typical protein. Then the first fish sauce can be drawn off. *Drawing off the second or "long" fish sauce:* The salt water is poured into the system of second-hand barrels to get the first type, "long" fish sauce. This process takes 7–9 days. Other similar process is repeated in order to get second and third "long" fish sauces. These extracts are stored in holders.
Fourth stage	**Mixing and bottling the extract of fish:** The first extract of fish is mixed with "long" extracts 1, 2 and 3 to get extract of fish with the required protein content. The extract is bottled in sealed glass or plastic bottles. Bottled extract of fish should be stored in a storehouse in natural weather conditions.
Transportation	N/A
Conditioning	*Barrels and containers:* Barrels, containers, and other tools must be made of safe, clean materials which will not affect the natural quality and typical characteristics of Phu Quoc fish sauce. Barrels can hold up to 10–15 tons of salted fish. They are usually cylindric, made of wood from typical trees from Phu Quoc island. The wood is flexible and withstands exposure to salt water, insulating and protecting the extract of fish.

Source: The authors (2017)

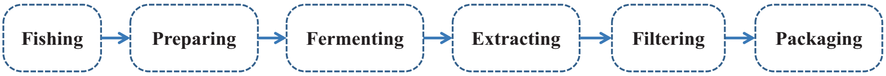

Fig. 3 Steps in technical process of Phu Quoc production. (Source: The authors 2017)

production of Phu Quoc extract of fish are caught within the territorial waters of Kien Giang and Ca Mau provinces in the gulf of Thailand. Due to the characteristics and the advantages of this fishery area, anchovies in the location are bigger and fatter than the anchovies in other areas such as Ba Ria-Vung Tau, Nha Trang, and Gulf of Tonkin.

Usually, anchovies are mixed with other kinds of fish and impurities when fished from the seas and this may reduce the quality of Phu Quoc fish sauce in general. Under the regulations of the PDO Control Board, anchovies for the PDO Phu Quoc fish sauce must be filtered and cleaned so that the impurity rate is less than 15% (i.e. more than 85% of anchovies) (Luong 2014).

After fishing, filtering, and cleaning, fresh anchovies are mixed with salt (NaCl). Salt is the second main material which is used for preserving fish, without the use of ice or cooling systems, and for natural fermentation. Under PDO Control Board regulations, the salt for the PDO Phu Quoc fish sauce must be sea salt which is produced in Ba Ria-Vung Tau, Phan Thiet or equivalent. The salt then needs to be stocked for at least 60 days from production date at 15 cm higher than the ground (Luong 2014).

Barrels

Salted anchovies are stored and processed in stable barrels which can hold up to 10–15 tons of salted fish for about 12–15 months. Barrels are usually cylindric, made of wood from typical trees from Phu Quoc island such as “ho phat”, “chay”, “boi loi”, and “den den” which are less affected by insects, termites, and wood eaters. They are also flexible, withstand long-lasting exposure to saltwater, and insulate and avoid bad effects on the extract. Barrels are an important element in Phu Quoc fish sauce production. Some Non-PDO processors can use barrels of concrete or manmade materials, but PDO processors under the strict rules of the PDO Control Board in Phu Quoc must use barrels made of wood. In general, barrels, containers, and other tools for the PDO Phu Quoc fish sauce must be made of safe clean materials which are not toxic and which do not affect the natural quality and typical characteristics of the Phu Quoc fish sauce.

Production Technology

Fishing and mixing with salt Anchovies must be cleaned and filtered from other fish and impurities after fishing. Fresh anchovies then are quickly and evenly mixed with the salt in the proportion of 2.5–3 fish and 1 salt. Mixed anchovies are stored in the boat cellar and the liquid extracted from the mixed anchovies is removed. Salted anchovies are stored in barrels. Finally, more salt is added to cover the surface of salted anchovies in barrels in a 5 cm layer.

Storing and fermenting Before storing and fermenting, barrels and tools need to be cleaned and prepared. Salted anchovies are stored in barrels with a salt cover. After 7 days of storing and fermenting, salted anchovies are strongly pressed and locked by a wood cover, some fish fluids from the mixed anchovies drip down and they are collected to re-fill barrels. The storing and fermenting period is about 12–15 months under the natural conditions in roofed houses.

Extracting the fish sauce The first fish sauce is extracted and re-filled many times until the first fish sauce becomes clear and pure. Usually, the first extract of fish is mixed and filtered for the PDO Phu Quoc and high-class fish sauce products. After that, the second (and third) fish sauce is also obtained by adding the mixing saltwater into the chain of barrels, extracting, and re-filling many times until the second (and third) fish sauce becomes clear and pure. The second (and third) fish sauce is mainly used to produce industrial fish sauce with various additives. The Non-PDO fish sauce processors also may mix the first fish sauce and second (and third) fish sauce to produce the traditional fish sauce with lower quality.

Phu Quoc Fish Sauce Value Chain

The core value chain of the Phu Quoc fish sauce includes three main actors: upstream, the fishing boat, at processing level the fish sauce processor, and downstream the fish sauce retailer. The full Phu Quoc fish sauce value chain consists of: (i) direct intermediate suppliers of inputs, such as salt and fresh water, who sell salt and fresh water to the fisher and the processor for production; (ii) anchovy middle traders who buy anchovies from fishers and sell them to processors; and (iii) industrial fish sauce re-processors who purchase the pure and traditional fish sauce to produce the industrial fish sauce in large volumes, and (iv) fish sauce exporters who buy the fish sauce from the processors or the re-processors and export to world markets. Most fish sauce processors purchase anchovies directly from the fishing boats, but some of them buy through anchovy middle traders. Most Phu Quoc fish sauce processors supply the fish sauce directly to retailers without using wholesalers, and some of them also directly export to world markets without using middle exporters. The end-user markets include both local and global markets. In fact, most overseas consumers of Phu Quoc fish sauce come originally from Vietnam. Phu Quoc fish sauce is a special, famous, and traditional product, and its main value chain is relatively short and effective. There are additional supporting and supplying actors along the value chain, such as: (i) Phu Quoc Fish Sauce Association (SFA) including Phu Quoc fish sauce processors, fishers and the Phu Quoc PDO Control Board which supervises the quality and supports Phu Quoc fish sauce processors with PDO labels/seals and certificates; (ii) suppliers of services and inputs like finance, logistics, transportation, marketing, and others; and (iii) the government, which participates with promotion and support policies. The Phu Quoc fish sauce value chain is also strongly and effectively supported by various local and international institutions such as the European Commission, the MUTRAP project, the French Embassy, universities and research centers. Figure 4 gives an overall view of the Phu Quoc fish sauce value chain.

The vertical integrations of the actors in the Phu Quoc supply chain are presented in Fig. 5. In general, there are four main chains showing vertical integration, as follows:

Chain 1: Fishers => Processors => Retailers
In the first and traditional chain, the anchovy fisher, the fish sauce processor, and the fish sauce retailer are different actors without official contracts and agreements. There are three subjects in this chain.

Chain 2: Fishers & Processors => Retailers
Some biggest fish sauce processors, especially the PDO fish sauce producers, invest in fishing boats to increase profits and product quality. There are only two subjects in this chain; fish sauce processors with fishing boats and fish sauce retailers.

Chain 3: Fishers => Processors & Retailers
Fish sauce processors sometimes have their own retail shops and sell directly to consumers, especially through online shops or small shops in their own houses in target markets. There are two actors in this chain, including fishers and fish sauce processors with retail shops.

Chain 4: Fishers & Processors & Retailers
Big companies especially have fishing boats, a processing factory, and retail shops. They cover all activities, so that there is only one actor in this chain.

Governance of the PDO of Phu Quoc Fish Sauce Value Chain

The conditions for PDO application are set out in the handbook for the management and use of Phu Quoc PDO. In general, Phu Quoc fish sauce processors and products must meet the quality standards, traceability requirements, and be located in the Phu Quoc area. The documents for application to join, accept and remove members from the PDO are also shown in the handbook.

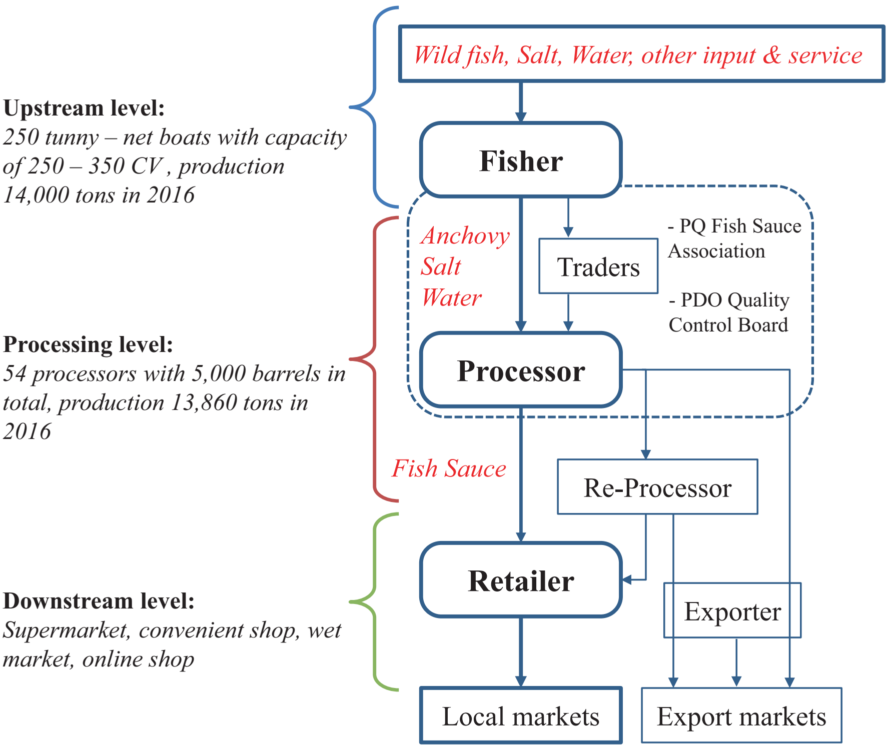

Fig. 4 PDO Phu Quoc value chain. (Source: The authors 2017)

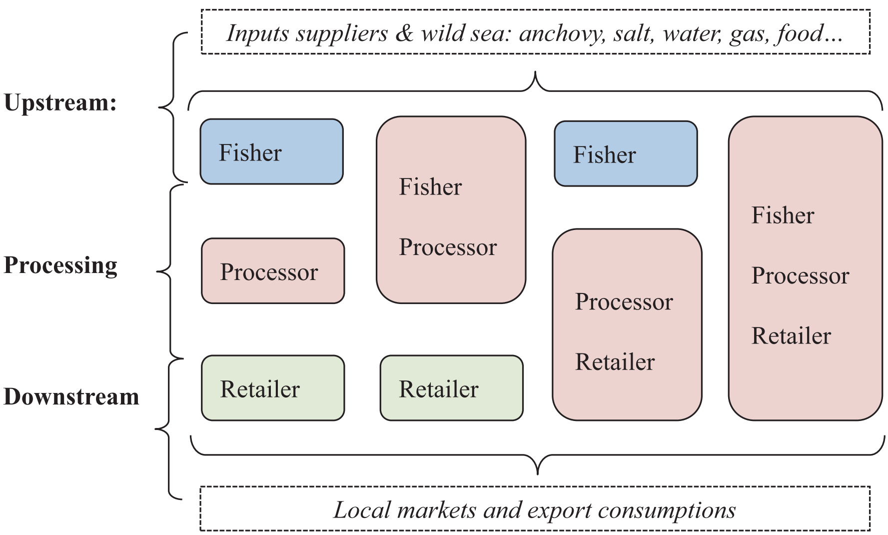

Fig. 5 Vertical integration in a hypothetical supply chain. (Source: The authors 2017)

Luong (2014) describes three levels of the inspection system: (i) producers, (ii) internal; and (iii) external. At producer level there is self-control by fish sauce producers to ensure they meet the requirements for PDO. Internal control is implemented by the Phu Quoc Fish Sauce Association to ensure the prestige of PDO members (and of the Association) as well as the quality and origin of products. External control is implemented by the Control Board, which monitors and controls all businesses of the Phu Quoc PDO value chain and the usage of the associated label. All levels must follow a control plan which is approved by the Phu Quoc District PC.

The Phu Quoc FSA (2011) shows that the Phu Quoc producer association developed the "Specification of Phú Quốc" on October 19, 2005 and established an internal control board to manage and control the compliance of the members or processors with the Specification. The Specification includes information on: (1) definition of the product; (2) geographical area; (3) typical characteristics of Phu Quoc; (4) links between the protected designation of origin and product quality; (5) detailed steps of the manufacturing process; (6) proof of the reputation of the product; and (7) certification and control of the product.

The Control Board consists of five members from the Department of Fisheries, the Department of Agriculture and Rural Development, and three paid standing members who have expertise and experience, but no potential conflict of interest with producers. The Control Board coordinates with the standard and quality office of the Department of Science and Technology to conduct frequent spot checks and unannounced quality tests based on the report of Phu Quoc FSA. When the fish is caught, the control board checks whether it is fresh and meets requirements. The following information is recorded for each catch: fishing boat number, arrival time, storage barrel number, the name of the production site, and the quality of fish. Checks are also made on the next steps: fermentation, drawing off, finished product, bottling and labelling. A sample of the end product is sent to the Center for Quality Control and Fishery Hygiene of the Ministry of Agriculture and Rural Development for food hygiene checks and quality testing. Based on the protein content of the fish extract, the Control Board checks compliance with standards laid down in the product specification. Where there is an infringement, the Board applies different levels of sanction: (i) preventing the processors from packaging or labeling their products as Phu Quoc and PDO; (ii) removing the producers from the Association so that they are no longer eligible to use the PDO label (Fig. 6).

Sustainability Diagram Based on Strength2Food Indicators

The reference product is the Non-PDO Phu Quoc fish sauce, which is also traditional fish sauce and produced in Phu Quoc island without the PDO certification. The sustainability analysis of the PDO Phu Quoc fish, implemented according to the specific methodology of Strength2Food (Bellassen et al. 2016), sauce generally shows that the PDO results in better economic, environmental, and social indicators for the agents in the chain (Fig. 7).

No.	Controlling factors	Self - Control	Association	Control Board
1	Input materials	X		
-	*Fishing area*	X		
-	*Rate of anchovies*	X	X	X
-	*Salt quality and origin*	X		
2	Barrel and tools			
-	*Barrel material (wood)*	X	X	X
-	*Bucket, can (containing fish sauce)*	X		
3	Processing technology			
-	*Storing & fermenting process*	X		
-	*Storing & fermenting time*	X	X	X
-	*Extracting technique & method*	X		
-	*Mixing technique & method*	X		
-	*Packaging technique & method*	X		
4	Label and stamp use	X	X	X
5	Fish sauce quality		(*)	(*)
-	*Nitrogen degree*	X	X	X
-	*Color*	X	X	X
-	*Smell*	X	X	X
-	*Taste*	X	X	X

Source: Luong (2014)

Note: "X" means: must be controlled and checked. (*) means: checking when there are signs of regulations breaking, conflicting, and complaining

Fig. 6 GI control mechanism of Phu Quoc fish sauce. (Source: Luong 2014)

Economic Issues

On average, sale prices of the PDO products (fish material and fish sauce) are 54% higher than those of the Non-PDO products. The lowest **price premium** is at the upstream level, at only 6%, due to the small difference between the PDO and Non-PDO raw materials. The highest price premium is at the processing stage, at 131%, since the PDO fish sauce is packaged in bottles and sold to the end-user markets at a high sale price while the Non-PDO product is mainly sold to the re-processing companies or/and sold to the end-user markets at a lower sale price. This is partly thanks to the GI technical specifications which require that the packaging of the PDO fish sauce must be done on Phu Quoc Island with the regulation labels/seals, information, and designs. However, this is a two-way interaction. The PDO enhances the brand name, improves the production process, increases price, and promotes the prestige of processors. Hence, in turn, mainly the big processors with better processing systems and higher market shares meet the various strict requirements and can apply for the PDO.

The overall difference in **operating margin** between the PDO and Non-PDO value chains is about 130%. The biggest difference in operating margin is at the downstream level, reflecting the lower costs of two main items: intermediate costs and wages. First, the fish sauce cost is the main part in the intermediate cost of retailers and the cost of the PDO retailers is lower than that of the Non-PDO retailers. The main reason is the bigger trade discount given by the PDO processors to the PDO retailers, sometimes it happens when members of the same family are involved.

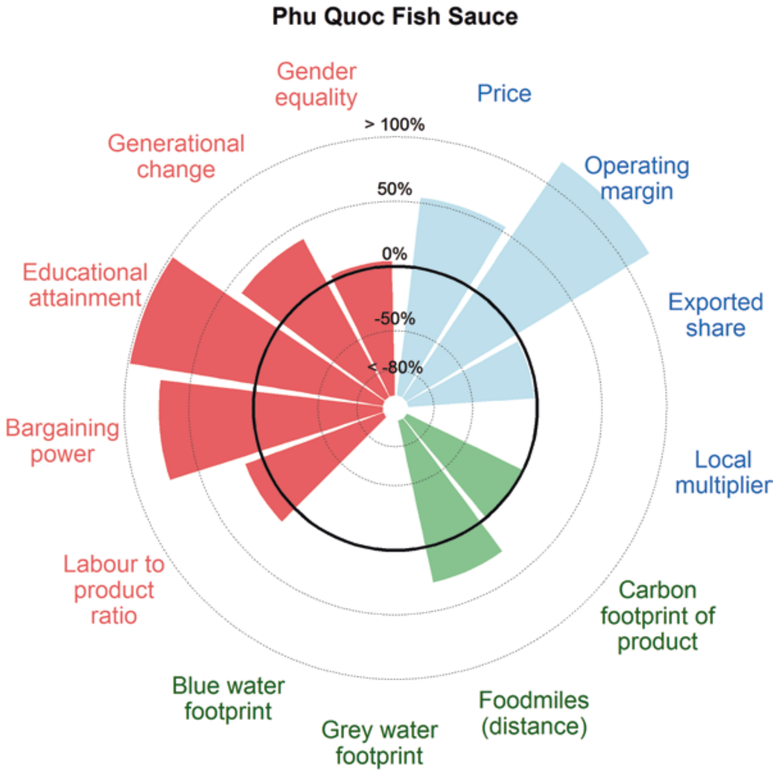

Fig. 7 Sustainability performance of PDO Phu Quoc fish sauce (supply chain averages). (Each indicator is expressed as the difference between PDO Phu Quoc fish sauce and its reference product. For environmental indicators, for which lower is better, the opposite of the difference is displayed (e.g. +20% when the carbon footprint is 20% lower)). (Source: The authors 2018)

Secondly, the lower wage rate of the PDO retailers indicates the fact that the PDO retailers utilize resources more effectively than the Non-PDO retailers, who are usually older people selling fish sauce in their free time as a part-time job for extra earning or fun. The driver of the difference is partly the technical specifications, standards, and prestige of the PDO. In particular, the PDO promotes market orientation, brand name, and profits of the stronger retailers. In turn, retailers with larger scope and more resources are more interested in PDO products and also promote the prestige and awareness of the PDO.

In general, the exported share of the Non-PDO fish sauce is higher than the PDO product in both EU and extra-EU markets, with a difference of 8%. The exported share of the Non-PDO fish sauce is much higher than for the PDO product on the EU market, while the exported share of the Non-PDO fish sauce is lower than the PDO product outside the EU market. The higher rate of the Non-PDO fish sauce export to EU is due to taste habits, export systems, and the nature of the value chain. Firstly, GI technical specifications give the PDO fish sauce a stronger fishy and salty taste and smell, so it is more appreciated by Asian than European consumers. Secondly, because of the export code to the EU market, most fish sauce to the EU is mainly entrusted export and big processors may not prefer this. In addition, the traditional fish sauce exporters in Phu Quoc mainly export the Non-PDO fish sauce to traditional partners and markets which are familiar with the Phu Quoc brand name and do not require the PDO. This is due to the specific nature of the value chain itself, rather than PDO recognition.

Environmental Issues

For **carbon footprint**, there is no clear significant difference between the PDO and Non-PDO (462 kgCO2e/ton vs 459 kgCO2e/ton for the reference). The diesel consumption by boats remains the main factor in the overall footprint and is lower in the PDO chain than in the Non-PDO chain. The main explanation is that Non-PDO fishing boats use more fuel than PDO fishing boats because of the longer distances travelled to catch higher quantities of anchovies. Diesel consumption by fishing boats in Vietnam is 2–4 times lower than for Norwegian captured fish (Winther et al. 2009), but Norwegian fishermen may travel further to catch their fish. The carbon footprint difference at fishing level is offset by the opposite difference at processing level. The diesel consumption of the PDO processor is higher than the Non-PDO processor because of the lower processing ratio, or lower quantity of the final fish sauce product of the PDO fish sauce.

For **food-miles**, the PDO Phu Quoc supply chain is compared to the conventional fish sauce also produced on Phu Quoc Island, from U3 to D1. Over the entire supply chain, from fish ports to distribution units (U3-D1), the FQS performs better than its reference as regards distances traveled, but performs worse as regards the emissions released at the transportation stage. The PDO fish sauce travels 30% shorter distances (4000 km vs 5500 km) but releases 15% more emissions (115 vs 100 kg CO2 eq). The difference is driven first by exports, since the FQS fish sauce is mostly exported within Asia, implying shorter distances, while conventional fish sauce is mostly exported outside Asia. Second, domestic export distribution implies shorter distances for the conventional product, as 91% of conventional fish sauce is sold locally to industrial fish sauce processors, against 1.3% of the FQS production. This however does not offset the shorter export distances traveled by the FQS. Another major difference relates to the share of co-products, which is relatively high (82%) for the FQS, against under 1% for the reference product. However, co-products impact only the processing level, which accounts for few kilometers and emissions along the value chain, and does not make much difference overall. The distribution level (P1-D1) concentrates most of the kilometers embedded in the product and most of the emissions generated for transportation along the value chain. So, for the food-miles indicator, the PDO Phu Quoc fish sauce is more sustainable than its reference in terms of distance traveled, but less sustainable in terms of emissions released.

Social Issues

Concerning labour requirements, the **labour to product ratio** of the PDO is 14% higher than the Non-PDO. The biggest difference is at the processing level (0.0239 awu/ton for the PDO processors 0.0176 awu/ton for the Non-PDO processors). The PDO firms usually employ more labour than the Non-PDO firms as all of the PDO fish sauce products are packaged in bottles and sold to the end-user markets. Moreover, the PDO packaging process must be done on Phu Quoc Island with the regulation labels/seals, information, and designs, according to the GI technical specification. On the other hand, the Non-PDO fish sauce may be sold to re-processing companies and does not need to be packaged, labelled or sealed. Regarding labour productivity, the 43% higher turnover to labour ratio is mostly driven by the higher price of the PDO fish sauce compared the Non-PDO fish sauce. Thus, the technical specification of the GI contributes significantly to the difference in both labour requirement and labour productivity by generating more professionalism in the packaging process.

Bargaining power distribution shows a good balance for both the FQS supply chain and the reference, even though processors have a slight advantage. The advantage at the processing level for the PDO can be explained by the higher scores reached for "transactional" variables: they enjoy higher levels of contractual flexibility (i.e. Lower value for the "prop_contract" variable). On the other hand, the processing level advantage for the Non-PDO is explained by the advantage obtained for the "competitive context variables": there are slightly fewer actors at this level and the market is more concentrated than at the U3 level. This seems to be driven by the specific organisation of the value chain. However, bargaining power positions for both the PDO and the Non-PDO supply chains can be considered as relatively weak, as levels in both supply chains barely manage to reach a bargaining power score of 0.50. This implies that any significant event affecting the supply chain is likely to translate into a significant change in bargaining power distribution. Finally, bargaining power is significantly better distributed for the PDO than for the Non-PDO, thus indicating that the PDO possesses a significant sustainability advantage (73%) over the Non-PDO.

The 98% higher value of the **educational attainment** indicator for the FQS, compared to the reference product, is mostly driven by the differences at the processing and upstream stages. At the upstream level, 1.1% of the workforce on the PDO fishing boats have the highest level of educational attainment, (degree or higher degree) while this percentage is zero on Non-PDO fishing boats. This may be due to the fact that the crew of PDO fishing boats appear to hold more official fishing vessel licenses. In addition, the PDO processors usually have their own fishing boats, so that the owners may employ better qualified crew members and other staff than the Non-PDO. Similarly, PDO processor and retailer workforces show a higher educational attainment than Non-PDO processors and retailers, probably because the PDO chains have more effective and modern management structures and distribution systems.

For **age balance**, the PDO product is 39% more sustainable than the Non-PDO products. The high value of the generational change indicator for both the supply chains of the PDO and the Non-PDO are due to the physically demanding nature of the work. At upstream level, physically demanding labor requires strength and stamina, and young workers are drawn to these jobs thanks to the high margin the products can secure. The higher generational change indicator is mostly driven by the difference at the downstream level. Non-PDO retailers are generally older and work in the fish sauce business in their free time. They buy the Non-PDO Phu Quoc fish sauce from the processors to sell to their relatives, friends, and neighbors as a part time job for extra earnings. On the other hand, PDO retailers are usually younger people working for their main incomes. This may also explain the higher net margin of the PDO retailers. Moreover, the PDO significantly affects the psychology, pride, and prestige of the effective retailers and, in turn, the retailers with more capabilities are more interested in the PDO products.

There is no clear difference between the PDO and the Non-PDO in **gender equality**. At the fishing stage, both PDO and Non-PDO actors employ mostly male staff, because of the physically demanding nature of the work on fishing boats. The processing stages of both the PDO and the Non-PDO are characterised by some gender equality. The important role of females in the supply chains of both the PDO and Non-PDO reflects family ownership of even large businesses by women. The Chair of the Association of Phu Quoc fish sauce is currently female. The highest difference is at the retailing stage. Non-PDO retailers are characterised by lower levels of gender equality, due to the low level of male employment and entrepreneurship. The difference at downstream level is because workers in the main retail channels for Non-PDO fish sauce, i.e. small retail outlets such as wet markets, online shops, or traditional markets, tend to be female.

Conclusions

With over 200 years of history, Phu Quoc fish sauce has become an authentically traditional product although the value chain is currently facing various challenges to its quality, specialty, and sustainability. The PDO is a good solution for the Phu Quoc fish sauce value chain but various constraints make its use still limited. The main constraints on PDO product development in the Phu Quoc fish sauce value chain can be summarised as follows (RIMF 2016; VOV Vietnam 2017): (i) the recent decrease in quality, quantity and size of fresh anchovy supply (resources); (ii) the limited awareness and information about the PDO on Vietnamese markets; (iii) no official regulation on the distinction and difference between traditional and industrial fish sauce exists; and (iv) the big initial investment required to produce the PDO product and the strict regulations of PDO fish sauce production.

However, the PDO has the potential to develop sustainably and play a key role in the Phu Quoc fish sauce value chain in the medium and long term thanks to these aspects: (i) rising consumer concerns for health and interest in healthy food; (ii) a fish sauce scandal which led consumers to be more aware of the distinction between traditional and industrial fish sauce, and to place greater trust in clear and full product information on origin, quality, and ingredients; (iii) the PDO is a crucial tool to export Phu Quoc fish sauce to developed markets and to prevent other enterprises using the brand name of Phu Quoc; (iv) the PDO with strict and effective regulations of quality, management, and production will encourage PDO fish sauce processors to comply with environmental and social legislation; (v) the PDO Phu Quoc fish sauce is an authentic traditional fish sauce product and part of Phu Quoc's tourist attractions; and (vi) as the first certified PDO product in Vietnam, the PDO program of Phu Quoc fish sauce is strongly supported by the government and international organizations.

The sustainability analysis of the PDO Phu Quoc fish sauce shows that overall PDO fish sauce products result in better economic, environmental, and social indicators, compared to the reference one. The price premium at the fishing stage is very small and is bigger at the processing and distribution levels. The GVA is relatively different, while net results are similar for both the PDO and the Non-PDO products at the fishing level. The processing and distribution levels show the largest difference in net results between the PDO and the Non-PDO, while the fishing level shows a small difference. There is a higher share of the Non-PDO export to the EU due to the recent appearance of the PDO, taste habits, and the export code. The PDO fish sauce performs better than the Non-PDO product as regards extended food miles and carbon footprint. The employment indicator at the fishing level differs only slightly, while the PDO product brings small improvements at the processing level. The bargaining power distribution of the PDO fish sauce value chain is much better than that of the Non-PDO product value chain. The other social indicators also indicate that the PDO fish sauce value chain performs better than the Non-PDO product value chain.

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Filippo Arfini and Valentin Bellassen

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