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ARTICLES

Societal Acceptability of Insect-Based Livestock Feed: A Qualitative Study from Europe

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Abstract

Against the background of high demand for protein-rich feed in the EU and the environmental degradation associated with intensive livestock farming, insect-based feed is discussed as a potential sustainable alternative to conventional feed. However, the establishment of such an innovation depends not only upon technical and economic feasibility, but also on social factors impacting acceptability. The aim of this paper was to determine the acceptability of different social actor groups towards the use of insects as livestock feed, and to gain insights into value-based arguments leading to positive or negative attitudes and perceived benefits and risks. By means of qualitative content analysis, we analysed responses of an EU public consultation process linked to the authorization of insect protein in pig and poultry feed. We found a broad range of value-based arguments that influence the complex judgement process of acceptability that have been neglected in prior quantitative surveys. In particular, our results bring forward more critical voices, such as animal welfare concerns and scepticism that insect-based feed can contribute to a more sustainable livestock system. Based on these findings, we discuss whether insects as feed are a viable contribution to a sustainability-oriented transformation of the agri-food system. We conclude that under certain conditions (when raised on low-value organic side streams such as manure) insect-based livestock feed may contribute to incremental sustainability improvements. Overall, however, the innovation has limitations, not only in terms of regulatory conditions but especially with regard to ethical concerns.

Keywords Bioeconomy · Acceptance study · Livestock system · Innovation · Sustainability transformation

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Introduction

The global production and consumption of animal-source food contributes to a significant share of the anthropogenic pressure on earth systems and its planetary boundaries (Steffen et al., 2015). In Western Europe the production is dominated by industrial livestock farming (Peyraud et al., 2014), resulting in high numbers of livestock units in many regions and a high demand for protein-rich feed for pigs and poultry in particular (Wang et al., 2018). This kind of intense production system is associated with various types of environmental degradation. On the one hand, specialised livestock production systems are increasingly supplied with soybean and maize imports from third countries to cover the European Union (EU) protein gap (ibid.). As a consequence, in feed-producing countries in the Americas, the expansion of feed crops has resulted in deforestation, habitat fragmentation and biodiversity loss (Green et al., 2019). In addition, fish meal, used as aquaculture, poultry and swine feed, is associated with the depletion of wild fisheries stocks (Naylor et al., 2000). On the other hand, intensive livestock farming and the related globalised trade of animal feed is one of the major contributors to the alteration of the global nitrogen cycle (Wang et al., 2018). Thus, regions with intensive livestock farming produce high nutrient excesses and greenhouse gas emissions, particularly where excess manure or poor manure management is involved (Wang, ibid.). This in turn leads to water and air pollution and biodiversity loss (Peyraud et al., 2014). In identifying threats toward the resilience of earth systems, Steffen et al. (2015) found that anthropogenically modified nitrogen and phosphorus flows as well as the man-made loss of biodiversity already exceeds planetary boundaries. Besides these social-ecological distortions contributed by intensive livestock production, there are also ethical issues regarding animal welfare (Gremmen et al., 2019), not to mention the health concerns associated with consuming too many animal products (Willett et al., 2019).

Against the background of these undesirable socio-ecological effects, various innovations are discussed and developed as possible solutions. One of these partial solutions is the raising and producing of insects for feed (Sogari et al., 2019; van Huis, 2019). Insects for feed have been put forward as having the potential to help close the EU protein gap through regionally produced feed. At the same time insects have the potential to valorise waste such as food waste and agricultural by-products (Čičková et al., 2015), thus contributing to a circular bioeconomy. Further benefits are seen in low land and water requirements during production (Bosch et al., 2019) and good nutritional quality of the resulting feed (Makkar et al., 2014). In addition, a lower ecological footprint when compared to soy and fishmeal is named as a potential benefit, though this varies across production systems (Bosch et al., 2019). However, there are also a number of barriers, such as finding a suitable feed substrate or ensuring food and feed safety (van Huis, 2019). Most waste products that could increase the recyclability and reduce the environmental footprint of insect-based production are so far banned as feed substrate in the EU (Bosch et al., 2019).

In recent years, insects for feed have received increasing scientific attention and there has been growing research especially on technological and biophysical

aspects (Sogari et al., 2019). Focus has been on insect development, feed conversion efficiency, nutrient composition of the larvae, risk management, and environmental footprint (e.g. Bosch et al., 2019; Finke et al., 2015; Smetana et al., 2016). However, the extent to which insects as feed are a viable solution with the potential for broader adoption and dissemination depends not only on technological or economic factors, but also on social factors of acceptability in particular. Several authors have highlighted the importance of addressing acceptability as early as possible in innovation processes (Frewer et al., 2011; Siegrist & Hartmann, 2020). Acceptability studies can provide an early assessment of the need for modification or of the prospects for success of an innovation (Busse et al., 2019). In the case of insects as livestock feed, this concerns on one hand actors directly involved in feed choices, such as livestock farmers, feed producers and consumers as well. In this context, Wüstenhagen et al. (2007) speak of market acceptance. On the other hand, it also relates to questions of broader societal acceptability (ibid.), as the production methods of industrial agriculture are increasingly under social criticism and linked to a series of ethical concerns and conflicts. Investigating value-based arguments behind acceptability decisions from a broader societal perspective can provide insights into the process of co-evolutionary processes of human-nature-animal relations of different actor groups. This also means that in the context of a sustainability-oriented transformation, acceptability studies can show the extent to which changes in values and norms are taking place.

There are already a number of studies on the acceptability of insects as feed with different foci, methods and contexts of application. These studies show a high proportion of respondents who have a positive attitude towards insect-based feed. However, almost all studies to date focus on consumer preferences and attitudes and are limited to a quantitative study design (Borrello et al., 2017; Domingues et al., 2020; Kostecka et al., 2017; Laureati et al., 2016; Naranjo-Guevara et al., 2021; Onwezen et al., 2019; Szendrő et al., 2020). While these studies show consumer attitudes as a function of different variables such as gender, nationality, knowledge and awareness, or phenomena such as neophobia or attribution of meaning to nature and sustainability, they provide little nuanced insight into the attitudes of different groups of social actors and the range of their value-based arguments that influence and justify their acceptability decisions.

The aim of this paper is to fill this knowledge gap by presenting a qualitative study on the acceptability among various actor groups towards the use of insects as livestock feed in the European Union. By analysing feedback given in the scope of an EU public consultation regarding insects as pig and poultry feed, we sought to address the following research questions: i) What are the degrees of acceptability of different actor groups towards the use of insects as pig and poultry feed? ii) What are the value-based arguments that influence the judgement process that leads to positive or negative attitudes and the perceived benefits and risks? Finally, we want to discuss if insects as feed are a viable contribution to a sustainability-oriented transformation of the agri-food system.

Table 1 Range of attitudes and degrees of acceptability based on Busse et al. (2019)

Attitude	Degree of acceptability	Description
Positive	Engagement	The acceptability object is positively evaluated out of inner conviction and proactive support is expressed through actions
Positive	High acceptance	The acceptability object is positively evaluated out of inner conviction
Positive	Supportive conditional acceptance	The acceptability object is positively evaluated overall, but some uncertainty is expressed and linked to conditions
Neutral	Critical conditional acceptance	The acceptability object is neither positively nor negatively evaluated, uncertainties are expressed and linked to conditions
Neutral	Indifference	The acceptability object is of no subjective concern
Negative	Low acceptance	The acceptability object is critically evaluated out of inner conviction
Negative	Rejection	The acceptability object is negatively evaluated and rejected out of inner conviction
Negative	Opposition	The acceptability object is negatively evaluated out of inner conviction and active opposition is expressed through actions

Conceptual Framework: Acceptability and Value-Based Arguments

Acceptability studies often accompany the introduction of new technologies and innovations to understand motives behind adoption or rejection of potential users. It is recommended that acceptability should be addressed as early as possible in innovation processes (Frewer et al., 2011; Siegrist & Hartmann, 2020). Thus, such studies are frequently carried out under the premise of increasing acceptance and the increasing probability of adoption and diffusion of an innovation. However, acceptability can also show whether an innovation is socially desired. This can be of special interest in the field of agricultural and food production where ethical considerations, linked in particular to the sector of intensive livestock farming, and an increasing polarization between different societal groups (e.g., an increasing urban–rural divide from the perspectives of values or the phenomenon of anti-veganism) seem to be on the rise (Gremmen et al., 2019; Nowack & Hoffmann, 2020). Moreover, innovation is about change. Innovations can have benefits, but later turn out to be risky and have unintended side effects. In the discourse on sustainability impacts, unintended side effects, and risks of sociotechnical progress (Funtowicz & Ravetz, 1993), the concept of responsibility has gained importance. This seems to be especially true for the field of livestock farming as well as for the field of bioeconomy, where living beings and the living environment are at stake. Thus, in the sense of a responsible research and innovation approach, qualitative acceptability studies may also support an early anticipation of future socio-ecological consequences of new technologies and innovation (Owen et al., 2013). Finally, acceptability studies are snapshots and, when examined over time, can also show the extent to which changes or transformation in values and norms are taking place.

Acceptability and Acceptance

We differentiate between the concepts "acceptance" and "acceptability". The term "acceptance" is used across a wide range of disciplines and is often perceived as an everyday normative term. We follow the definition of Fournis and Fortin (2017) who define acceptance as one of several possible outcomes of a complex judgement process of acceptability. In their review of acceptance studies, Busse and Siebert (2018) present different degrees of acceptability outcomes ranging from opposition and rejection (negative outcomes) to acceptance and engagement (positive outcomes) towards an acceptability object. Next to degrees of acceptability, the authors also identified levels of acceptability decisions, these levels being attitude (an internal judgement before acting), action (the expression of those attitudes) and utilisation (the long-term use of an innovation). In the present study, the acceptability object refers to the use of insects as livestock feed. As the use of insects as pig and poultry feed is novel in the EU and was not established at the time of data collection, only the attitude level of the acceptability levels was considered. As such, the acceptability degrees "engagement" and "opposition" are not applied in the analysis, as they are associated with the action level (see Table 1).

Societal and Public Acceptability

With "societal" pertaining to interactions between individuals, groups or society in general, we use the term "societal acceptability", and define this as how an acceptability object (e.g. insect-based livestock feed) is perceived by relevant societal actors based on the degree to which the acceptability object is (dis-)liked by these actors (Wolsink, 2012). Public acceptability is defined by Wolsink (ibid.) as "the degree to which a phenomenon is taken by the general public, the degree to which the phenomenon is liked by individual citizens". This gives a broader perspective and includes a range of social groups, and is comparable to how we define societal acceptability, as we aim to encompass a range of actors and actor groups (e.g. economic actors, research institutions, NGOs and individual citizens).

Value-Based Argument

Aside from determining the attitudes of societal actors toward insect-based livestock feed on a positive-neutral-negative scale, an analysis of value-based arguments provides insights into the factors that influence these attitudes. In understanding an argument as a statement or statements for or against something, adding a value-based dimension to this incorporates an inner conviction of what is valuable or desirable (on an individual or group level). In their work on argumentation frameworks, Bench-Capon (2003) states that value-based argumentation "allows the representation of rational discussion pertaining to matters of value as well as fact and logic". With statements from respondents for or against the use of insects as livestock feed, value-based arguments can be categorised into benefits (perceived beneficial results or effects) and risks (perceived hazards) respectively. Associated

with these arguments are conditions (generally associated with risk mitigation and a potential prerequisite for acceptance) and solutions (generally associated with risks and often suggesting an alternative more in line with the values of those making an "against" argument).

Research Design and Methods

Data Collection

To study the acceptability among different actor groups towards the use of insects as livestock feed and the relating value-based arguments of these actors, we analysed responses of an EU public consultation process. Against the background of the improved epidemiological situation regarding BSE (bovine spongiform encephalopathy) over the past two decades and the EU seeking to make better use of the protein and other feed materials produced domestically, the European Commission recently adopted a regulation[1] to allow the use of insect protein and non-ruminant protein in poultry and pig feed (European Commission, 2021). Before introducing this new regulation, the commission carried out a public consultation in which different social actors (e.g. economic actors, representatives of civil groups, citizens) were able to give feedback. Under "Have your say: Authorisation to feed non-ruminants with ruminant collagen/gelatine and with proteins from insects, pigs and poultry", the public consultation took place from March 9th until April 6th 2021 over the commission's web portal. Individual citizens and representatives of actor groups were able to give feedback, the format of which was open, i.e. there were no guiding questions or statements. The responses were made publically available on the commission's website and ranged in length from one sentence to up to 20 pages. In total 72 responses were given, and all feedback was downloaded in PDF-format for analysis.

Qualitative Content Analysis

Data processing was performed using the software MAXQDA. All responses were coded, evaluated and interpreted following the seven-step guide to a thematic qualitative content analysis by (Kuckartz, 2014) and are based on an iterative research strategy using a deductive-inductive approach. We focused our analysis on attitudes toward the use of insects as pig and poultry feed and the associated value-based arguments. Other topics, which were also covered in the same regulation, were not considered (though some statements addressed processed animal proteins in general, which also includes insect protein).

In the first step, each respondent was assigned a country or origin and an actor type. We identified companies/business organisations (including insect production

[1] COMMISSION REGULATION (EU) 2021/1372 of 17 August 2021 amending Annex IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council as regards the prohibition to feed non-ruminant farmed animals, other than fur animals, with protein derived from animals (Text with EEA

companies); agri-food business associations (including farmer's unions); research institutions/research projects; NGOs (environmental, animal rights and veterinary); and citizens. Each respondent's degree of acceptability was then assessed based on statements made in the feedback. To identify the "for" and "against" groups, those assigned the acceptability degrees of high acceptance and supportive conditional acceptance were grouped together as those who showed positive attitudes towards the use of insects as pig and poultry feed, and those with acceptability degrees of rejection and low acceptance were grouped together as those who showed negative attitudes towards the use of insects as pig and poultry feed. Those who showed critical conditional acceptance (n = 2) were considered neutral, showing neither overly positive nor negative attitudes, and thus not included in either group.

In identifying value-based arguments, a deductive-inductive approach was used in the analysis. Following six deductive categories were applied when beginning the analysis: Technical and Logistic; Economic, Financial and Marketing; Organisational and Spatial; Institutional and Legal; Environmental; and Social and Cultural. This is based on themes identified by Donner et al. (2021), that frequently came up in acceptability studies and case studies on agri-food innovations (e.g. Frewer et al., 2011; Siegrist & Hartmann, 2020; Sogari et al., 2019). In first-cycle coding, value-related arguments were identified and coded into the a-priori thematic categories. Second-cycle coding resulted in inductive sub-categories and an adjustment of the main categories, which were as follows: Sustainability; Animal Welfare; Technical and Biophysical Processes; Social-Cultural Issues; and Economic-Financial Issues. During third-cycle coding, codes in the sub-categories were paraphrased and assigned one of the following four attributes: benefits, risks, conditions and alternative solutions. This was to better organise value-based arguments and understand linkages between factors influencing acceptability and degrees of acceptability.

Results

Degrees of Acceptability of Different Actor Groups Towards the Use of Insects as Pig and Poultry Feed

The attitudes in the form of different degrees of acceptability among the participants of the consultation revealed a differentiated picture along different actor groups (see Fig. 1). About half of the respondents (n = 38) showed positive attitudes, meaning they formulated statements documenting a 'high acceptance' and 'supportive conditional acceptance'. This group of actors included above all economic actors or their representatives such as agri-food business associations or companies. Approximately the other half of the participants (n = 32) showed a rather negative attitude, which was expressed in formulations of 'low acceptance' or even 'rejection'. These

Footnote 1 (continued)
relevance). Available online at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1372

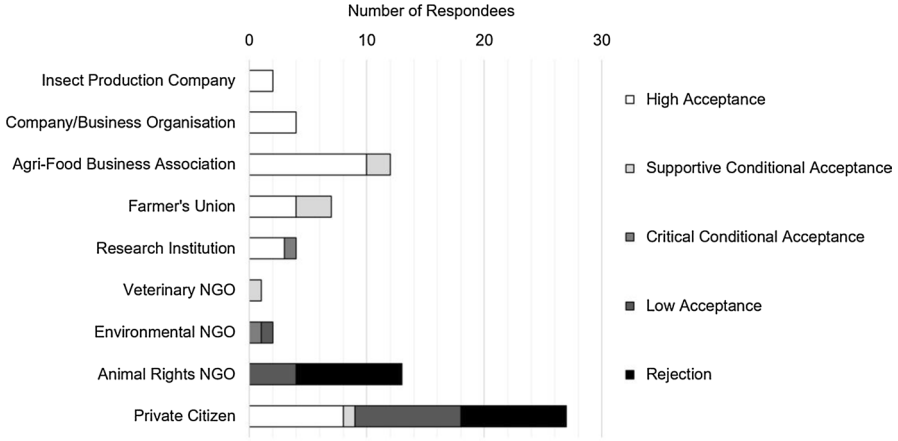

Fig. 1 Acceptability degrees of various actor groups regarding the use of insects as pig and poultry feed

actors mainly belonged to non-governmental organisations working for animal rights or participated in the consultation as citizens. A more diverse picture of attitudes emerged among environmental organisations, research institutions or citizens compared to advocacy organisations. One environmental NGO and one research institution showed neutral attitudes, formulating a 'critical conditional acceptance' in which their evaluation could be considered neither positive nor negative.

Value-Based Arguments with Regard to the Acceptability of Insects as Livestock Feed

The analysis of the submitted comments revealed various value-based arguments that could be clustered along the five main themes: (i) Sustainability (in terms of the use of natural resources), (ii) Animal welfare, (iii) Technical and biophysical processes, (iv) Socio-cultural issues, and (v) Economic-financial issues. For each of these main topics, arguments were found that reflected either a benefit or a risk perspective. In some cases, conditions for the acceptance of insects as feed were also formulated, or alternative solutions were proposed, both generally associated with risks. Actors with positive attitudes towards insect-based livestock feed (acceptability degrees ranged from "high acceptance" to "supportive conditional acceptance") brought forward more arguments from a benefit perspective, while those with negative attitudes towards the use of insects as livestock feed (acceptability degrees of "rejection" and "low acceptance") presented more arguments from a risk perspective. Table 2 provides an overview on the main themes and the related value-based arguments as the result of the qualitative content analysis.

Table 2 Value-based arguments from third-cycle coding

Main themes	Categories	Value-based arguments	Number of mention	Breakdown by actor group						
				AFBA (incl. FU)	CBO (incl. IP)	AR-NGO	E-NGO	V-NGO	IC	RI
Sustainability	Benefits	Increased self-sufficiency and feed security for the EU	22	13	4	1		1	2	1
		Increased circularity and waste reduction through bioconversion	14	7	3				2	2
		Smaller ecological and climate footprint compared to conventional feed	11	6	3				1	1
		Efficient nutrient cycling	1	1						
		Insect farming has a small land-use footprint	1							1
	Risks	Lock-in of an unsustainable agri-food system	9			7			2	
		No or little reduction of agriculture's ecological and climate footprint	9			3	1		5	
		Diversion of human-edible food to animal feed	4			2	2			
		Insects and insect pathogens could escape the facilities	3			2				1
		Diversion of livestock feed to insect feed	1				1			
		Shift of agriculture's environmental impacts from one area to another	1				1			
Animal welfare	Benefits	Insects provide quality nutrition for pigs and poultry	14	7	3				2	2
		Insects are part of the natural diet of swine and birds	9	3	1	1			4	
		Insect breeding simulates natural insect rearing conditions	1		1					
	Risks	Not enough is known of insect welfare and sentience	13			6			6	1
		Large-scale suffering of (likely sentient) insects	10			3			7	
		Unknowns regarding human, livestock and insect health	2			1				1
	Solution	Alternative: extensive farming of pigs and poultry	4			3			1	

Table 2 (continued)

Main themes	Categories	Value-based arguments	Number of mention	Breakdown by actor group						
				AFBA (incl. FU)	CBO (incl. IP)	AR-NGO	E-NGO	V-NGO	IC	RI
Technical and biophysical processes	Benefits	Negligible BSE-risk status	6	5						1
	Risks	Spread of existing or new zoonoses/epidemics	7			3			4	
		Transfer of harmful substances from feed substrate to insects/ insects to livestock	5	1		1	1		1	1
		Avoiding cross-contamination is a logistical challenge	1	1						
		Cross-contamination of animal proteins	1			1				
		Increased risk of antibiotic-resistant bacteria	1						1	
		Treatment of feed for safety reasons uses energy and may lower feed quality	1	1						
	Condition	Effective measures that ensure feed safety must be enforced and monitored	12	5	3		1	1	1	1
Socio-cultural issues	Benefit	Domestic production may positively impact farmer reputation	1	1						
	Risk	Low acceptance of consumers and/or farmers	3	1					2	
	Solution	Alternative: a more plant-based diet and less livestock	7			6	1			
Economic-financial issues	Benefits	Stronger domestic market due to meeting demands on an EU-level	4	4						
		Additional income opportunities for farmers	2						2	
	Condition	Production costs and end price of feed must be competitive	3	1			1	1		

"Number of mentions" indicates how often this particular argument came up in the collective responses of the public consultation. The actor groups have been abbreviated as follows: agri-food business associations (AFBA), farmer's unions (FU), companies and business organisations (CBO), insect production (IP), animal rights, environmental and veterinary NGOs (AR-NGO, E-NGO, V-NGO), individual citizens (IC) and research institutions (RI)

Sustainability

"Sustainability" was the predominant theme reflected in the value-based arguments related to insects as feed, and related to the broadest variety of different arguments. Both benefits and risks where seen in relation to the sustainability of insect-based feeds.

Benefits A main approving argument was "increased self-sufficiency and feed security for the EU". This argument was mainly put forward by farmers unions and agri-food associations. Sustainability benefits cited included increased use of existing domestic resources for feed production and reduced dependence on high-protein feed imports from third countries (Q1, see Q1-n in supplementary information), resulting in a "smaller environmental and climate footprint compared to conventional feed" due to lower emissions for feed transport, less pressure to clear land in feed-producing countries, and less impact on the oceans (Q2). Another supporting argument was the benefit of "increased circularity and waste reduction through bioconversion". In considering that certain insect species are able to feed on waste products such as food waste and agricultural by-products, the benefit was seen in the potential to reduce the amount of waste while at the same time producing high-quality feed proteins though bioconversion (Q5):

> *"Insects convert food waste into high nutritious protein, allowing a circular economy and tackling the problem of the excessive food waste in Europe." (Insect Production Company)*

It is argued that by raising insects on agricultural residues or food waste products, circularity may be increased (Q6) and a diversion of that which could otherwise be fed directly to livestock (e.g. cereal crops) could be avoided (Q7).

Risks At the same time, however, risks are also perceived by some actors showing a divide as to whether insect-based livestock feed can be considered a sustainable alternative.

Especially citizens, animal rights or environmental NGOs see the risk of "no or little reduction of agriculture's ecological and climate footprint". Critical actors also express concern over potential negative environmental impacts such as high energy demands for insect production systems (Q3) or over the potential transfer of contaminants from the feed substrate to the insects or pathogens from insects to livestock. Also questioned is the economic viability of raising insects on waste (under "Economic and financial issues") and the contribution of bioconversion of waste by insects to the environmental impact of feed production (Q3). While the "protein gap" in the EU was acknowledged by the critical actors too, it was suggested that reducing the demand for high-protein feeds would be a more effective solution to close the protein gap. This was mentioned along with the alternative solution of "more plant-based diets and less livestock" (Q4). In this context, a main concern (prevailingly by animal rights NGOs and citizens) was that using insects as livestock

feed reflects a "lock-in of an unsustainable agri-food system" and further strengthens intensive animal production systems, which could hinder a transformation towards a more sustainable agri-food system. This argument could often be seen in combination with the risk of "no or little reduction of agriculture's ecological and climate footprint" (Q8-9):

> *"Unfortunately, this is also a very backward concept that you are striving for and you would only be perpetuating an outdated system that can do absolutely nothing for the current important areas such as reduction of environmental degradation, loss of biodiversity and prevention of global health threats."*
>
> Citizen.

Animal Welfare

'Animal welfare' was the second most discussed theme. While a whole range of sustainability-related arguments were brought forward, the arguments regarding animal welfare show less diversity. Here, we found two actor groups on opposite sides: economic actors and animal welfare NGOs/concerned citizens. While economic actors consider insects as a natural, good-quality feed, animal welfare NGOs perceive insect farming and subsequent slaughter as detrimental to insect welfare.

Pig and Poultry Welfare Regarding pig and poultry welfare, the main perceived benefits were "insects provide quality nutrition for pig and poultry" and "insects are part of the natural diet of swine and birds", put forward mostly by agri-food business associations and farmer's unions, but also citizens and companies/business organisations (including insect production). Those arguing these points mentioned that the proteins, fats and micronutrients present in insect-based feed were suitable to help cover the nutritional needs of poultry and pigs (Q10). In this context also the naturalness of insect-based feed was emphasised, as poultry and swine are omnivorous and frequently eat insects in nature (Q11):

> *"Insects are a traditional and natural protein source to many animals: Fish, poultry and pigs cover a large part of their protein requirements in nature through insects. Research shows that chicken fed with insects are not only healthier but also supports natural behaviour and improves animal welfare."*
>
> Insect Production Company.

However, if wanting to provide a more natural behaviour for pigs and poultry, it was suggested that processed feed such as insect-based feed may not be the right solution. An alternative solution was suggested, that less intensive animal husbandry and bringing more animals out to pasture would do much more for the welfare of pigs and poultry (Q12).

Insect Welfare In addition to concerns about pig and poultry welfare, concerns regarding insect welfare have been raised repeatedly by animal welfare organizations

and citizens. In particular the lack of knowledge on invertebrate welfare was criticised (Q13). Several respondents feared that the inclusion of insect farming would further intensify livestock production and expressed concern that it could increase animal suffering in agriculture (Q14, 15):

> *"Even small insect farms slaughter as many as 500 million animals every year, and European insect startups are planning to build new farms that could each raise and slaughter tens of billions of animals per year. The risk of suffering is great and the scale is vast."*
>
> Animal Welfare NGO.

Technical and Biophysical Processes

Under the theme 'Technical and Biophysical Processes' potential risks as well as risk management was discussed. In particular, concerns were raised about the transfer of harmful substances. This was brought forward by respondents from several actor groups, with no clear majority addressing this topic. For example, the feed substrate on which insects are raised (in particular if insects are used as waste valorisation) was critically discussed as a source of health issues (Q16-17). Several respondents advocating for insect-based livestock feed also addressed the importance of feed safety and risk management, stating that strict hygiene and processing regulations are likely or even certain to ensure feed safety, and named the condition that such measures must be enforced and monitored (Q18-19). However, against the background of BSE (a type of transmissible spongiform encephalopathy caused by prions) outbreak in the UK in the 1990s (and the reason behind the strict rules applied to using processed animal proteins as feed), several agri-food business associations addressed the benefit of the BSE-risk being negligible for insect-based feed and other non-ruminant animal proteins as feed (Q20). Yet concerns were raised that while insects might not be susceptible to prion diseases, they may still be a passive disease vector (Q21). In this context, several respondents raised concerns regarding zoonoses and disease outbreaks that went beyond the topic of transmissible spongiform encephalopathy (Q22-23).

Socio-Cultural Issues

Social-cultural issues played a minor role in the discourse on insect-based feed. Arguments relating to the habits and beliefs of societal groups were mentioned by only few actors, e.g. that farmer's and consumer's attitudes could positively or negatively influence the success of the innovation. One farmer's union suggested that substituting imported protein-rich feed with domestically produced feed could have a positive impact on farmer reputation. Several of the animal rights NGOs addressed social behaviour in regard to food consumption patterns. They demand a socio-cultural change in food consumption behaviour and argue for a more plant-based diet,

as this would reduce demand for protein-rich livestock feed (Q24), positively impact human health (Q25), and in general reduce environmental impacts.

Economic-Financial Issues

Meeting demands of protein-rich feed on an EU-Level was perceived as an economic benefit of insect-based feed by a small number of actors. In addition, insect-based feed is recognized as an economic prospect and new income opportunities for farmers, also to remain competitive in the international market (Q26). However, even though agri-food industry trade associations advocate the use of insect, pig and poultry proteins as feed, they tend to view processed animal proteins as feed as a niche product (Q27-28). An environmental NGO pointed out that substrates such as food waste would likely lower production costs, but at the same time raising insects on lower-quality substrates typically translates into lower insect protein yields which will likely have a negative impact on profits. Overall, economically motivated arguments played a minimal role in the discussions found in the consultation.

Value-Based Arguments by Actor Group

Those showing support for insect-based feed were predominantly economic actors or their representatives, such as agri-food business associations, farmer's unions and companies/business organisations, including insect production companies (see Fig. 1). The value-based arguments brought forward were similar across the respondents of these actor groups. The perceived benefit of increased self-sufficiency and feed security for the EU dominated the discourse and was often linked to the perceived benefit of a smaller ecological and climate footprint compared to conventional feed due to the use of local resources and the potential for waste conversion. Additionally, insect-based feed was perceived across these actor groups to provide good-quality and natural nutrition to pigs and poultry.

In contrast, animal rights NGOs were the most critical actor group. Also within this group, the value-based arguments and attitudes presented were similar and largely shared. The most common perceived risk was a lock-in of the current (unsustainable) agri-food system and the concern that insect-based feed may not contribute to lowering the ecological and climate footprint of agriculture. Another concern was that of insect farming being detrimental to insect welfare. In this context, the knowledge gap regarding insect welfare and sentience was emphasised. Overall, opponents highlighted the need for a more plant-based diet and less livestock as solution.

The actor groups of citizens and researchers are more divided in their perspectives. Depending on their attitude, their arguments coincide with those of the economic actors (high acceptance) or those of the animal welfare NGOs (low acceptance/rejection).

Discussion

This study aimed to determine the attitudes of different actor groups across society towards the use of insects as livestock feed, and to gain insights into the value-based arguments that influence the judgement process. In the following, we will first discuss our results with respect to prior acceptability studies on insects as feed and then, second, discuss if insects as feed can be considered a viable contribution to a sustainability-oriented transformation of the agri-food system.

Multiple Factors Influence the Acceptability of Insect-Based Feed

Previous studies on the acceptability of insect-based feed have been mainly based on quantitative surveys. While these studies could show that a high proportion of respondents are willing to consume meat produced by insect-based feed, it contributed little to understanding the judgement processes behind acceptability (decisions). Results of our qualitative content analysis add a wide range of different value-based arguments that influence the attitudes and thus acceptability of insects as livestock feed. Compared to previous studies that found high shares of positive attitudes among consumers (e.g., Naranjo-Guevara et al., 2021; Szendrő et al., 2020; Kostecka et al., 2017; Laureati et al., 2016: Verbeke et a. 2015), our results show quite critical attitudes towards insect-based feeds based on arguments that have received rather little attention so far. These include especially ethical concerns with regard to sustainability impacts, animal welfare, or undesirable side effects of the technological processes such as risks of pathogen transmission. Interesting to note, neophobia, often expressed as fear or disgust of insects as food or feed and a key survey item in many quantitative consumer studies (Laureati et al., 2016; Naranjo-Guevara et al., 2021), did not play a role for acceptability in our study. We see the special significance and contribution of our study in the variety of these value-based arguments which can be supportive for future research, e.g. by serving as survey items and thus revealing their different influence (also in interactions) on the acceptability of insect-based feeds.

Our results also showed a gap in actors' attitudes that runs between the producing agrarian economic actors on the one hand and the more critical consuming actors on the other (see also Nowack & Hoffmann, 2020). We argue that this is indicative of the current conflict in agriculture (Gremmen et al., 2019). Representatives of the producer side (agri-food associations, farmers' organizations, and businesses) tend to be much more positive about the acceptability of new technologies and innovations, while those on the non-producing side (e.g. individual citizens, non-profit organisations) are more sceptical and risk-aware. Several scholars (Biber-Freudenberger et al., 2020; Zscheischler et al., 2022) could show that these more positive assessments and the neglect of risks is especially related to the economic interests of the actors and their cultural embeddedness. However, our results also show that these economic interests are hardly made visible by arguments. Instead, the proponents primarily offer ethical justifications that influence their acceptability decisions. The public consultation process is part of a societal discourse and a political instrument,

and economic actors put forward sustainability-related arguments with the aim of improving public acceptability. Similar to other studies, our results showed that advocates of insects as livestock feed highlight the possibilities to reduce EU's dependency on protein-rich feed imports (Marberg et al., 2017; Verbeke et al., 2015) and to decrease the ecological and climate footprint compared to conventional feed (Marberg et al., 2017; Szendrő et al., 2020; Verbeke et al., 2015). In addition, these actors emphasise the nutritive value of insects and potential positive effects on pig and poultry health (Naranjo-Guevara et al., 2021; Verbeke et al., 2015). Value-based arguments of these actors follow an anthropocentric justification.

In contrast with economic actors, those with negative attitudes towards insects as feed especially refer to perceived risks. They question whether insects could really provide a more sustainable feed alternative and generally criticise the current agri-food system as a whole and in particular the exploitation of animals. A major concern is that the innovation of insects as livestock feed further strengthens an agri-food system that is perceived as overall unsustainable and detrimental to livestock welfare. These actors especially expressed concerns over the unknowns regarding invertebrate welfare and the potential for (large-scale) suffering of insects (Pali-Schöll et al., 2019). Their arguments show ethical concerns of sentientism.

Insect-Based Feed as Contribution to a Sustainable Agri-Food System?

Insect-based feeds are often presented as a more sustainable alternative to conventional feed (e.g., Marberg et al., 2017; Verbeke et al., 2015). However, sustainability is a normative, relational and partly contested concept. Not only the definitions of sustainability differ; the evaluation of sustainability also depends on the chosen indicators, values and norms and on the comparison to other alternatives (Gamborg, 2018). Accordingly, the assessments of the different groups of actors—as shown in our study—vary depending on the level of consideration (local production level versus global agri-food system) or to the respective weighting of the different values and associated ethical concerns.

Advocators for insect-based livestock feed in the consultation process emphasised its potential for increasing feed security and reducing the detrimental environmental effects of intensive livestock farming. Still, these perceived benefits only apply under certain conditions. One condition concerns the feeding substrate of the insects themselves. While fly larvae raised on wastes such as manure or food waste have the potential to reduce the environmental footprint of protein-rich feed production, particularly in terms of land use (Bosch et al., 2019; Smetana et al., 2016), insects raised on higher-quality substrates such as grains even appear to have a higher environmental impact compared to conventional protein-rich feed (Bosch, ibid.). Raised on low-value organic side streams such as manure and plant residues, in contrast, insects may increase the circularity of agricultural production and reduce undesirable environmental impacts (Barragán-Fonseca et al., 2022) albeit at the possible expense of lower insect protein yield (Čičková et al., 2015; Smetana et al., 2016).

In addition, present legislation makes it difficult for insect-based feed to offer a more sustainable alternative to soy meal. Under current EU law, it is prohibited to cultivate insects on organic waste, with the exception of controlled food waste (i.e. waste from production and retail that does not contain meat or fish). However, even if organic wastes such as catering waste, abattoir waste and manure should be authorised as feed substrates for insects, there are further aspects to consider. If a sustainable alternative to soy- and fishmeal is the goal by valorising organic waste through insects, it must also be considered if wastes are being diverted from other processes creating resource competition (van Zanten et al., 2015). If large-scale insect production is being planned, we must consider the amount of feed substrate needed. Should organic waste be authorised and utilised as insect feed, we must question whether the amount will suffice without compromising its other uses such as bioenergy, biogas and fertiliser use. One potential risk of such a system may be a lock-in of the current system that produces e.g. food waste and manure, or even an incentivisation to produce more waste. Feed substrate, whether it be organic waste or feed substrates currently used for livestock will likely be a limiting factor in insect production. If the goal of insect-based feed is to be a more sustainable alternative, it will likely only take up a niche position on the livestock feed market. Against this background, the central argument of "increased self-sufficiency and feed security for the EU" of the proponents of insect-based feed seems rather questionable. According to current figures (Albaladejo, 2023), the EU's self-sufficiency rate for soy is only 3 per cent nowadays. About 26 million tonnes of soy (beans and meal) have to be imported annually, while forecasts indicate that by the end of 2030 there will only be a production capacity of 1 million tonnes[2] of insect meal in the EU. This would increase self-sufficiency by about 3,8 per cent.

Our results also showed that acceptability decisions and sustainability evaluations are influenced by varying ideas of change (radical versus incremental change). Actors who rejected the innovation of insect-based feed argued that insect-based livestock feed may further strengthen an agri-food system that is perceived as overall unsustainable and detrimental to animal welfare. These actors see the need for a fundamental transformation of the whole agri-food system where consumption of animal-source food should be reduced and a shift towards plant-based diets is urgently needed. In contrast, the intensive livestock system that dominates Western Europe can be seen as a stable regime made up of a dominant system of actors, institutions, technologies and user practices (Bünger & Schiller, 2022). These regime actors are deeply embedded and dependent within this system and thus, change-averse. As a consequence, they favour innovations that rather lead to limited incremental changes that optimise the current system, particularly through technological development (ibid.).

[2] IPIFF (2021): An overview of the European market of insects as feed. International Platform of Insects for Food and Feed (IPIFF). Available online at https://ipiff.org/wp-content/uploads/2021/04/Apr-27-2021-IPIFF_The-European-market-of-insects-as-feed.pdf.

There are some that may consider insects as feed a radical innovation (e.g. Borrello et al., 2017), however insect-based feed as a mere substitution of conventional protein-rich feed will likely lead to incremental change.

Limitations of the Study

While our study reveals insights into the range of different value-based arguments that justify acceptability decisions about insect-based feed, and thus clearly expands the existing knowledge from quantitative consumer preference studies, it also shows a number of limitations. Firstly, the data collection took place at a time when insect-based feeds were not yet established on the market. Therefore, the results remain at the "attitude level". These attitudes can change—in both directions. For example, risk perceptions may change after the technology has been approved and disseminated, depending on whether the assumed risks turn out to be true or not. On the other hand, we used data from a consultation process whose collection we could not further influence. Representatives of interest groups with a strategically established position participated as well as individual citizens with partial opinions. Nevertheless, our results show that there is a high degree of overlap in the value-based arguments. However, it can be assumed that citizens participating in the consultation were more engaged with the issue than the average and therefore took the initiative to submit their feedback, which tends to result in more critical voices. Ultimately, we see the main limitation of this study in the lack of possibility to gain more insights into the social context of the respondents. This should be the subject of more in-depth qualitative approaches in the future.

Conclusions

In this study, we identified a set of value-based arguments that influence acceptability regarding insect-based livestock feeds. Our findings provide new insights into the judgment process that influences acceptability decisions, which have been neglected in quantitative surveys so far. Future quantitative studies could build on our findings by developing an improved set of survey items and focusing more on the reciprocal influence and weighting of different factors and values in acceptability decisions.

Our study also showed more critical voices toward insect-based feed than previous acceptability studies. Particularly ethical concerns regarding sustainability impacts, animal welfare, or undesirable side effects of the technological processes such as risks of pathogen transmission were mentioned.

We conclude that under certain conditions (when raised on low-value organic side streams such as manure) insect-based livestock feed may contribute to incremental sustainability improvements and an increased circularity. However, the innovation has limitations, not only in terms of regulatory conditions but especially with regard to ethical issues and its potential for a sustainability-oriented transformation.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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