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REVIEW ARTICLE

Sustainability in the dairy industry: a systematic literature review

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Abstract

The dairy industry can contribute to global food security in a sustainable way by efficiently converting milk into dairy ingredients and products, even though they are polluting on a large scale. In this context, this study aimed to conduct a systematic literature review on sustainable indicators and dairy industries. The methodology used has a qualitative and quantitative approach and its technical procedure was the systematic literature review. The bases of journals consulted, using the keywords "sustainability indicator" and "dairy industry" which resulted in 130 valid scientific articles. The main results show that the sustainability indicators in the dairy industry are emerging and lacking research; being found seven papers, that highlight 12 indicators of the environmental, 11 of the social and eight economic dimensions, that may be considered fragile and initial. The studied problems are related to wastewater treatment methods, electric power consumption, efficiency of the industrial plant, among others, and the benefits on the theme are related to solutions to the difficulties, such as electricity reduction, sustainable practices. Among others, it is concluded that the dairy industries address the sustainability theme since 2011, with an ambiguous trend, being found evidence of the fragility of the sustainability indicators was found, mainly in the initial stage of their conception, when considering holistic approach (triple bottom line).

Keywords Sustainability · Dairy industry · Milk · Indicators · Cleaner production · Environmental science

Introduction

Milk and dairy products comprise a globally essential food for humanity, as they provide proteins and minerals that are essential to human growth and maintenance. Thus, the importance of dairy products in the balanced diet of human health due to their nutritional value cannot be ignored, in particular because they contain iron, sterols, proteins, and vitamins (Muehlhoff et al. 2013). Augustin et al. (2013) emphasize that in the face of climate change, growing world

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population and limited resources food security are the basis of maintaining humanity. This essentiality is also positively reflected in the productive system and the economy (Sharma et al. 2017).

Santos et al. (2017) emphasize that the interest in environmental impacts derived from food production is increasing, mainly by consumer preferences for green products, by regulatory agencies, business-to-business relationship, among others. In this regard, the dairy industry must contribute to global food security in a sustainable way, i.e., develop a holistic approach to the efficient and effective conversion of milk into dairy ingredient and products (Augustin et al. 2013). Therefore, the ecological, social, and economic pressure is increasing in the industrial organizations, because the pollution generated by them has increased today to levels never reached (Li and Mathiyazhagan 2018).

Dairy industries and milk production are large-scale pollutants (Brião and Granhen Tavares 2007), are among the most polluting industries due to their high water consumption (Vourch et al. 2008a), considered the largest source of water. Wastewater from food processing (Farizoglu and Uzuner 2011) generates high effluent volume due to water consumption (Rad and Lewis 2014), faces increasing problems in relation to waste products from the production process (Salzman et al. 2017), which generally represents the main source of wastewater in several countries (Kasmi 2018), among others.

Sustainability is essential for decisions in the development and management of industries, but the holistic and integrated approach encompassing the triple bottom line aspects of sustainability remains problematic (Buys et al. 2014). In this logic, Blok et al. (2015) point out that current production processes are far from ideals in terms of sustainability. In addition, they suggest that sustainability is not just a complement or an isolated but integrated and connected attitude with of corporate operations. Li and Mathiyazhagan (2018) found that organizations generally are not concerned with updating and maintaining sustainability performance. In addition, Luthra et al. (2017) emphasize that most industries are unwilling to incorporate sustainable practices.

There is a concern in the literature regarding safe, nutritious, and sustainable milk-based products that are appropriate, have sensory appeal, and are ethically produced (Augustin et al. 2013). The literature review on the US dairy industry pointed to factors that would affect future sustainability, namely climate change, rapid innovation and scientific and technological advances, globalization, the inability to integrate social values, and the lack of multidisciplinary research initiatives (Von Keyserlingk et al. 2013).

Recent studies on sustainability and dairy industries focused on transport life cycle assessment (LCA) (Djekic et al. 2018), energy mix analysis, and energy efficiency (Lima et al. 2018). Water footprint assessment based on ISO 140046 (Bai et al. 2018), analysis of the financial viability of solar heating (Sharma et al. 2018), analysis of various sources of atmospheric emissions and their environmental impact (Kasmi 2018), exploration of the technical efficiency of milk processors (Popović and Panić 2018), among others. The analyses of these subthemes approached demonstrate heterogeneity, because they are distinct, and a comprehensive analysis on the subject related to the understanding of the sustainability of the dairy industries would require a complex reasoning.

In this context, this study aims to conduct a systematic literature review on sustainability indicators and dairy industries regarding the following aspects: (a) historical evolution, (b) milk derivatives, (c) main results of the studies, (d) degree of importance of the publication, (e) countries and universities with more studies on the subject, and (f) future trends. Systematic literature review is justified by providing a broader picture of sustainability and the dairy industry, saving time rather than reading each individual publication individually. Isolated reading becomes painful and tiring for most managers and professionals who are at risk of being influenced by one or a few studies that are not representative of the subject under discussion (Boiral et al. 2018).

The results of this systematic review can help practitioners and academics, due to their rigorous scientificity, to understand historical developments, issues and benefits, and a future trend on sustainability and dairy industries. Moreover, it represents a theoretical contribution to clarify dubious or unexplored questions, but which are considered relevant in relation to the theme in question, thus contributing to the establishment of gaps in the form of subthemes that can be explored in the future.

Methods

Scope and system boundaries

The production of fresh bovine milk globally in 2017 was 696 billion kg (IDF 2018). The estimated growth in milk production from 2018 to 2027 is 22%, and most of the increase in milk production is expected to occur in developing countries (80%), in particular Pakistan and India's participation by 2027, 32% of world milk production (OECD/FAO 2018).

The global average per capita milk consumption was 111.88 kg in 2015–2017 and the estimate for 2027 would be 179.13 kg, considering processed and fresh milk (OECD/FAO 2018). Moreover, Fig. 1 shows the existence of regional disparities in per capita consumption among developing countries, where consumption of fresh milk predominates, but in developed countries, the preference is for products processed from milk.

The production and consumption of milk and its derivatives reflect a significant impact in relation to the environment, as the process of industrialization of milk generates waste (Gonçalves et al. 2017; Carvalho et al. 2013): (a) liquids: milk

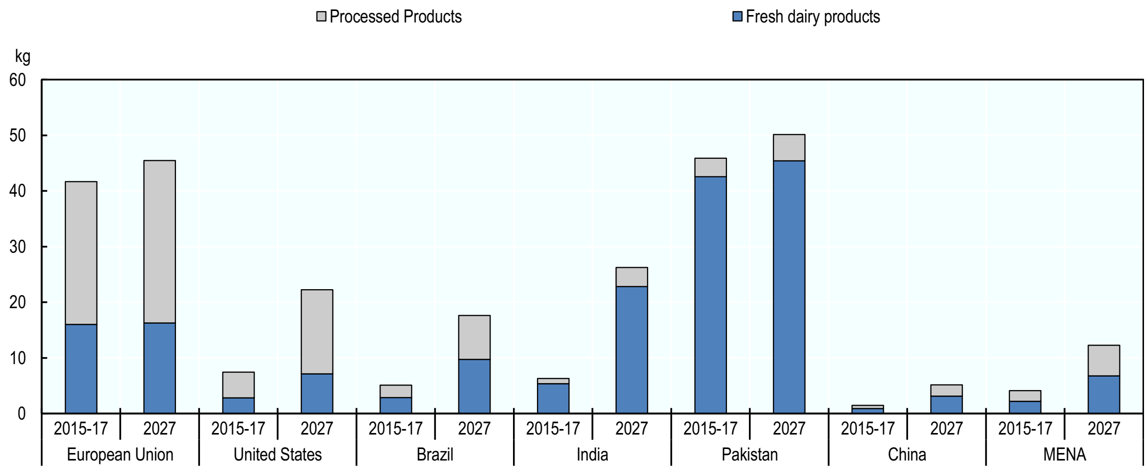


Fig. 1 Global per capita milk consumption, Source: Adapted from OECD/FAO (2018)

and derivatives, sugars, essences, condiments, sanitizing chemicals, lubricants, wastewater, whey, fats, among others; (b) solids: pieces of fruit, paper, plastic, packaging, toilet paper, cardboard, waste from the effluent treatment plant (ETE) (sand, fat, biological sludge), boiler ash, cans, glass, among others; and (c) atmospheric emissions: noise, vibration, vapors, particulate matter, sulfur oxides (SO_2 and SO_3), nitrogen oxides (NO and NO_2), and carbon monoxide (CO). These authors further point out that the diversification and quantification of dairy residues can be generated regardless of industry size and industrial plant size.

The sustainability life cycle of milk and dairy production (Fig. 2) ranges from milk production on farms, the industrialization, and processing of dairy products to the marketing of dairy products.

The steps (Fig. 1) from milk production to commercialization, without exceptions, generate impacts on the environment (Strydom et al. 1993). Kasmi (2018) points out that the high diversity of dairy products produced by the dairy industry generates a variety of wastes in quality and quantity that can cause serious pollution problems. This author further emphasizes that the elimination of untreated or partial wastewater

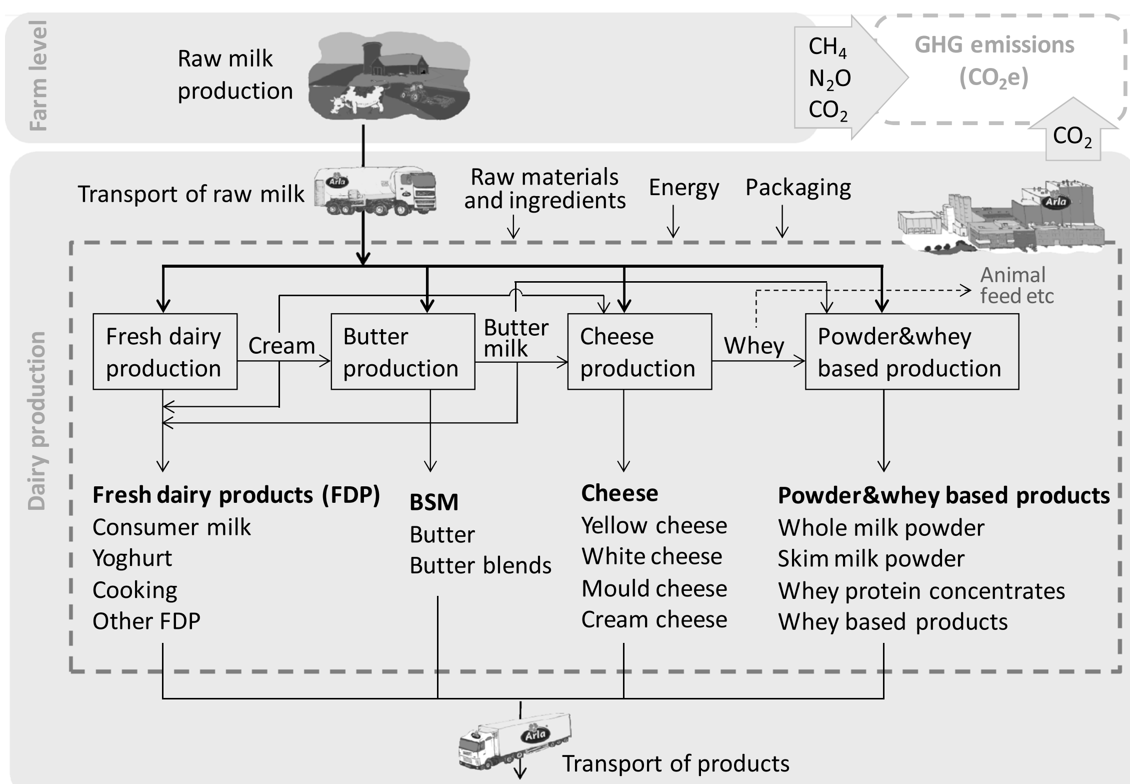


Fig. 2 Dairy processing flowchart and system boundaries, Source: Flysjö et al. (2014, p. 87)

from dairy products remains problematic in the dairy industry what requires a simple and economical solution.

Typology, research techniques, and data collection

This research has a qualitative and quantitative approach and its technical procedure focuses on the systematic literature review. Systematic review is suggested in cases in which the researcher demands a rigorous and verifiable methodology, that is, contributes to the reduction of the bias of the results and conclusions (Sampaio and Mancini 2007). In this sense, the suggested steps of these authors in the research were followed: (a) definition of the research objective, (b) choice of keywords and database, (c) selection of studies evaluating titles and abstracts, (d) tabulation of information of selected articles, and (e) presentation of results. Therefore, each step was stratified subsequently based on empirical data obtained in this research.

The aim of this systematic review is to identify the characteristics, benefits, limitations, conclusions, and trend of scientific publications on sustainability indicators in dairy industries. The keywords that were chosen as the query base correspond to the "sustainability indicator" "dairy industry" in the English language. The research was conducted in the English literature, because about 85% of scientific publications focus on that language globally (Schütz 2018).

The keywords were inserted in the journal databases and returned with the following results: Springer link (10), Emerald Insight (7), Science direct (38), Wiley Online Library (3), Scopus (67), and Google Scholar (120). The total number of bibliographies identified reached 245, and from these, the title, abstract, keywords, and references were read. The references of the publications were read and analyzed using the snowballing technique that promotes the rescue of references that did not appear in the collection of the initial scientific titles (Jalali and Wohlin 2012).

The previous reading aimed to select scientific publications that would be coherent with the following inclusion criteria in this research: (a) cover at least one aspect of the triple bottom line of sustainability, (b) have been published by peer review, (c) be a scientific article, and (d) be based on the dairy industry. In this stage, from the 223 bibliographies, 77 and 192 indications of the references of the initial bibliographies were selected and rescued, that is, that add up to 269. The reading and analysis of this list of references compiled 130 that are adherent to the object of this research. These references were collected and analyzed from December 2018 to April 2020.

Tabulation and analysis of results

The 130 scientific publications were tabulated simultaneously with reading using a spreadsheet considering the following information to be collected: (a) author and year, (b) title of the article, (c) purpose proposed, (d) keywords, (e) product studied, (f) main theme, (g) type of research, (h) sustainability indicators, (i) limitations/difficulties/disadvantages, (j) advantages/benefits, (k) main results, (l) published journal, (m) number of citations in Google Scholar, (n) published journal, (n) number of citations, (o) country of study, (p) university of the authors, (q) number and authors involved, (r) knowledge area of the author, (s) classification Qualis Capes of the magazine, and (t) HDI country classification.

In the process of this tabulation, the multiple advisor technique was used to increase the quality, validity, and reliability of the analysis, that is, this technique involved all the authors of this study in reading and examining the articles independently, organizing, and collecting the data information (Gast et al. 2017). In this sense, the following independent collections were compared and discussed to reach a consensus in the collection, analysis, and results.

The qualitative analysis of the collected data occurred through the interpretative technique, which has the objective of synthesizing the textual information and assisting in the deep understanding of the results (Severino 2007). The qualitative analysis also used the IRaMuTeQ 0.7 alpha 2 software, which proposes tools and treatments that help in the description and multidimensional analysis of the textual body, discovering the density and prominence of the words, the similarity, descending hierarchy, among others (Loubère and Ratinaud 2013).

Quantitative analysis was performed using the IBM SPSS Statistics Software using descriptive statistics tools (mean μ, standard deviation σ, coefficient of variation CV), spearman correlation (ρ), linear regression (R^2), and multivariate statistics (Mann-Whitney test).

Results

General characteristics of publications

The publications of scientific articles in this study focus on the time period from 1969 to 2020 (April) containing 130 publications (Fig. 3). There is a growing movement in the number of publications over the years, which is confirmed by linear regression ($R^2 = 0.383$).

The Mann-Whitney test points out that the average number of publications from 2011 to 2020 ($\mu = 6.6$; $\sigma = 3.2$; CV = 0.49) is significantly higher ($p = 0.000$) compared to the average from 1696 to 2010 ($\mu = 2.2$; $\sigma = 1.3$; CV = 0.59). This fact can be explained by the events that occurred in the 2000s; for example, in 2005, the Kyoto Protocol came into force where 192 countries ratified; in 2009, the Copenhagen agreement was postulated with accession of 141 countries; in 2010, the Cancún Declaration formalized the Copenhagen agreement and 195 countries signed.

The analysis of the quality of journals, in which the 130 studies were published, reveals that 66.2% of scientific journals have Qualis higher than B2 in the interdisciplinary

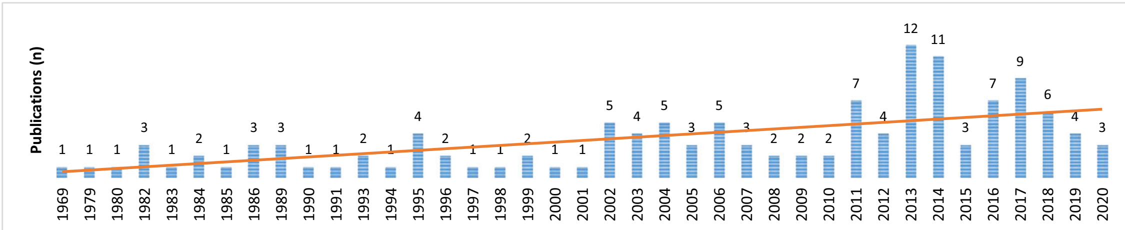


Fig. 3 Temporal distribution of publications

area (Fig. 4). In addition, it is noted that 39.2% of the publications were published in the Qualis A1 stratum, which demonstrates that the themes of the studies are in evidence and emerging in academia and society.

The Journal of Cleaner Production (stratum qualis A1) has the largest number of publications (11 articles), among the 75 scientific journals involved, and of these, only 55 articles were published in each. Descriptive analysis ($\mu = 1.73$, $\sigma = 1.71$, and CV = 0.99) reveals an inhomogeneity in the number of articles published per journal, i.e., concentrated in 20 scientific journals that published 57.7% of the articles.

The analysis of the number of citations by Google reveals that 7.3% of the articles were cited over 201 times; in addition, it is noteworthy that the four publications with the highest number of citations are related to literature review studies, for example, González Siso (1996), Daufin et al. (2001), Demirel et al. (2005), and Prazeres et al. (2012), with 821, 325, 547, 515 citations, respectively, April 2020 data.

The total number of authors involved in the 130 publications was 426, and of these, 19 subscribe to more than two articles (Fig. 5).

The authors Bernard Chaufer and Béatrice Balannce (Université de Rennes), Jahanna Berlin (Chalmers University of Technology), and Mortaza Aghbashlo (University of Tehran) are the most recurring publications. The average number of authors per scientific article ($\mu = 3.2$) has high dispersion and low precision ($\sigma = 1.2$; CV = 0.38). This reveals that researchers are not exclusively dedicated to research related to the dairy industry. It can be analyzed that this prevents the consolidation of a line of research and does not contribute to the expertise of a researcher, who tends to change the subject over time, not producing greater expertise in the area.

The educational institution with the largest number of scientific publications is the Université de Rennes with 4.8%, concentrated from 2001 to 2008 (Fig. 6). In addition, the Indian Institute of Chemical Technology, Istanbul Technical University, the University of Tehran, the University of California, the Chalmers University of Technology, the University of Wisconsin-Madison, and the Gebze Institute of Technology also contributed over two publications representing 18.7%. Thus, there is a high dispersion of institutions that encourage research in the areas of sustainability in dairy industries.

The countries with the largest number of scientific articles in their geographical area are related to the Turkey, USA, India, Australia, France, Brazil, among others (Fig. 7). This fact corroborates the high dispersion of educational institutions, as the geographic distribution reaches 38 countries.

Geographic regions with high publications correspond to developed (60.8%), developing (34.6%), underdeveloped (0.8%), and unrated (3.8%) countries. Comparing this

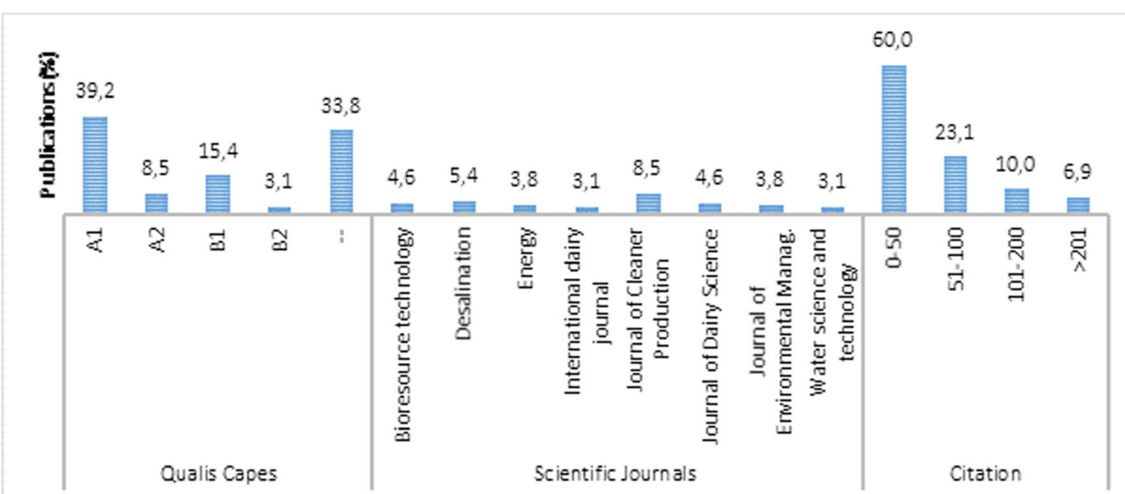


Fig. 4 Qualis Capes, scientific journals, and citations

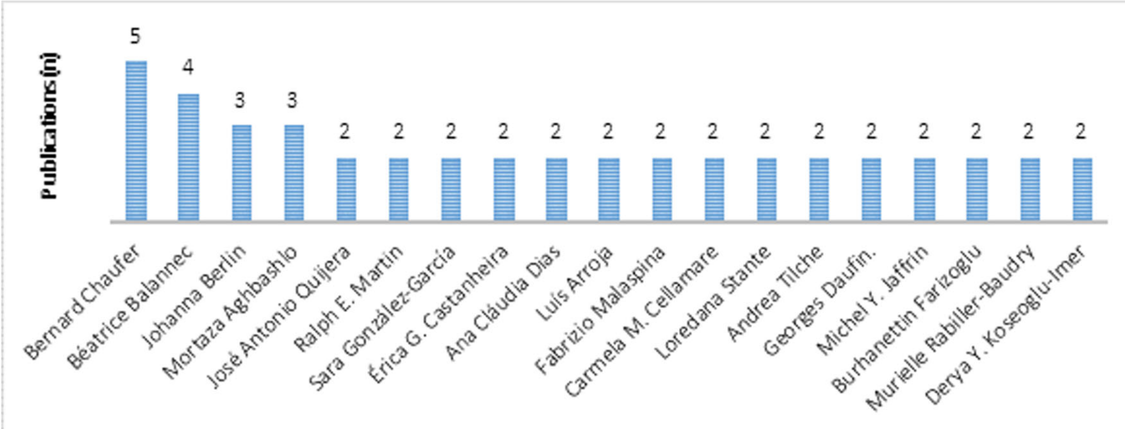


Fig. 5 Leading authors versus article production

information with fresh milk production reveals that the largest amount of research on sustainability in dairy industries occurs in countries with the highest production in kg/year. It is noted that there are a number of universities in emerging countries, which can be seen from the weight that the agro-industrial sector has on their economy, already noted at the beginning of the article. Brazil appears as a country with intermediate production, since it stands out more in the production of grains and meat than milk.

Analysis of thematic, triple bottom line, and product aspects

The subjects of the scientific articles were distributed by themes and Fig. 8 concentrates 91.5% of the topics covered.

Themes with the largest number of studies are linked to the treatment of whey (40%), use of whey (11%), life cycle assessment (12%), cleaner production (12%), and energy power consumption (10%), according to the chart 6. Discussions related to the term sustainability started in 2011, which corroborates the global events related to the Kyoto Protocol, Copenhagen agreement, Cancun declaration, among others.

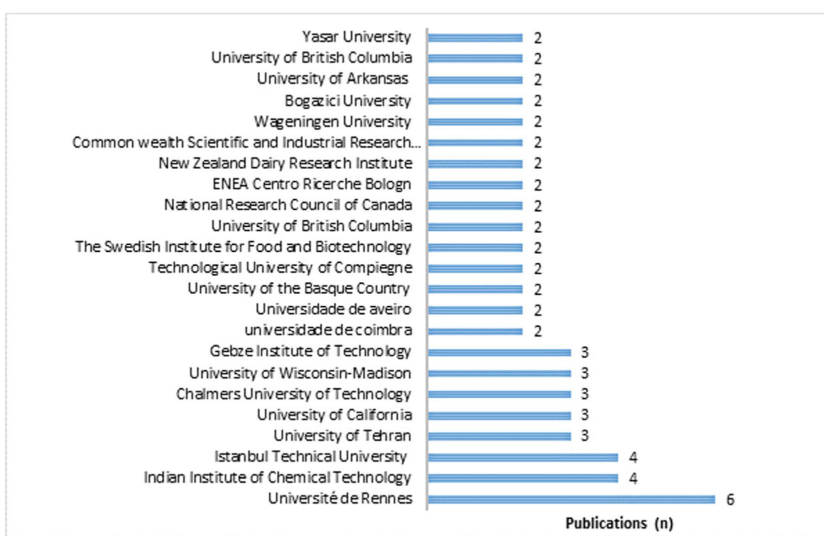
The temporal distribution of the nine themes addressed on the dairy industry (Fig. 8) reveals, through linear regression, that the number of publications presents an ambiguous trend, since their accuracy is below 22.3% ($R^2 < 0.223$), in all of them. That is, there is no clear trend on the themes that will be addressed in future study publications.

Approaches to the triple bottom line aspects of sustainability focus on environmental (67.4%) and environmental and economic (17.8%), totaling 129 studies (Fig. 9).

The accuracy of the linear regression adjustment in the evolution of the number of studies per aspect over the period averaged less than 26.0% ($R^2 < 0.260$), which also does not reveal a consistent trend on approaches related to aspects of triple bottom line of sustainability.

The sustainability indicators were addressed in only 5.4% (Fantin et al. 2012; Kim et al. 2013; González-García et al. 2013a; Bourlakis et al. 2014; Djekic et al. 2018; Üçtuğ 2019; Satolo et al. 2020) of the studies. Of these, only two studies

Fig. 6 Top universities versus article publishing



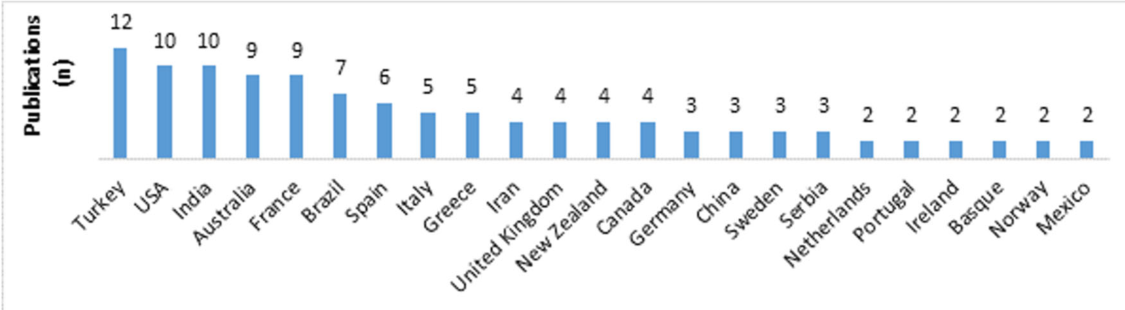


Fig. 7 Geographic areas of studies

(Djekic et al. 2018; Satolo et al. 2020) discussed the three aspects of sustainability simultaneously. The compilation of sustainability indicators indicates that the environmental aspect remained with 12 indicators, that is, ozone depletion (frequency $f = 7$, or f7), water eutrophication (f6), energy consumption (f4), ecotoxicity (f4), abiotic depletion (f4), global warming (f4), water acidification (f3), photochemical oxidation (f3), human toxicity (f3), and water consumption (f2). These environmental indicators present weaknesses regarding the desirable qualities defended by Veleva and Ellenbecker (2001); for example, global warming, photochemical oxidation, and ozone depletion are difficult to measure, complex to analyze and general, making it difficult to apply them in dairy business.

The social aspect highlighted 11 sustainability indicators, that is, product delivery capacity (f4), product quality (f3), flexibility with extra sales (f2), quality of raw materials, traceability system, packaging quality, number of employees, product availability, workers' health and safety, noise pollution, and traffic accidents with victims. These social indicators are consistent with the desirable qualities of Veleva and Ellenbecker (2001); however, there is an absence of relevant indicators in the social aspect, for example, customer and employee complaints, employee career and stability, discrimination.

The economic aspect had eight indicators, namely profit margin (f3), delivery and distribution cost (f2), production cost, storage cost, financial cost, participation in milk processing, percentage of dairy products, and percentage of delay. Economic indicators, despite presenting low frequency in studies, are aligned to desirable qualities, also defended by Tonelli et al. (2013), but some indicators are absent in this set, such as taxes, local suppliers, spending on salaries.

The products most addressed in the research are related to milk (in natura), cheese, and whey, which account for 64% of the studies analyzed (Fig. 10).

Cheese-derived whey is in evidence as it represents 13% each, and most studies focus on its treatment with more efficient tools.

Spearman correlation analysis (ρ)

The correlated variables were the themes of the studies (Fig. 8) in relation to the triple bottom line aspects of sustainability (Fig. 9). The results indicate that there was a significant strong correlation ($P < 0.01$; $\rho = 0.591$) between the consumption of

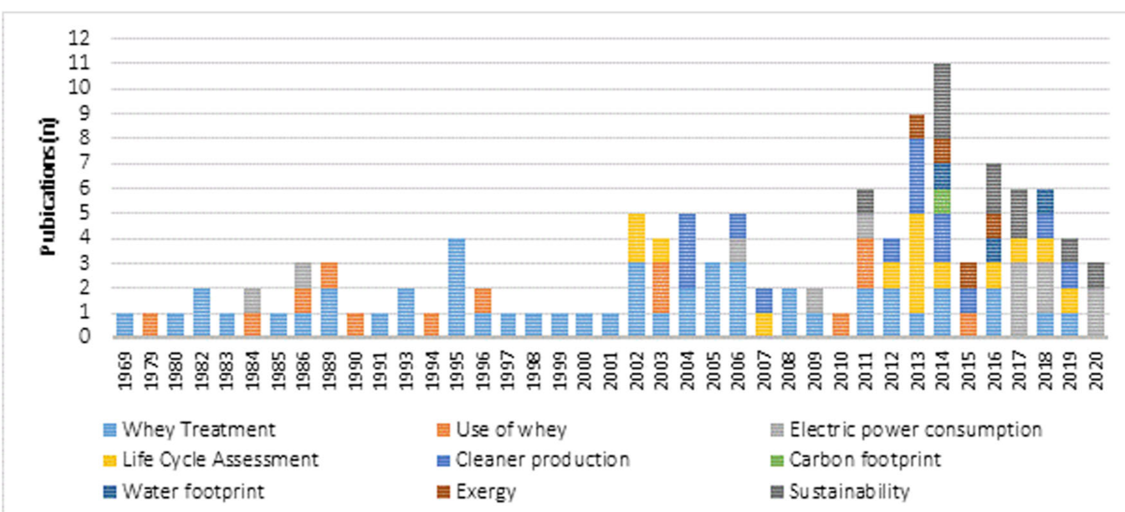


Fig. 8 Main themes

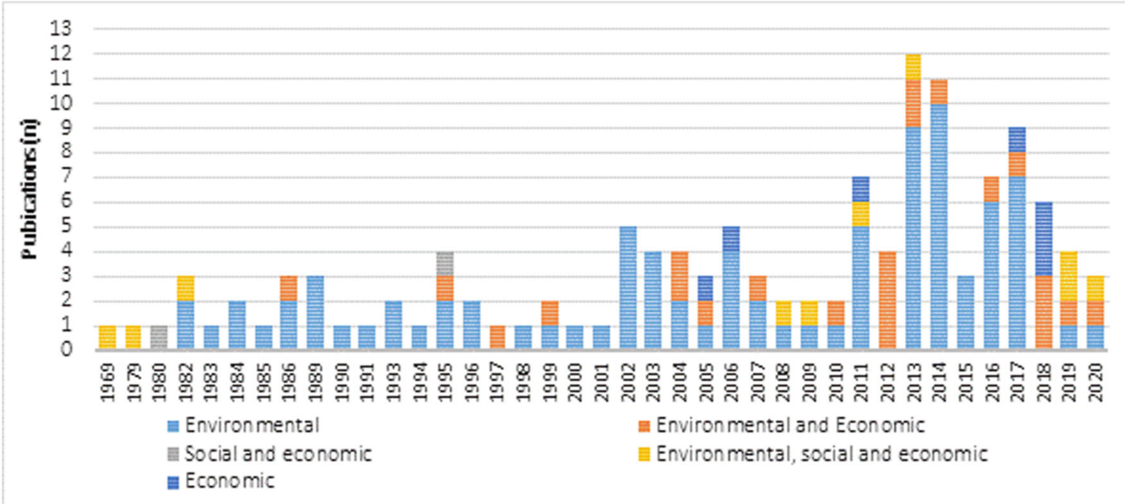


Fig. 9 Triple bottom line aspects of sustainability

electricity and the economic aspect (Table 1). That is, studies indicate that a reduction in electricity consumption influences the increase of economic gains.

The use of tools related to cleaner production ($\rho < 0.01$; $\rho = 0.529$) and life cycle assessment ($\rho < 0.01$; $\rho = 0.494$) had an environmental and economic motivation. In this sense, the use of tools such as cleaner production and life cycle assessment helps both to reduce environmental impacts and to increase the economic gains of dairy industries.

Environmental concerns motivated discussions related to life cycle assessment ($\rho < 0.05$; $\rho = 0.369$), exergy ($\rho < 0.01$; $\rho = 0.494$) and sustainability ($P < 0.05$; $\rho = 0.381$). Thus, the idea of sustainability is still linked to the environmental issue, i.e., not covering the aspects of triple bottom line together.

Goal, title, and keyword analysis

The core ideas addressed in the objective, title, and key words can be grouped into four groups, namely dairy industry, water, whey, and industrial processes (Fig. 11). The main veins reveal that the studies discuss issues involving the productive process of the dairy industry, in particular, the treatment of wastes and effluents related to whey and water.

Milk-processing operations, on the one hand, relate to life cycle assessment in an attempt to improve organizational and environmental technical efficiency; on the other hand, it is based on concerns about whey as to its use in the generation of by-products or reuse in the processing of milk with anaerobic treatments.

The dairy industry in particular is concerned with liquid effluents, productive performance, dairy products, energy efficiency analysis, and environmental performance. This fact reaffirms the problem of whey (liquid effluents), as it is the largest waste generated in milk processing, considering its negative impact on the environment, which corroborates the statements of Kasmi (2018).

Analysis of limitations, benefits, and conclusions

The most latent difficulties and/or problems pointed out by 33.1% of scientific studies in the dairy industries from 1969 to 2020 relate to the treatment of whey and liquid effluents in general (Table 2). In addition, other concerns include electricity consumption, studies on the theme, efficiency of the industrial plant, environmental impacts, economic issues, and expenses, among others. This group of concerns related to the difficulties in Table 2 was pointed out by 69.2% of the studies selected in this research.

The benefits pointed out by the studies basically focus on bringing solutions to these concerns, that is, solutions to environmental impacts through efficiencies in the treatment of liquid effluents, reuse and reduction in water, and electricity

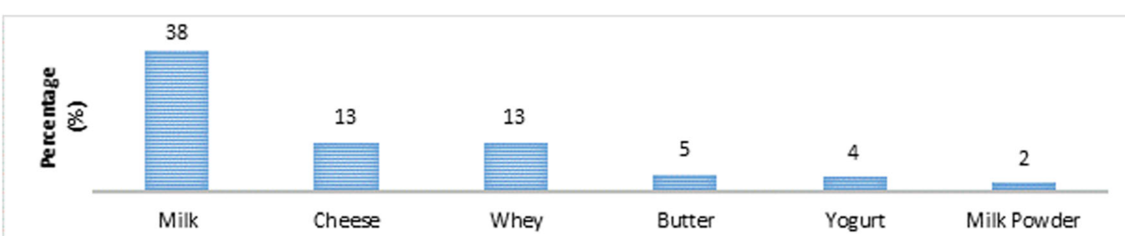


Fig. 10 Product or waste addressed in the study

Table 1 Spearman correlation

	Whey treatment (1)	Use of whey (2)	Electric power consumption (3)	Life cycle assessment (4)	Cleaner production (5)	Carbon footprint (6)	Water footprint (7)	Exergy (8)	Sustainability (9)	Environmental (10)	Environmental and economic (11)	Social and economic (12)	Environmental, social, and economic (13)	Economic (14)
1	1													
2	− .360*	1												
3	− 0.167	0.088	1											
4	0.081	− 0.212	0.016	1										
5	0.098	− 0.221	0.004	.507**	1									
6	0.168	− 0.101	− 0.082	0.255	.333*	1								
7	0.181	− 0.179	0.115	.454**	0.302	.562**	1							
8	0.04	− 0.033	− 0.171	.404*	.454**	.480**	.537**	1						
9	0.018	− 0.087	.327*	.387*	0.119	.436**	.456**	.365*	1					
10	0.276	0.188	0.144	.369*	0.217	0.284	0.164	.494**	.381*	1				
11	0.071	− 0.314	0.133	.494**	.529**	0.156	.361*	0.236	0.294	0.021	1			
12	0.186	− 0.145	− 0.117	− 0.136	− 0.126	− 0.038	− 0.067	− 0.079	− 0.099	− 0.118	0.018	1		
13	− 0.03	− 0.055	0.153	0.005	0.026	− 0.089	− 0.158	0.01	0.256	− 0.111	− 0.061	− 0.127	1	
14	0.195	− 0.036	.591**	0.12	0.138	− 0.062	0.206	− 0.129	0.244	0.133	0.177	− 0.089	− 0.037	1

*Correlation is significant at level 0.05 (bilateral)

**Correlation is significant at level 0.01 (bilateral)

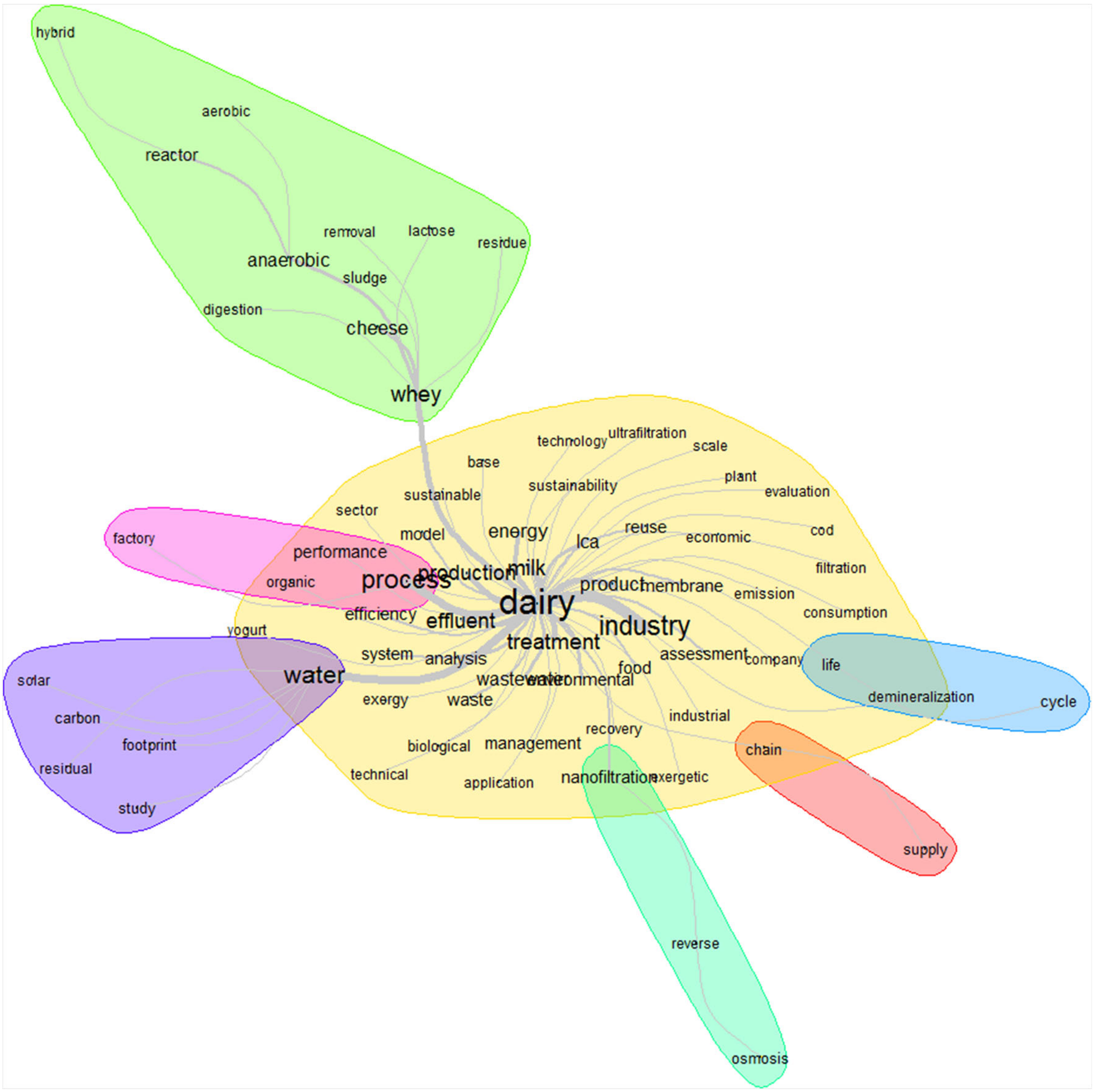


Fig. 11 Key study ideas, source: extracted based on IRaMuTeC similitude analysis

consumption, among others, including sustainable practices (Table 2). The main benefits mentioned cover 57.7% of the studies.

Conclusions that validate the efficiency of the tested effluent treatment systems cover 51.5% of the studies. In addition, energy efficiency has also been validated. The conclusions warn that different industrial plants located in disparate regions may present heterogeneous concerns, benefits, and conclusions. Thus, these findings represent 50.4% of the selected studies on sustainability in dairy industries.

Key result discussions

Scientific publications on sustainability in the dairy industry are growing globally, and the qualification of journals shows that the subject is emerging and needs further clarification through scientific research. In addition, the concern on the subject is not local, but it has a high dispersion regarding scientific journals, geographical areas, and educational institutions. This fact contributes to the complexity of these industries in finding a simple and economical solution for the liquid effluents that were generated in the process of industrialization of fresh milk, cited by Kasmi (2018).

The issues raised in the sustainability and dairy industry studies relate to the efficiency of processes (electricity, treatment, economics, studies) and environmental impacts. This concern meets the premise that the dairy industry is among the most polluting and large-scale, which is in line with studies by Brião and Granhen Tavares (2007) and Rad and Lewis (2014). Thus, these industries have significant impacts on the environment, emphasized by Gonçalves et al. (2017). In addition, dairy products industrialize a wide range of products and, consequently, highly polluted waste.

Table 2 Main difficulties, benefits, and conclusions

Perspectives	Results
Difficulties	Treatment of high level whey generation (wastewater, effluent, new technologies) (f43)[a]
	High energy consumption in the production process (f15)[b]
	Research shortage and studies in the area (f12)[c]
	Dairy processing efficiency (f23)[d]
	Environmental impacts of the dairy industry (f10)[e]
	High investment costs (f12)[f]
	Difficulties with economic performance and profit (f11)[g]
	High level of Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) (f11)[h]
Benefits	Environmental impact reduction and solution (f22)[i]
	Efficiency in wastewater treatment (whey and cheese) (f18)[j]
	Reuse and reduction of water consumption (f18)[k]
	Reduction of wastewater discharge (f14)[l]
	Electric consumption reduction (f15)[m]
	Economic and financial benefits and low cost (f17)[n]
	Improvement towards sustainable practices (f16)[o]
Conclusions	Wastewater and whey treatment system results are efficient and viable (quality) (f51) [p]
	The reduction of energy consumption was satisfactory (f17)[q]
	There are differences in the results of different industrial plants (f7)[r]

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f is the frequency of studies addressing the theme

The theme of sustainability is incipient in the dairy industry, as up to now, we can perceive sustainable initiatives and or isolated attitudes, but not the idea of sustainability considering the aspects of the Triple Bottom Line. This finding corroborates the perception of Augustin et al. (2013) that suggests the development of a holistic approach to sustainability. In addition, Blok et al. (2015) also argue for this prerogative that production processes are far from sustainable. Dairy industries are willing and concerned about the incorporation of sustainable practices, but they still lack scientific studies as to their operability in an integrated manner and connected with the dairy industrial processes. This logic was also pointed out by Luthra et al. (2017).

The results of this study can be used to define new research as it presents the state of the art in terms of sustainability and dairy industries. The studies, to advance in the area of sustainability, should approach a holistic vision with the help of a set of sustainability indicators specifically designed for this activity. Among the aspects of the Triple Bottom line of sustainability, the social one should be emphasized, as it is shyly approached.

Research on the elaboration of sustainability indicators is scarce, that is, only two studies were found that simultaneously cover the triple bottom line of sustainability. So, it is possible to state that a set of consistent and specific indicators for assessing sustainability in the dairy industries is still in the initial stage of development, suggesting existence of the gap in the scientific literature about identification and selection of the set of indicators. It should be noted that this set of indicators can assist in the planning of actions that can be articulated to achieve sustainable development. In this sense, the main means used by dairy industries to approach a sustainable industry today are environmental laws and standards and the pursuit of process efficiency to increase economic gains, rather than using a set of indicators.

Final considerations

Utilizing sustainability assumptions in dairy industries is essential because of their high level of pollution to drive their operations toward high levels of efficiency. In this sense, this study aimed to conduct a systematic literature review on sustainability indicators and dairy industries.

The main results show that publications on sustainability and dairy industries had a significant increase since 2011. The theme is recognized as emerging in the academic society, because most studies evaluated have Qualis classification equal to or greater than B2 (67%) and 39% are situated in stratum A1. In addition, the studies are scattered worldwide in relation to articles linked to geographical area, educational institutions, and authors.

The literature review intends to be valuable for the academy, as it highlights the articles with the highest number of citations. The geographical area with the largest number of studies corresponds to the developed countries, and, due to the accumulation of experience, they represent the countries with the largest volume of fresh milk production. However, several developing countries, such as India and Turkey, have been presenting an increasing volume of publications, maybe due to the presence of this industry in these countries.

Studies on the sustainability theme began only in 2011 and relate only to isolated sustainable practices, in particular waste treatment, electricity consumption, environmental impacts, economic issues, which also appear as the main problems faced in the energy industries of dairy products. The set of sustainability indicators in the dairy industry, compiled in this study, may be considered fragile and still lacks a deep level of discussions to select a cohesive set through the involvement of society, academia, and the industry. Moreover, the trends toward the publication of future research are ambiguous. Further work is needed, especially from emerging countries such as Brazil, which positions itself as an important international player in terms of sustainability. The development of a scale with sustainability indicators for agribusiness represents, in our view, an important contribution of the research, because it can help managers of these organizations to control and better assess their environmental impact and thereby take measures to reduce pollution and waste.

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