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The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States and Europe

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Cultivated and plant-based meats have been recognized as radical innovations that may revolutionize food production worldwide. Despite potentially being more sustainable than conventional meat, little is known about the consequences these innovations can bring to society. To help to clarify this topic, we studied the social impacts that cultivated and plant-based meats may bring to Brazil, the United States and Europe. Based on the perspective of 136 experts, our results are divided into market expectations, consumer access, consumer acceptance, impacts on farms, and business opportunities along the new chains. Experts generally predicted an optimistic picture of the social effects with several opportunities as alternative meats become available. However, the consequences for animal farmers seemed worrying in the experts' views. Overall, the opinion of Brazilian and American experts seemed more optimistic than that of Europeans. Our findings may be helpful for practitioners and people involved in rural policy interested in better guiding this transition process in the food production chain.

KEYWORDS

cultivated meat, plant-based meat, radical innovation, social impact, sustainable food production chain

Introduction

Meat has been considered essential by humans in their diets (Stanford and Bunn, 2001; van der Weele et al., 2019), although it is currently known that it is not, according to the Academy of Nutrition and Dietetics of the United States (Melina et al., 2016) and the National Health Service in England (NHS, 2018), amongst others. Even so, meat consumption records are expected in the coming years, especially with the projected increase in consumption in developing regions (OECD-FAO, 2020). With this scenario envisaged, several problems linked to meat production and consumption may increase, especially in the environmental, animal welfare, and public health domains.

On the environmental side, meat production is associated with the emission of greenhouse gases (Gerber et al., 2013), extensive use of soil (van Zanten et al., 2016) and water (Palhares et al., 2021), in addition to the advancement of livestock through forest conservation areas (Pereira et al., 2020). Meat is also linked to rural activities that generally harm animal welfare (Narayanan, 2016; Ransom, 2021); besides the negligence of the animals' rights by slaughtering them for human consumption (Regan, 1983). Regarding public health, meat is associated with several non-communicable diseases (Papier et al., 2021), the emergence of zoonoses that can cause endemics and pandemics (Halabowski and Rzymski, 2021) and indirect ingesting of antibiotics commonly used in animal-raising (Martin et al., 2015). The overall picture has been cited as tending to reduce the stability of the Earth system (Willett et al., 2019).

All these challenging issues seem to be calling for radical innovations, conceptualized as a considerable advancement in a technology that differs from previous standards (Bessant et al., 2014; Dean et al., 2022), in the food production chain. Currently, two new technologies may dramatically change the production of animal foods: cultivated meat (CM) and plant-based meat (PBM). This expected revolution in food production chains may offer a more efficient solution for meat demand. However, other challenges tend to emerge. CM and PBM are expected to represent a significant percentage of the world meat market in the coming decades, which may lead to a loss of share for conventional meat (Tubb and Seba, 2021). A widely publicized prediction shows a drastic change in the protein production chain, with 35% of the total meat market expected to be provided for by CM, 25% by PBM and 40% by conventional meat by 2040 (Gerhardt et al., 2020). Other forecasts (Tubb and Seba, 2021; Witte et al., 2021) also show that alternative meats are likely to represent a significant part of the global protein market in the coming decades, a scenario in which conventional livestock may have difficulties in competing with alternative proteins, especially if they are more advantageous concerning the price (Burton, 2019). Thus, CM and PBM may have several impacts, especially in the social domain.

The discussion about social impact, defined as "everything that affects people" (Vanclay et al., 2015, p. 2), regarding new technologies is substantial, as these radical or disruptive initiatives can cause changes in the entire system, including significant impacts on people and societies (Chang et al., 2022). When a technology promotes a large-scale change and disrupts a market, it can also affect social relationships, values and other social dimensions, causing a "technosocial disruption" (Hopster, 2021). Some of the effects of technologies with great social impact are also linked to the interpretations that people give to reality, such as a change in conceptual understanding between what is natural or artificial and between what is beneficial or harmful to people (Löhr, 2022). Besides, the classification as a disruptive technology may adopt as a criterion the degree of expected social impact, not just the economic impact (Hopster, 2022). Therefore, better understanding the social impact of a potentially disruptive technology, as alternative proteins, are increasingly seeming relevant.

If alternative meats, especially cell culture meats, are to be successful, their broad effects need to be discussed, as a number of changes are likely to occur in areas such as change in existing food systems, changes in land use, in rural organizations, etc. (Helliwell and Burton, 2021). However, studies on the social impacts of new meat analog products are still scarce and difficult to assess (Burton, 2019; Mancini and Antonioli, 2022).

Verbeke et al. (2015) and Wilks and Phillips (2017) revealed consumers' concerns with the new situation of conventional meat producers in a scenario where conventional meats lose market to alternatives. Other studies (Bryant and van der Weele, 2021; Newton and Blaustein-Rejto, 2021; Morais-da-Silva et al., 2022) show preliminary findings on the social impact of alternative meats. Even with these more focused studies on the social implications of alternative meats, there remains room for new contributions, especially if they are not restricted to a single geographic context. Bryant and van der Weele (2021, p. 3) also reinforced the importance of further studies capable of broadening the debate on social impacts, since "it is not clear what will happen to farmers and those employed in meat production." Moreover, addressing a diversity of countries—as is done in this study—can reveal how heterogeneous institutional and cultural landscapes are likely to translate into the social impacts that alternative protein meats may cause in different regions of the globe.

Based on these arguments and considering that understanding the impact that any technological intervention may generate in the social sphere is essential to manage better its effects (Martinez and Komendantova, 2020), seeking to reduce its negative and amplify its positive consequences, this investigation aimed to study the social impact that the transition from conventional meat production systems to CM and PBM may have in Brazil, the United States and Europe. We chose these three geographic contexts because of their relevance in consuming and producing meat products.

Literature review

Radical innovation in the animal food production chain

A radical innovation occurs when technological paradigm shifts and new technological trajectories are launched (Dosi, 1982; Freeman and Perez, 1988; Henderson and Clark, 1990). The literature has been associating radical innovation with "do different" (Bessant et al., 2014, p. 1,284) and with moving "into unknown territory" (O'Connor and McDermott, 2004, p. 11). We adopted the concept that present radical innovations "as novel, unique, or state-of-the-art advances in a product category

that radically alter the consumption patterns of a market and differ significantly from existing products" (Dean et al., 2022, p. 3). Thus, radical innovation refers to an entirely new production process (Mors and Vergragt, 2002) or the introduction of new products to the market, when such products incorporate technologies substantially dissimilar from the previous ones (Chandy and Tellis, 1998). Furthermore, radical innovations can ignite significant technological transformations along value chains (Dahlin and Behrens, 2005; Reis et al., 2021).

Radical revolutions in agriculture vary in the literature. For Rose and Chilvers (2018), the first radical revolution occurred in the transition from the hunting and gathering model to settled agriculture; the second one is related to the eighteen-century agricultural revolution in the United Kingdom, in which a refinement of farming techniques led to a remarkable increase in agricultural production; and the third revolution refers to the mechanization and the intense increase in productivity in the so-called green revolution in the post-second war period. Currently, agriculture is in the fourth revolution (Rose and Chilvers, 2018) or what is called smart farming (Blok and Gremmen, 2018) by using, for example, software with artificial intelligence to decide the best date for planting and harvesting activities (López and Corrales, 2018) and robots in various farming and animal production activities (Sparrow and Howard, 2021).

The currently most prominent and radical proposals in the animal food production chain are CM and PBM. While producing meat of animal origin, CM is highly innovative mainly because there is no need to slaughter animals (Post et al., 2020). Therefore, cultivated meat has been considered the second domestication, which is the domestication of cells, and has the potential to radically transform the animal food production chains (Tubb and Seba, 2021). As for PBM's production process is highly innovative, producing vegetable-based meats that mimic conventional animal-based meat products (Ismail et al., 2020; Rubio et al., 2020).

Thus, considering the conceptual definitions for radical innovation and the characteristics of CM and PBM in the food production chain, they may be regarded as examples of radical innovation. Our classification is in line with other studies (Reis et al., 2020, 2021; Tziva et al., 2020; Treich, 2021), which have also considered alternative meats radical innovations with great potential for changes in the food production chain. Reis et al. (2020) show, for instance, that the CM radical innovation can dramatically change the tuna value chain configuration by redefining chain stages, actors involved, and geographic scopes, decreasing the pressure on the environment and mitigating severe animal welfare issues.

CM and PBM technologies

The process of producing CM starts with the removal and isolation of specific alive animal cells. The cells are then multiplied in a bioreactor that supplies all the nutrients and environment needed for proliferation and differentiation into the desired type of tissue (e.g., fat, muscle); the resulting meat may be further processed to be commercialized (e.g., as hamburger) (Reis et al., 2020). Several techniques are used to improve products' texture and taste during the process. An essential feature of CM is that it is genuinely animal meat. Thus, CM startups are likely to partner with large meat-processing firms to produce, distribute and sell end products (Reis et al., 2020).

Plant-based traditional products, in turn, have been around for a long time, perhaps even thousands of years (e.g., tofu, tempeh). The first generation of PBM used textured vegetable protein (TVP), which showed significant differences from conventional animal-based meat regarding texture, appearance, taste, and others (He et al., 2020). More recently, the second generation of PBM appeared and has gained track in the market (e.g, PBM hamburgers). Those products use vegetable proteins and have "appearance, nutritional facts, aroma, and taste (..) very similar to authentic meat products." They also aim "to have a similar appearance and color to fresh raw meat" (He et al., 2020, p. 6), even showing blood-like juice, which characterizes their innovative "biomimetic" approach (GFI, 2022a). Second-generation PBM encompasses the potential to transform the meat chain, which characterizes radical innovations (Dahlin and Behrens, 2005; Reis et al., 2021). It should be noted, however, that production is dependent on plant-based inputs (e.g., soybeans, peas) and involves specific processes to create the base material for the meat-like product (e.g., plant drought or extrusion) (Yaman, 2019), which differs from CM production. The impact of PMB is likely to be significant since sales have increased; for instance, the growth in the American market was 45% in 2020 (GFI, 2022b).

The social impact of CM and PBM

Due to the highly groundbreaking, radical innovation generally is not restricted to products and services, but it causes drastic changes by transforming markets and industries (Miller et al., 2005) and promoting different types of impacts on society (Phillips, 2011). Therefore, radical innovation has broader consequences than just in the technological dimension. One of the additional consequences may be a social impact. By adopting a comprehensive view, social impacts may be defined as anything with consequences for people (Vanclay et al., 2015). We adopted a classic definition that understands social impact as "a significant improvement or deterioration in people's wellbeing or a significant change in an aspect of community concern" (Dietz, 1987, p. 56) to study the potential social impacts that CM and PBM may have for people. The literature has few contributions on this topic.

Some investigations have revealed consumer concerns about farmers (Verbeke et al., 2015; Wilks and Phillips, 2017), but this discussion has received little attention in these studies. Only three recent studies focused more specifically on the social dimension. Newton and Blaustein-Rejto (2021) investigated the social and economic consequences, divided into opportunities and challenges, for farmers and rural communities in the United States; and suggested future studies in other contexts. Morais-da-Silva et al. (2022) also studied the social impacts of alternative meats, but with a focus on the Brazilian context. They discovered several opportunities and challenges depending on the country's degree of engagement. Both inquiries were dedicated to studying the impacts of alternative meats, but with a specific geographic focus, leaving unanswered gaps and opening space for new investigations.

In France and Germany, Bryant and van der Weele (2021, p. 3) studied the point of view of producers and workers in the conventional meat industry regarding the transition to alternative meats. The investigation found that the degree of acceptance of alternative meats is higher among those directly involved in the production of conventional meat. The study also suggests that moral concerns about farm animals among producers are growing, but talking about them may be interpreted as a betrayal of their peers. The authors also highlight the need for studies that consider the impact on producers and workers, potentially those who may be most impacted by the transition (Bryant and van der Weele, 2021). Thus, further studies are needed to understand better alternative meats' potential social impacts on different countries.

Methodology

Research approach

To achieve the goal of this research, we investigated the viewpoint of a sample of experts in the alternative and conventional protein industry in Brazil, the United States and Europe. Forecasting studies have widely used experts' perspectives to understand better future events (Mauksch et al., 2020), primarily when the subject is in the domain of a few people or when there is little information available (Bogner and Menz, 2009). Expert opinions are also relevant when predicting future events, such as the potential impacts that a technological change may bring (Haleem et al., 2019). Thus, experts' perspectives may contribute to clarifying the social implications of the transition, even if partial, from conventional meat production to the production of CM and PBM.

We have chosen Brazil, the United States and Europe as our target geographical spaces for their tradition as major meat consumers or producers. In Europe, we have selected countries representing different perspectives, recruiting participants in Belgium, France, Germany, Italy, Poland, and The Netherlands.

Data collection

We developed a five-point Likert scale questionnaire to assess expert opinion on expected social impacts of alternative meats. The questionnaire development was based on qualitative research carried out previously (Morais-da-Silva et al., 2022), in which the significant potential social consequences were explored, and on other relevant scientific publications (e.g., Burton, 2019; Bryant and van der Weele, 2021; Helliwell and Burton, 2021; Newton and Blaustein-Rejto, 2021; Mancini and Antonioli, 2022). The questionnaire covered four questions about market expectations, six on consumer access to the novel products, three involving consumer acceptance, eight on farmers' impact, and five about business opportunities along the new chain. The questionnaire and additional required documents were submitted to the Ethics Committee for Research with Humans at the Federal University of Paraná and the project was approved under protocol number 38617320.0.0000.0102.

The experts included in this study are involved with alternative or conventional meat chains. They were divided into four groups. The first comprises professionals from the industry, such as entrepreneurs, and managers of CM, PBM, and meat-processing firms, among others. These categories of experts were essential to our study, as they represent the best knowledge about the technological frontier of the industry and thus, may be in a good position to ponder about its potential future social impacts. The second group of experts involved researchers in the field, affiliated with universities and research institutes. As they may represent a more critical opinion, this group seemed fundamental to assessing more profound social consequences. The third group, composed mainly of third-sector organizations, brought the perspective of intermediary organizations, which approach the scenario from a distinct perspective. The fourth group involved government organizations and regulatory bodies, which are directly involved in making alternative meats available to consumers and in the transition policies for minimizing adverse and maximizing positive effects for society.

The identification of potential respondents followed multiple paths. We consulted the list of alternative meat companies on The Good Food Institute (GFI) website to identify industry experts, which featured 416 nominations in our target places. We then sent invitation emails to these companies using contacts available on their websites. Approximately 10% were not identified because they did not provide websites or contact emails. As we received few responses, we searched for the same companies on LinkedIn, identified people with management positions and sent messages directly, when this option was available on the social network or when the email of the potential respondent was available.

Research experts were identified from publications in CM and PBM that were registered on the Web of Science. We

listed 165 emails from researchers and sent them individual invitations with this approach. We also looked for experts from third-sector organizations related to alternative proteins, such as people from NGOs, and government and regulatory bodies working on alternative proteins. We sent invitation emails to all of them. Finally, we used the authors' personal contacts to approach additional potential respondents. We also solicited in the invitation emails that, if possible, respondents shared the links with experts in the field.

Overall, we identified and invited 879 experts, received back 217, 161 of which were fully complete. We then excluded 25 participants from countries that were not in our focus, resulting in 136 questionnaires. Of all respondents, 25.7% were from Brazil, 41.2% from Europe (9 from Belgium, 12 from France, 7 from Germany, 10 from Italy, 7 from Poland and 11 from the Netherlands) and 33.1% from the United States. Table 1 provides more details on the participant's characteristics.

Data analysis

Based on the responses received and with the non-parametric characteristic of the data (Shapiro–Wilk test on SPSS), we conducted descriptive and comparison analyses amongst groups by location with the Kruskal–Wallis test, which is used to compare values from independent samples (Katz and McSweeney, 1980). With Bonferroni correction, Dunn's *post-hoc* test was used for multiple comparisons between pairs of location groups.

Results and discussion

The results of this study are divided into five topics: market expectations, consumer access, consumer acceptance, impact on farms, and business opportunities along the new chains of CM and PBM.

Market expectations

The expectations that alternative proteins may occupy a considerable share of the food market in the future, as well as the consequences for the production chain of food of animal origin, have been highlighted by some studies. The Rethink X study pointed out a reduction of up to 90% in conventional milk and meat production in the United States by 2035, which would lead to a collapse in the country's production chain (Tubb and Seba, 2021). The Boston Consulting Group forecast shows that by 2035 11–22% of the set of protein consumed, such as meat, eggs, and dairy products, may be of alternative origin; the percentage varies according to technological and regulatory advances (Witte et al., 2021). The forecast by A. T. Kearney Consulting has been receiving more prominence, and it presents a scenario where CM and PBM will occupy 60% of the global meat market in 2040 (Gerhardt et al., 2020); this forecast indicates that CM will represent 35% and plant-based meat 25%, leaving a proportion of 40% of the worldwide meat market for conventional meat by then.

In order to understand how the experts consulted considered the future of meat production, we asked them four questions. The results of descriptive statistics are shown in Table 2.

Considering the information about the scenario predicted by Gerhardt et al. (2020) and the expectations of the experts consulted, a higher trend of agreement is seen concerning the market for PBM in 2040. In this case, 64.7% of the experts agreed or strongly agreed with the prediction that plant-based products may dominate 25% of the meat market. About CM, 38.9% of the experts agreed with an expected share of 35% of the meat market in 2040. Regarding the questions approaching future demand, the results are also more optimistic for PBM than for CM, as 69.1% of the experts agreed and strongly agreed with a high demand for PBM. In comparison, 53.7% of them set themselves the same way for CM.

These results may be related to the current availability of plant-based products for consumers in the three studied countries compared to the novelty of CM. The concepts of neophobia (Wilks et al., 2019; Krings et al., 2022) and unnaturalness (Laestadius, 2015; Laestadius and Caldwell, 2015) concerning the rejection of new foods may help explain the expected more favorable consumer behavior toward foods that are already known by consumers as compared to completely new foods, which are not yet available in the supermarkets, such as CM.

Furthermore, required technological advances and current higher costs may be relevant elements that, considering the moment of data collection, may have placed CM in a less favorable position than PBM, according to the view of experts. Although CM technology has evolved considerably in recent years, there are still critical technical barriers, concerning culture media (Hadi and Brightwell, 2021; O'Neill et al., 2021) and scaffolds (Seah et al., 2021), for example. The high costs involved and the timid scale of production may also affect the more conservative position of respondents concerning CM, as several studies point to price as one of the leading conditioning factors for consumer acceptance (Verbeke et al., 2015; Bekker et al., 2017; Wilks and Phillips, 2017; Valente et al., 2019; Bryant and Barnett, 2020).

In addition to the overall analysis of all the study data, one of the questions showed different response patterns across locations. Question 3 highlighted differences between Europe compared to Brazil and the United States. No statistically significant difference was observed between Brazil and the United States. Thus, our data suggest that experts recognize

TABLE 1 Demographic data of the analyzed sample, as per on-line interviews from August to October, 2021.

Variable	Category	Number of respondents (%)			
		Overall	Brazil	Europe	United States
Sample size	Location	136 (100)	35 (25.7)	56 (41.2)	45 (33.1)
Gender	Masculine	69 (50.7)	15 (42.8)	28 (50.0)	26 (57.8)
	Feminine	66 (48.5)	20 (57.1)	28 (50.0)	18 (40.0)
	I prefer not to answer	1 (0.74)	0 (0.0)	0 (0.0)	1 (2.2)
Sector	Research	63 (46.1)	14 (40.0)	30 (53.6)	19 (42.2)
	Industry	50 (36.8)	15 (42.9)	16 (28.6)	19 (42.2)
	Third sector	20 (14.7)	3 (8.6)	10 (17.9)	7 (15.6)
	Government	3 (2.2)	3 (8.6)	0 (0.0)	0 (0.0)
Function	Researcher	57 (41.9)	14 (40.0)	26 (46.4)	17 (37.8)
	Others	27 (19.9)	7 (20.0)	8 (14.3)	12 (26.7)
	Director/President	25 (18.4)	6 (17.1)	13 (23.2)	6 (13.3)
	Manager	17 (12.5)	4 (11.4)	6 (10.7)	7 (15.5)
	Specialist	7 (5.1)	3 (8.6)	1 (1.8)	3 (6.7)
	Consultant	3 (2.2)	1 (2.9)	2 (3.6)	0 (0.0)
Self-judgment regarding knowledge of the sector	I have a moderate level of knowledge	59 (43.4)	13 (37.1)	22 (39.3)	24 (53.3)
	I have a high level of knowledge	38 (27.9)	10 (28.6)	17 (30.4)	11 (24.4)
	I know a little	23 (16.9)	7 (20.0)	5 (17.9)	5 (11.1)
	I am a specialist	16 (11.8)	5 (14.3)	6 (10.7)	5 (11.1)
	I have heard about alternative meats	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
	I do not know anything about alternative meats	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

a more promising potential for consuming CM in Brazil and the United States than in Europe. The literature presents several studies that can be discussed with such results. Surveys conducted in Brazil show that 59.3% (Fernandes et al., 2021) and 63.6% (Valente et al., 2019) of consumers are willing to try CM. In the United States, consumer acceptance was reported as 64.6% (Bryant and Dillard, 2019) and 66.6% (Wilks and Phillips, 2017). In Europe, although results vary from country to country, some studies indicate that 39.3% of Belgians (Bryant and Sanctorum, 2021), 54% of Italians (Mancini and Antonioli, 2019), 58.3% of Germans and 44.2% of French (Bryant et al., 2020) would be willing to try CM. Such acceptance percentages suggest a more favorable position in Brazil and the United States in relation to Europe, corroborating our results. However, Gómez-Luciano et al. (2019) showed that the acceptance of CM should be lower in Brazil than in the United Kingdom, Spain and the Dominican Republic. The difference in the acceptance of CM in Brazil needs to be better investigated in future studies.

Consumer access

Consumer access to products is a key issue in the alternative meat market. Several studies show that price is a central challenge and a potential barrier to accepting alternative proteins (Verbeke et al., 2015; Bekker et al., 2017; Wilks and Phillips, 2017; Gómez-Luciano et al., 2019; Valente et al., 2019; Bryant and Barnett, 2020; GFI, 2020). Although some consumer groups state that they are willing to pay a premium price for CM compared to conventional meat due to the benefits of the first (Verbeke et al., 2015; Bryant and Sanctorum, 2021), most are not willing to do so (Bryant and Barnett, 2020). However, besides price difficulties, there is an expectation that alternative meats, mainly CM, may become one way to reduce hunger in the world (Tucker, 2014; Bekker et al., 2017; Wilks and Phillips, 2017; Gómez-Luciano et al., 2019; Zhang et al., 2020). This ambition contrasts with the argument that alternative meats, especially CM, may be directed toward the elite, mainly due to the high expected price (Laestadius and Caldwell, 2015).

TABLE 2 Analysis for Q1–Q4 regarding marketing expectation in Brazil ($N = 35$), Europe ($N = 56$), and the United States ($N = 45$), using Likert scale from 1 (strongly disagree) to 5 (strongly agree), as per interviews from August to October, 2021.

Question	Location	Mean	Median	95% confidence interval for mean		Kruskal–Wallis test
				Lower	Upper	Sig.
Q1—The scenario foreseen for 2040 (Gerhardt et al., 2020) applies to my country regarding CM	Brazil	3.17	4	2.70	3.65	0.216
	Europe	2.68	2	2.35	3.01	
	United States	2.80	3	2.43	3.17	
	Overall	2.85	2.5	2.63	3.06	
Q2—The scenario foreseen for 2040 (Gerhardt et al., 2020) applies to my country regarding PBM	Brazil	3.63	4	3.15	4.11	0.433
	Europe	3.68	4	3.36	3.99	
	United States	3.42	4	3.06	3.78	
	Overall	3.58	4	3.37	3.79	
Q3—We will have a high demand for CM in my country	Brazil	3.54[b]	4	3.12	3.97	0.016
	Europe	2.91[a]	3	2.57	3.25	
	United States	3.51[b]	4	3.16	3.86	
	Overall	3.27	4	3.06	3.48	
Q4—We will have a high demand for PBM in my country	Brazil	3.74	4	3.32	4.17	0.948
	Europe	3.82	4	3.56	4.09	
	United States	3.71	4	3.37	4.05	
	Overall	3.76	4	3.58	3.95	

Different superscript letters (a and b) indicate a significant difference ($p < 0.05$) between locations.

Considering the importance of access to alternative meats, we asked six questions to our experts on the topic. The results are shown in Table 3.

For the questions about the access to alternative meats over time by consumers with lower purchasing power, 23.5% of experts agreed or strongly agreed that there will be access to CM for these people in 10 years (Q5), while 50% estimated this access in 20 years (Q6). This finding is in line with the argument that initially, the price of CM will be higher and, consequently, cell-based products will be more focused on people with higher income (Laestadius and Caldwell, 2015). As time goes on, access may expand mainly through competition amongst producers and the greater efficiency in the process that may be achieved (Bryant and Barnett, 2020), pushing conventional meat into the premium segment and taking mass-market shares for CM (Bonny et al., 2015). The innovation management theory explains that radically innovative products are more expensive when they are first placed on the market, but the prices tend to decrease as incremental improvements in the product and its process help reduce costs over time (Dosi, 1982). Besides, public policies may redirect subsidies currently intended for producing conventional meat to alternative proteins chain, favoring a reduction in prices to final consumers.

Responses to Q7 and Q8 also show the experts' concern about the price of alternative meats. Our data shows that 72.8% of experts agree or strongly agree that the price of CM will be an obstacle to commercialization, while 58.8% of experts have this concern for PBMs. A robust body of research supports this finding in several countries, for which price is an essential predictor of alternative protein consumption (Verbeke et al., 2015; Bekker et al., 2017; Wilks and Phillips, 2017; Gómez-Luciano et al., 2019; Valente et al., 2019; Bryant and Barnett, 2020; GFI, 2020). The Kruskal–Wallis test indicated a statistically significant difference among the responses considering the location in Q7, and the *post hoc* test identified a trend for the comparison between Brazil and Europe (adjusted $p = 0.058$), suggesting more significant concern in the Brazilian than in the European scenario regarding the low income of consumers as an obstacle to the commercialization of CM. Further research to clarify this potential difference is warranted.

Responses to Q9 bring an interesting aspect concerning access to CM by the poorest. When the experts were asked whether low income may be an advantage for the sale of CM as its price becomes reduced, 49.3% of respondents agreed or strongly agreed with this statement. This result may suggest that

TABLE 3 Analysis for Q5–Q10 regarding consumer access in Brazil ($N = 35$), Europe ($N = 56$), and the United States ($N = 45$) using Likert scale from 1 (strongly disagree) to 5 (strongly agree), as per interviews from August to October, 2021.

Question	Location	Mean	Median	95% confidence interval for mean		Kruskal–Wallis test
				Lower	Upper	Sig.
Q5—People with less purchasing power will be able to access CM within 10 years	Brazil	2.54	3	2.11	2.98	0.858
	Europe	2.54	2	2.26	2.82	
	United States	2.67	3	2.29	3.04	
	Overall	2.58	3	2.38	2.78	
Q6—People with lower purchasing power will be able to access CM within 20 years	Brazil	3.34	3	2.93	3.76	0.469
	Europe	3.45	4	3.16	3.73	
	United States	3.60	4	3.22	3.98	
	Overall	3.47	3.5	3.27	3.67	
Q7—The low income of consumers is likely to be an obstacle to the marketing of CM	Brazil	3.91*	4	3.50	4.33	0.039
	Europe	3.43*	4	3.10	3.75	
	United States	3.98	3	3.78	4.18	
	Overall	3.74	4	3.55	3.92	
Q8—The low income of consumers is likely to be an obstacle to the marketing of PBM	Brazil	3.66	4	3.19	4.13	0.221
	Europe	3.09	3	2.77	3.41	
	United States	3.53	4	3.25	3.82	
	Overall	3.38	4	3.18	3.58	
Q9—The low purchasing power of consumers will become an advantage for CM, as its price decreases	Brazil	3.57	4	3.13	4.01	0.071
	Europe	3.34	4	3.04	3.64	
	United States	3.04	3	2.71	3.38	
	Overall	3.30	3	3.10	3.50	
Q10—CM should be a solution to the need for increased production and food due to the population increase	Brazil	4.20	5	3.77	4.63	0.132
	Europe	3.73	4	3.36	4.11	
	United States	3.93	5	3.53	4.34	
	Overall	3.92	4	3.69	4.15	

*$P = 0.058$.

although a high price is expected for alternative meats, their costs may sufficiently reduce over time to turn the products accessible to people with less purchasing power. This rationale has been published by Bryant and Barnett (2020).

As for Q10, 72.8% of experts agreed or strongly agreed that CM may be considered a solution to food security given the expected human population growth. This finding is in line with the expectation that CM may be a promising technology to increase food production (Sharma et al., 2015), considered by consumers as a potential aid in dealing with world hunger (Laestadius, 2015; Mancini and Antonioli, 2019; Bryant and Barnett, 2020).

Consumer acceptance

A significant body of literature has been devoted to understanding consumer attitudes toward alternative proteins. Onwezen et al. (2021) study mapped 91 investigations carried out between 2014 and mid-2020 in different countries

and continents. Two other studies also reviewed consumer acceptance of alternative proteins (Bryant and Barnett, 2018, 2020). Most of these studies considered consumers' opinions; however, our research addresses questions about consumer acceptance from the standpoint of the participant experts. We asked experts three questions on the topic; the results are shown in Table 4.

For Q11, 44% of experts agreed or strongly agreed with high acceptance levels on whether CM will be well-accepted in the investigated locations. This percentage is slightly below the rates observed by consumer surveys in the focus locations. When consumers are questioned, responses regarding the willingness to taste CM are between 50 and 70% (Wilks and Phillips, 2017; Bryant and Dillard, 2019; Mancini and Antonioli, 2019; Valente et al., 2019; Bryant et al., 2020; Fernandes et al., 2021). Thus, the experts consulted seem to have a more conservative view than the consumers themselves. Specialists are more concerned with technical aspects regarding prices and other technological challenges than consumers, as such challenges may represent potential barriers to consuming alternative meats (Tomiyama et al., 2020). The technical aspects seem little understood by the general public (Zhang et al., 2020) and even by specialists in conventional meat chains (Heidemann et al., 2020).

In Q12, we asked if CM would be healthier than conventional meat products, considering that healthiness is essential for the acceptance of CM. Results showed that 52.9% of the experts believed that CM would be healthier. The Kruskal–Wallis test showed a trend for the difference between countries ($P = 0.056$), in which Brazilian specialists were more optimistic about CM's healthiness than conventional meat. The literature has shown that the perception of the wellness of alternative products is closely linked to CM being considered unnatural by a considerable part of consumers (Laestadius, 2015; Laestadius and Caldwell, 2015; Bekker et al., 2017). On the other hand, some results suggest that health claims may lead to greater acceptance of CM products (Bryant and Barnett, 2020). The study by Gómez-Luciano et al. (2019), for example, found that the healthiness and nutritional properties of CM products are predictors for potential consumers in Brazil, the United Kingdom, Spain and the Dominican Republic. Thus, although the healthiness of CM is relevant to consumers, just over half of the experts consulted believe that it will be healthier than conventional meat. Further studies on the healthiness of alternative foods are required to clarify this critical aspect better.

In Q13, we asked experts about the acceptance of PBM relative to CM and observed that 58.8% of respondents strongly agreed or agreed that PBM may be more acceptable by consumers than CM. This trend has also been suggested by other studies in the field (Bryant and Barnett, 2020; Onwezen et al., 2021). However, this position may change as CM becomes more common, as has already occurred with other products that have emerged throughout human history (van der Weele and Driessen, 2019). Thus, our data corroborate the existing literature on the preference for PBM over CM, but this may change as the latter becomes widely available on the market.

Impact on farms

Some studies have pointed out that the potential impacts on animal farms may be a major problem linked to the emergence of alternative meats. For example, Shaw and Mac Con Iomaire (2019) reported that Irish consumers were concerned about farms, as meat production is an important sector of the country's economy. Bekker et al. (2017) and Wilks and Phillips (2017) also mentioned consumer concerns involving current meat producers. Only three studies focusing on the socio-economic impact on animal producers were identified, one in the United States (Newton and Blaustein-Rejto, 2021), one in Brazil (Morais-da-Silva et al., 2022), and one in France and Germany (Bryant and van der Weele, 2021). On the other hand, several studies point out that the negative impact for farmers may be one of the disadvantages of alternative proteins (Treich, 2021; Mancini and Antonioli, 2022; Moritz et al., 2022).

The literature has been classifying innovations that bring significant impacts to social dimensions as "technosocial disruption" (Hopster, 2021, 2022), which may be the case of alternative proteins capable of bringing opportunities and challenges to social aspects. To further clarify alternative meats' impact on animal farmers, our study asked eight questions to the experts. The results are presented in Table 5.

Question Q14 shows that 75.7% of experts disagree or strongly disagree that all sizes of animal farms are expected to have the same impact due to the entry of CM into the market. There are different scenarios in the literature concerning this issue. According to the study by Newton and Blaustein-Rejto (2021), larger farms in the United States should be impacted first because they are poorly diversified, unlike smaller farms with multiple fronts. On the other hand, in the study by Morais-da-Silva et al. (2022), conducted in Brazil, it is suggested that small farms may suffer first because they have fewer scale gains and, thus, less advantage to compete in a more limited market. Further studies seem warranted to clarify this issue or confirm that the effect differs according to location.

The answers to question Q15, showed that 42.6% of respondents agreed that CM would bring opportunities for animal farmers to switch to other activities within the meat production field. Experts were also asked whether animal producers may enter new activities in the cultivated (Q16) and PBM chains (Q17). Expert opinion was similar for both cases, with 47.1% agreeing with this possibility for cultivated and 46.3% for PBM. The studies by Newton and Blaustein-Rejto (2021), conducted in the United States, and by Morais-da-Silva et al. (2022), completed in Brazil, proposed that animal producers may enter the new alternative meat chains, mainly as suppliers of vegetable ingredients. Newton and Blaustein-Rejto (2021)

TABLE 4 Analysis for Q11–Q13 regarding consumer acceptance in Brazil ($N = 35$), Europe ($N = 56$), and the United States ($N = 45$) using Likert scale from 1 (strongly disagree) to 5 (strongly agree), as per interviews from August to October, 2021.

Question	Location	Mean	Median	95% confidence interval for mean		Kruskal–Wallis test
				Lower	Upper	Sig.
Q11—CM will be well accepted by consumers in my country due to its positive aspects compared to conventional meat	Brazil	3.34	4	2.92	3.77	0.221
	Europe	2.96	3	2.68	3.25	
	United States	3.27	3	2.91	3.62	
	Overall	3.16	3	2.97	3.36	
Q12—CM will be healthier than conventional meat for human consumption.	Brazil	4.00	4	3.60	4.40	0.056
	Europe	3.29	3	2.90	3.67	
	United States	3.60	4	3.21	3.99	
	Overall	3.57	4	3.35	3.80	
Q13—PBM products are likely to have a greater acceptance than CM in my country	Brazil	3.29	4	2.84	3.73	0.298
	Europe	3.73	4	3.45	4.01	
	United States	3.62	4	3.25	4.00	
	Overall	3.58	4	3.38	3.78	

also revealed that animal producers may specialize in providing animal cells to produce CM; however, this activity will likely not be able to absorb a significant proportion of animal farmers.

Concerning Q16, a difference was found in Europe-Brazil and Europe-United States. Europe had a lower mean and median than the other two locations, suggesting that experts from Brazil and United States are more optimistic than European ones about the opportunities for farmers in the CM chain. Possibly, opportunities as suppliers of vegetable ingredients (Newton and Blaustein-Rejto, 2021; Morais-da-Silva et al., 2022) for the new chain are currently more perceptible to Brazilian and American respondents.

When asked whether CM (Q18) or PBM (Q19) will pose challenges for animal producers, 57.4% of respondents agreed with the statement for CM and 47.8% for PBM. This position shows concern with the conventional sector if alternative proteins advance, especially with the proportions that some forecasts have estimated (Gerhardt et al., 2020; Tubb and Seba, 2021; Witte et al., 2021).

Significant differences were found for Q18 and 19. In Q18, the Brazil-United States responses were significantly different, suggesting that experts believe that Brazilian animal producers will face less negative impact with the entry of CM. In Q19, both the Brazil-United States and the Brazil-Europe responses were different, suggesting that experts believe Brazilian animal producers will be less affected than those in the United States and Europe regarding PBM entry. This more optimistic position concerning Brazil may have at least two justifications.

The first is that the transition in Brazil can be expected to be more gradual as the country has strong cultural connections with conventional meat and because animal products are cheaper in the country than in other countries (Morais-da-Silva et al., 2022). Even though this is no consensus in the literature, the study by Gómez-Luciano et al. (2019) showed that acceptance for CM in Brazil would be lower than in the United Kingdom, Spain and the Dominican Republic. Thus, animal producers in Brazil may be less affected by the entry of CM and PBM because the demand in the country may be smaller or attenuated in the long term.

The second justification relates to the substantial demand for alternative meats in the Brazilian scenario. Some Brazilian studies already show that the demand for alternative meats should be significant in Brazil, with rates of 59.3% (Fernandes et al., 2021) and 63.3% (Valente et al., 2019) of acceptance for CM. This new market would also bring opportunities in the new chains for animal producers in Brazil, with the supply of vegetable ingredients being the main one (Morais-da-Silva et al., 2022). From this perspective, although alternative meats gain participation on the national scene, animal producers would find activities within the new chain, bringing them less negative impact. Thus, further studies are needed to explore better the effects that animal producers are likely to face with the entry of alternative meats, perhaps in the near future, as new products become more abundant.

TABLE 5 Analysis for Q14–Q21 regarding impact on farms in Brazil ($N = 35$), Europe ($N = 56$), and the United States ($N = 45$) using Likert scale from 1 (strongly disagree) to 5 (strongly agree), as per interviews from August to October, 2021.

Question	Location	Mean	Median	95% confidence interval for mean		Kruskal–Wallis test
				Lower	Upper	Sig.
Q14–All animal farms, regardless of size, will have their production reduced at the same intensity due to the entry of CM; i.e., there will be no different pattern of impact according to farm size	Brazil	1.91	2	1.51	2.32	0.227
	Europe	2.20	2	1.91	2.48	
	United States	2.02	2	1.69	2.35	
	Overall	2.07	2	1.88	2.25	
Q15–CM will bring opportunities for animal farmers to switch to other activities within the meat production field	Brazil	3.26	3	2.82	3.69	0.361
	Europe	2.93	3	2.59	3.27	
	United States	2.87	3	2.51	3.23	
	Overall	2.99	3	2.78	3.20	
Q16–Animal producers are likely to enter new activities related to CM production	Brazil	3.37[a]	4	2.90	3.84	0.003
	Europe	2.59[b]	2	2.28	2.90	
	United States	3.31[a]	4	2.94	3.68	
	Overall	3.03	3	2.81	3.25	
Q17–Animal producers are likely to enter new activities related to producing plant-based products	Brazil	2.91	3	2.52	3.31	0.196
	Europe	3.29	3	2.98	3.59	
	United States	3.36	4	2.99	3.72	
	Overall	3.21	3	3.02	3.41	
Q18–CM will bring major threats to the activities of animal farmers	Brazil	2.77[a]	3	2.78	3.20	0.000
	Europe	3.43[b]	4	2.31	3.23	
	United States	3.93[b]	3	3.10	3.76	
	Overall	3.43	4	3.61	4.26	
Q19–PBM will bring major threats to the activities of animal farmers	Brazil	2.26[a]	2	1.87	2.64	0.000
	Europe	3.52[b]	4	3.23	3.80	
	United States	3.29[b]	4	2.91	3.67	
	Overall	3.12	3	2.91	3.33	
Q20–A major source of resistance will be animal producers' associations and unions	Brazil	4.29	5	3.94	4.63	0.570
	Europe	4.27	4	4.02	4.52	
	United States	4.42	5	4.16	4.68	
	Overall	4.32	5	4.17	4.48	
Q21–Any resistance from animal farmers' associations tends to be temporary as new activities for them become available	Brazil	3.63[a]	4	3.26	4.00	0.000
	Europe	2.79[b]	3	2.48	3.10	
	United States	2.60[b]	2	2.29	2.91	
	Overall	2.94	3	2.74	3.14	

Different superscript letters (a and b) indicate a significant difference ($p < 0.05$) between locations.

Questions Q20 and Q21 approached how animal producers may act, perhaps to stop the advance of alternative meats. In Q20, 87.5% of experts agreed or strongly agreed that animal producer associations and unions will be a significant source of resistance to the products from the new industry. In Q21, 39.7% agreed or strongly agreed that this resistance tends to diminish over time and with the opportunities that may arise for animal producers. Thus, the data suggest that animal producers will present a resistance position and that the chances of changing their position over time are significant. Regarding the comparison amongst locations, there was a statistically significant difference in Q21 for Brazil, as compared with Europe and the United States, suggesting that Brazilian producers will reduce their resistance as soon as more opportunities arise. Thus, the differences point to a more favorable scenario for decreasing resistance in Brazil, which seems coherent with other differences observed in our results, which tend to depict a more optimistic scenario for alternative meats in Brazil. These are interesting and unexpected findings that warrant further studies.

Resistance among animal farmers was addressed by Bryant and van der Weele (2021). They revealed that moral concern related to using animals for food production among people working directly in animal production is growing, but that addressing this issue may be considered a betrayal of the category. Another study found, interestingly, that the propensity to eat CM is greater among farmers and workers in the meat chain than in the general population (Bryant et al., 2020). These findings help to explain our results that while there should be resistance among animal producers to the entry of alternative proteins, this resistance may diminish over time as new opportunities for them arise. This position seems more optimistic in Brazil than in the United States and Europe.

Business opportunities along the new chain

Business opportunities may arise when economic imbalances arise from innovation waves (Schumpeter, 1983) or technological paradigm changes (Dosi, 1982), which affect how social needs are met, bringing opportunities for new ventures adjusted to the new paradigm. In this sense, the new plant-based and CMs may open up new opportunities for both new and existing producers along the production chains. Five questions were asked to the experts to clarify this topic, and the results are presented in Table 6.

When experts were asked whether new business opportunities may arise regarding supplies for the new CM chain (Q22), 93.2% agreed or strongly agreed with this statement. There was a significant difference between Brazil and Europe. Brazilian values were higher, indicating a greater expectation of business opportunities in the supply of ingredients grown in the country. Morais-da-Silva et al. (2022) indicated that business opportunities may be associated with vegetable ingredients for culture media, scaffolding structures for cell growth, and plant ingredients for mixed meat products, which aggregate CM with plant ingredients directly in the final stage of product preparation. The study by Newton and Blaustein-Rejto (2021), conducted in the United States, also indicated the opportunity for providing genetic material with local animal breeds; maybe Brazilian producers may also take advantage of this opportunity. Again, this tends to be a very small-scale activity if alternative proteins deliver the expected results in terms of environmental and animal welfare benefits. As such, not many opportunities are likely in this area.

Considering the Q23 results, 87.9% of experts agreed or strongly agreed that PBMs may open up business opportunities for ingredient suppliers. The two studies that have already considered these opportunities (Newton and Blaustein-Rejto, 2021; Morais-da-Silva et al., 2022) reported that plant ingredients may be highly demanded. Besides the plant ingredient opportunities for PBMs, there will also be a demand for plant ingredients to serve as a growing medium for CM. As for Q24, 91.4% of experts agreed or strongly agreed that CM may open up entrepreneurial opportunities in cell-growing factories. The Brazilian data were significantly different from European and the United States data, demonstrating greater optimism from Brazilian specialists regarding the opportunities that may arise at the stage of cell-culturing factories for CM in the country.

Some resources may be required to take advantage of these opportunities. According to Reis et al. (2020), in a study on the main capacities of the industries operating in the up-to-date business for CM, the main competencies required are related to technology, business structuring, market positioning, and relationship with stakeholder capabilities. The authors also describe that the companies dominating the sector are startups and small and highly technological companies (Reis et al., 2020). However, the scenario is beginning to change with the more recent entry of world giants from the conventional meat sector, such as BRF, Cargill, JBS, and Tyson (Baker, 2021).

The entry of companies typically from the conventional meat sector may help explain the results obtained in Q25 and Q26, for which 85.4% of experts agreed or strongly agreed that the conventional industry may have new business opportunities in the CM sector. In comparison, 87.1% of experts held the same position for PBM. According to an article in The Guardian, although startups initially supported the alternative protein market, it is now also in the hands of giants from the conventional meat sector, such as Tyson, and from other sectors, such as Merck, which invested companies in the alternative meat sector (Dutkiewicz and Rosenberg, 2021).

TABLE 6 Analysis for Q22–Q26 regarding business opportunities along the new chain in Brazil ($N = 35$), Europe ($N = 56$), and the United States ($N = 45$) using Likert scale from 1 (strongly disagree) to 5 (strongly agree), as per interviews from August to October, 2021.

Question	Location	Mean	Median	95% confidence interval for mean		Kruskal–Wallis test
				Lower	Upper	Sig.
Q22–CM will generate opportunities for new ventures and businesses in the country on the first stage of the chain (suppliers of the systems)	Brazil	4.83[a]	5	4.70	4.96	0.037
	Europe	4.42[b]	5	4.17	4.66	
	United States	4.51[ab]	5	4.28	4.74	
	Overall	4.56	5	4.43	4.69	
Q23–Regarding PBM, it will bring new business opportunities for ingredient suppliers	Brazil	4.45	5	4.08	4.83	0.100
	Europe	4.24	4	4.01	4.47	
	United States	4.39	4	4.18	4.60	
	Overall	4.35	5	4.20	4.50	
Q24—CM chain is likely to create opportunities for new ventures and businesses in the country on the second stage of the chain (CM growing factories)	Brazil	4.91[a]	5	4.82	5.01	0.000
	Europe	4.29[b]	5	4.03	4.55	
	United States	4.48[b]	5	4.22	4.74	
	Overall	4.52	5	4.38	4.66	
Q25—CM will bring new business and product opportunities to conventional meat processing companies	Brazil	4.50	5	4.21	4.79	0.052
	Europe	4.04	4	3.75	4.33	
	United States	4.24	4	3.98	4.51	
	Overall	4.23	4	4.06	4.39	
Q26—Regarding PBM, it will bring new business and product opportunities to conventional meat processing companies	Brazil	4.36	5	4.01	4.72	0.527
	Europe	4.24	4	3.98	4.50	
	United States	4.27	4	4.00	4.53	
	Overall	4.28	4	4.12	4.44	

Different superscript letters (a and b) indicate a significant difference ($p < 0.05$) between locations.

Contributions, limitations, and future research

Contributions to the literature

Our study helps clarify research gaps concerning the potential social impacts that radical innovation in the animal food chain may bring. By providing results on experts' views on market expectations, consumer access, consumer acceptance, impacts for animal farmers, and opportunities along the new chain, many of which are unprecedented in the literature, our study helps advance the scientific understanding of the area. Thus, we respond to the call for this type of study in recent publications (Bryant and van der Weele, 2021; Newton and Blaustein-Rejto, 2021; Morais-da-Silva et al., 2022).

Furthermore, when considering expert opinion for predictions of the social outcomes of alternative meats as radical innovations, our results become especially relevant. Unlike studies with potential consumers, many of whom have no proximity to the topic, studies considering the opinions of those directly involved in the specific field are better positioned to construct a deeper discussion. People in the industry, entrepreneurs, researchers and other group of experts tend to have more detailed and solid opinions, which may provide robust knowledge advances.

Practical contributions

Our findings suggest that the entry of alternative meats into the animal food production chain has several social impacts. Therefore, reflecting on ways to take advantage of the positive consequences and better deal with the negative ones seems essential. For market expectations to be met, products to be available to consumers and business opportunities to occur, some advances must be made in the institutional environment. Support for research evaluating nutritional and safety issues, promoting advances in scaling production and other technical advances, among others, seem essential in this scenario. Developing and approving regulations may also help push meat alternatives forward so that social opportunities occur. As for consumers, our data indicated significant openness, with relevant concerns about price and health.

Our results may also help formulate strategies to mitigate the likely negative social impacts. Reducing space for conventional meat producers stood out as one of the main challenges for transitioning to alternative meats. Therefore, public policies are required to make the process less challenging and create more opportunities. Our data indicated that conventional meat producers may have options for other types of food production; however, specific public policies are likely required to support producers and make the transition smoother and more efficient. Thus, our work brings relevant data and original insights, contributing to clarifying aspects that may support the establishment of best strategies, so that the expected transition be just to all involved.

Limitations and suggestions for future research

Our study has some limitations. First, we base our findings on the opinion of people currently working in the field. These people may have difficulty predicting the future mainly because predicting social consequences is complex, even more so in such a new field. In addition, experts likely considered the current technological frontier and consumer acceptance at a time when products, particularly those from CM, are not yet available. Therefore, elements such as technological advances, degree of acceptability by consumers, and changes in public policies may considerably alter the results of the forecasts indicated by our specialists. However, at the moment, considering the expectations of people immersed in the production of conventional and alternative meat foods, the results presented in this study may facilitate the understanding of what is likely to occur in the future. Furthermore, our study mainly focuses on comparing specific geographic contexts based on the opinion of a limited sample of experts. Future studies will be able, based on our results, to analyze more specifically each element of social impact, its causes, and its variations according to the context. Our study is also limited by the small participant sample, although it is a qualified set of people.

Further studies are required especially if they are based on larger samples and also include other contexts. Large potential consumer countries, such as Asian countries, are important additional contexts to be investigated. We also suggest new studies focused on animal producers, as this actor was presented as the one that should have the most harmful social consequences with the entry of alternative proteins on the market. Based on the broad forecasts presented in this initial investigation, future studies may concentrate on process variables that can change the path of social impacts regarding alternative proteins. For example, how can technological advances and policy incentives allow the participation of small farmers in the alternative protein industry? How can changes in public subsidy policies strengthen the alternative production chain, making products more competitive in the market? How can education and training policies help relocate people to work in the new food production chains? These questions may have a relevant impact on the social implications of alternative proteins.

Conclusion

The results of this study point to a future scenario with a high share of alternative meats in the total protein consumed globally. Cultivated and plant-based meats, as radical innovations responsible for this change, can have numerous social consequences for countries. The studied expert opinions seemed to favor an optimistic view regarding the market expectations, consumer access in the medium to long term and the business opportunities that may be created. The primary concern was the conventional meat producers, who tend to face a decrease in their protein market share in the coming decades.

Our study also highlights some differences among the geographic contexts investigated. Brazilian and American experts perceived a higher demand for alternative meat than European respondents. Brazilian specialists were also more optimistic than European and American experts concerning the human health aspects of cultivated meat than conventional meat. Regarding the impact for animal farmers, specialists from Brazil and the United States were more optimistic regarding alternative meat's opportunities to conventional meat producers. Specialists from the United States and Europe were more concerned than Brazilians about the impacts conventional farmers may have with the entry of alternative meats. Brazilian and United States specialists were also more optimistic about the business opportunities in the new meats chain.

These differences suggest an overall more optimistic view from Brazil and the United States experts compared with those in Europe. We believe that two main factors may cause this more optimistic scenario. First, a tradition of high meat consumption

and large agricultural production has marked both countries. This fact may have influenced the opinion of specialists, through a belief that this leading role in food production tends to continue even with a significant change in the production chain. The second may be related to the announcement by large companies and world leaders, such as the American Tyson and the Brazilians JBS and BRF, of investments in alternative meats developed in their headquarters. Further studies are warranted to confirm and understand this more optimistic view from Brazil and the United States in relation to Europe.

In some cases, Brazilian experts were also more confident than those in the United States. Further studies are required to verify and better understand these geographical trends, with a more significant number of respondents and across the years, especially because many factors with an evident influence on the social impacts of alternative meats are yet to be decided. Overall, we hope that our findings may be helpful for practitioners and public policy-makers interested in better guiding this transition process in the food production chain, so that no one is left behind.

Data availability statement

The datasets presented in this article are not readily available because correspondence and requests for materials should be addressed to RM-d-S. Requests to access the datasets should be directed to RM-d-S, rodrigo.morais.silva@ufpr.br.

Ethics statement

The questionnaire and methodology for this study was approved by the Human Research Ethics Committee of the Federal University of Paraná (Comitê de Ética em Pesquisa com Seres Humanos da Universidade Federal do Paraná)—CEP/UFPR, under protocol number 38617320.0.0000.0102. The patients/participants provided their written informed consent to participate in this study.

Author contributions

RM-d-S: conceptualization, methodology, data collection, data analysis, and writing—original draft. GR and CM: conceptualization, methodology, writing—review and editing, supervision, and project administration. HS: conceptualization, writing—review and editing, and project administration. All authors contributed to the article and approved the submitted version.

Conflict of interest

This research was funded by GAIA—Global Action in the Interest of Animals (Belgium) and the HS had a consultant position at GAIA during the execution of the study. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.1056615/full#supplementary-material

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