Food Policy 111 (2022) 102337

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

The social impacts of a transition from conventional to cultivated and plant-based meats: Evidence from Brazil

Rodrigo Luiz Morais-da-Silva [a,*], Germano Glufke Reis [a], Hermes Sanctorum [b], Carla Forte Maiolino Molento [c]

[a] Management School, UFPR Federal University of Paraná, Av. Lothário Meissner, 632, Jd Botânico, Paraná, Curitiba, Panará, Brazil
[b] GAIA Global Action in the Interest of Animals, Galerie Ravenstein 27, 1000 Brussels, Belgium
[c] Animal Welfare Laboratory, UFPR Federal University of Paraná, Rua dos Funcionários, 1540 Juvevê, Curitiba, Paraná, Brazil

ARTICLE INFO

Keywords:
Social impact
Meat production chain
Cultivated meat
Plant-based meat
Stakeholder engagement
Transition policies

ABSTRACT

Cultivated and plant-based meats are emerging as innovative alternatives to improve the food production system. Although some environmental impacts and market acceptance assessments have already been developed, little emphasis has been given to potential social impacts. Based on the Brazilian case, one of the largest meat producers in the world, this study seeks to answer what the social impacts of a transition from conventional to cultivated and plant-based meats may be. Empirical data were collected from in-depth interviews with 35 experts involved in animal production and alternative products. Our results indicated nine opportunities and five challenges that the country may face. We discussed these findings in relation to the degree of involvement of relevant actors and suggested that high stakeholder engagement may contribute to capitalizing on social opportunities, and that low stakeholder engagement will likely not mitigate the challenges. We also highlight the need for policies that better drive a transition process, even if partially, in a fair and inclusive way. Our study advances the field of food systems in transition, being the first one to investigate the social impacts of alternative proteins on a developing country. Many of our findings seem to be generalizable to other countries involved in the production of food from animals.

1. Introduction

Food systems have been gaining more attention from policymakers due to their wide-ranging consequences in different dimensions (Béné et al., 2019; de Krom and Muilwijk, 2019; De Schutter et al., 2020; Moragues-Faus and Battersby, 2021), such as food security and environmental sustainability. Important guidance documents with a global reach emphasize these concerns. 'Zero hunger' and 'Sustainable consumption and production' are listed within the 17 sustainable development goals of the 2030 Agenda (United Nations, 2015); both are directly connected to food systems. The Intergovernmental Panel on Climate Change report also highlights the need for change in food production models, to alleviate the pressures on climate (IPCC, 2020).

Changes in the meat production systems and consumption seem to be the most frequently requested. Current meat consumption is around 325 million tons, with a tendency to grow in the coming years (OECD-FAO, 2020). Nevertheless, animal production brings several environmental, animals ethics, and human health challenges (Bozzo et al., 2021; van der Weele et al., 2019). Despite these negative consequences, conventional meat is considered a traditional nutrient source, additionally recognized as an important cultural element (Loughnan et al., 2010; Oleschuk et al., 2019). Its production chain generates jobs and income for around 1.3 billion people worldwide (FAO, 2022).

Considering this scenario of various negative consequences of the conventional meat production system coupled to the prospect of increased global meat consumption, some alternative proteins have drawn attention. Cultivated and plant-based meats have been receiving investments from companies and government incentives, as well as arousing academic interest. Cultivated meat, also called cultured meat, cell-based meat or clean meat, is developed by removing a small amount of stem cells from a live animal and cultivating them in a bioreactor (Broad, 2020; Post et al., 2020). In its new version, plant-based meat is made from vegetable ingredients, processed through technological methods, with flavor, texture and nutrition characteristics similar to

* Corresponding author.
E-mail addresses: rodrigo.morais.silva@ufpr.br (R. Luiz Morais-da-Silva), glufkereis@ufpr.br (G. Glufke Reis), info@huginenmunin.be (H. Sanctorum), carlamolento@ufpr.br (C. Forte Maiolino Molento).

https://doi.org/10.1016/j.foodpol.2022.102337
Received 13 October 2021; Received in revised form 27 July 2022; Accepted 2 August 2022
Available online 13 August 2022

conventional meat (Rubio et al., 2020).

While these alternative meats may be considered efficient means of mitigating sustainability and other related problems without the need to substantially reduce meat consumption (Bryant and Barnett, 2020), the social implications of a transition have been scarcely studied. A few scientific publications have brought to the debate some specifics about the social issues considering the likely partial transition scenario (e.g. Bryant and van der Weele, 2021; Newton and Blaustein-Rejto, 2021; Verbeke et al., 2015; Wilks and Phillips, 2017). However, it is not clear what may happen with farmers (Bryant and van der Weele, 2021) and there is a need for further studies in different countries to investigated the likely social impacts of a transition to a scenario in which alternative meats meet a significant part of the demand for proteins (Mancini and Antonioli, 2022; Newton and Blaustein-Rejto, 2021).

Therefore, considering the existing research gap, this study seeks to answer the following research question: what may be the social impacts of a transition from conventional to cultivated and plant-based meats? The term transition in this article refers to a potential change in global meat production and consumption chains, reducing the share of conventional meats while significantly increasing the proportion of alternative proteins. This trend is highlighted by some forecasting studies (e.g. Gerhardt et al., 2020; Tubb and Seba, 2021; Witte et al., 2021). We use the scenario suggested by Gerhardt et al. (2020), which shows that by 2040, 40 % of the total global meat market will be supplied for by conventional, 35 % by cultured and 25 % by plant-based meats.

To answer the main research question of this article, our study sought to understand the main social opportunities and challenges with the entry of alternative meats in Brazil. The country was chosen because it is one of the world's largest meat producers and exporters (FAO, 2021a) and because it is largely dependent on the agribusiness sector, which corresponded to around a quarter of the total Brazilian GDP in 2020 (CEPEA-CNA, 2021).

2. Conventional, cultivated and plant-based meats

Although meat has been considered an important food by people in their diets (Stanford and Bunn, 2001), several problems in the environmental, animal ethics and public health dimensions related to its production and consumption have gained prominence in recent decades. On the environmental side, about 14.5 % of the greenhouse gas emissions come from raising animals for food (FAO, 2019; Gerber et al., 2013). Meat production uses large amounts of water, whose consumption varies according to the system adopted, ranging from about 15,000 L to more than 30,000 L per kilo of beef (Palhares et al., 2021). The use of land and the advancement of pastures for cattle over conservation areas is another challenge, as in the Amazon Forest (de Pereira et al., 2020). Among other environmental concerns, animal production has been identified as one of the main drivers of climate change (IPCC, 2020), which may put "the reduction or elimination of livestock farming at the forefront of strategies for averting disastrous climate change" (Eisen and Brown, 2022, p. 1).

Animal ethics is another dilemma in the current meat production model. Official estimates show that in 2019 72.1 billion chickens, 1.3 billion pigs, 602.3 million sheep and 324.5 million cattle were slaughtered for meat production (FAO, 2021a). Furthermore, the meat production process often uses intensive facilities and artificial genetic selection to make the animals grow faster and at the lowest possible cost (Narayanan, 2016; Tarazona et al., 2020), which often causes them serious welfare problems. Regarding public health, meat consumption has been associated with several diseases related to obesity, heart disease and diabetes, among others (Papier et al., 2021). In addition, the use of antibiotics in conventional meat production systems is associated with the development of antibiotic-resistant microorganisms (Serwecińska, 2020), which are regarded as a major threat to medicine. There are also indications of an association of meat production and consumption with the introduction of infectious diseases (Espinosa et al., 2020), as probably occurred for the emergence of Covid-19 (Boni et al., 2020).

In this scenario, alternative proteins such as legumes, algae, insects, cultured meat and plant-based meat have emerged as options for human consumption (Onwezen et al., 2021), with the last two receiving more attention. Cultivated meat has been considered the second domestication, i.e. the domestication of cells, following the domestication of animals which occurred more than ten thousand years ago, and its reach has been described as a potential to radically transform the animal food production chain (Tubb and Seba, 2021). The cultivated meat production process involves removing a small amount of cells from a live animal, cultivating them in a bioreactor with supply of adequate nutrition, followed by processing and commercializing (Reis et al., 2020). Current plant-based products are increasingly similar to conventional meat in appearance, taste and texture (He et al., 2020), with no ingredient of animal origin. The plant-based meat production process involves three main stages: isolation and treatment of vegetable proteins in the pre-processing stage, formulation in which vegetable proteins are mixed with specific ingredients and nutrients, and processing using different technologies that promote a texture similar to conventional meat (Rubio et al., 2020).

The environmental gains of alternative meats are promising (Sinke and Odegard, 2021; Tuomisto and Teixeira De Mattos, 2011), especially when compared to the current ecological footprint of conventional meat. For example, a Life Cycle Assessment (LCA), which included the analysis of global warming gas emissions, land use, water consumption and others, revealed that cultivated meat has 93 % less environmental impact than conventional beef, 53 % less than conventional pork and 29 % less than conventional chicken production chains, when using renewable energy (Sinke and Odegard, 2021). The LCA that compared plant-based and conventional meats has also shown a clear advantage of the first over the second (Detzel et al., 2021). For animals, the gains also seem huge (Heidemann et al., 2020), as the number of individual animals involved in the food production system may be reduced, wild animals may benefit from decreased habitat loss and human-animal interactions in general may be reconfigured. This reconfiguration is likely far-reaching, allowing for the rethinking of a variety of issues that remain underdiscussed in the current human-animal relationship paradigm. One example is the acceptance of a variety of practices that cause animal suffering, such as the intensification of animal production systems requiring strict animal confinement and the selection of extreme production-driven genetic traits; a second example relates to the difficulties in applying animal protection laws in the context of farm animals (Soriano et al., 2021).

From an economic point of view, market gains have also been highlighted. Some studies have shown a high acceptability degree regarding cultivated and plant-based meats by consumers (Bryant and Sanctorum, 2021; GFI, 2020; de Valente et al., 2019; Gómez-Luciano et al., 2019). Predictive analysis shows an impressive space for alternative meats, of 60 % of the total meat in 2040 (Gerhardt et al., 2020) and even the collapse of conventional meat production in the United States in 2035 (Tubb and Seba, 2021). On the other hand, a recent study reports a lack of consensus on high plant-based meat purchase intention showing that a reduction in the price of plant-based products is unlikely to significantly impact the production of beef in the United States, unless substantial changes in factors such as taste occur (Lusk et al., 2022). While some predictions may be considered audacious, the impact of alternative meats will likely be significant.

3. The social impacts of cultivated and plant-based meats

Social impact may be understood as a significant improvement or deterioration in people's well-being (Dietz, 1987) and may be sensed by a person, a family unit, a social group, a social organization, or an entire society that may feel the direct or indirect impacts of a change (Tello, 2020; Vanclay et al., 2015). The social impact may be represented in a

continuum from positive to negative, also passing through a neutral position. Positive social impact may include better subsistence conditions for a population. In contrast, the negative social impact may be increased insecurity and loss of income. There is also a neutral position, in which there is no noticeable impact on those possibly affected (Barrow, 2010). Despite the importance of social impact assessment, it is generally considered a secondary aspect to economic and environmental dimensions in studies (Messmann et al., 2020). This may be so because social impact is difficult to assess, its cause and effect relationships are not direct and "it is impossible to detail all dimensions of social impact" (Vanclay, 2002, p. 185). Investigating social impacts is relevant, especially if they are predictive of changes (Hervieux and Voltan, 2019; Vanclay et al., 2015) as they may contribute to better outcomes in social change processes.

In the case of alternative proteins, the social impacts of a transition remain poorly evaluated (Bryant and van der Weele, 2021), since few studies were exclusively dedicated to this topic. Some investigations have shown that meat consumers have expressed concerns regarding potential adverse effects for conventional meat producers (Verbeke et al., 2015; Wilks and Phillips, 2017). In addition, van der Weele and Driessen (2013) considered that people may be afraid of innovations in food production related to highly technological scenarios. More recently, the same authors have discussed how normal meat becomes stranger as cultured meat becomes more normal, indicating the need to deal with ambivalence and ambiguity (van der Weele and Driessen, 2019).

However, only one research paper has explicitly focused on the socioeconomic impacts of alternative meats, when Newton and Blaustein-Rejto (2021) studied potential consequences for United States farmers and rural communities. Newton and Blaustein-Rejto (2021) suggested that further studies would be useful, to study agents other than farmers and rural communities and the need to investigate different contexts, as the impacts may vary considerably depending on location. In addition, the impacts of a transition to alternative proteins may have significant impacts on low- and middle-income countries that export their animal products to other countries (Mancini and Antonioli, 2022), such as Brazil and other emerging nations.

4. Methodology

4.1. Research approach and data collection

Considering the exploratory aspect of the proposal, our research applied a qualitative research methodology. This approach is useful to study 'how' or 'why' about complex issues and little-known phenomena that require interpretations from the actors' point of view (Yin, 2009). For data collection, we used in-depth interviews with experts. Expert viewpoint is recommended when the study explores primary insights into a new field with little or no information (Bogner and Menz, 2009; Haleem et al., 2019). Research-based on expert perception may also help predict potential future changes, as well as their expected consequences (Haleem et al., 2019; Lopez et al., 2020). In our study, we seek to investigate experts' points of view regarding what social impacts are expected in Brazil with the insertion of alternative meats. Our criteria for selecting the experts to participate in the research were their high level of knowledge about either conventional or alternative meats, or both, and their ability to think strategically about the likely impacts those expected changes may bring to the country.

Considering these inclusion criteria, our operational procedures for selecting specialists were performed by the following route. The first step was to invite some participants on a meeting concerning the future of the agribusiness sector in Brazil, organized by the Ministry of Agriculture, Livestock and Supply of the Brazilian Federal Government. In this meeting, alternative proteins and their consequences for the country were debated, among other topics. About 50 experts from different areas related to agribusiness attended this event. We selected and sent invitations to those dedicated to the field of animal protein or its analogous products. We also asked them to suggest other names to be included in the list of potential interviewees. As an additional criterion, we have included further experts of national relevance in the conventional or alternative protein sector. After all invitations were sent, 35 experts agreed to be interviewed. Table 1 provides details on respondents and interviews.

Before conducting the interviews, we submitted the project to the Federal University of Paraná's ethics committee for research involving humans, which was approved under protocol number 38617320.0.0000.0102. We used a semi-structured interview guide, in which we asked our interviewees to comment on i) how they perceived the future of conventional and alternative meats in Brazil, ii) how the country was reacting to this transition, iii) what might be the main social opportunities, and iv) what might be the main social challenges. Although our interview guide included these subjects, we conducted the interviews with an open approach to get as much of the interviewees' points of view as possible. Such approach provided more information than predicted by the specific issues included in the interview guide. The average length of the interviews was 45 min, with the shortest interview lasting 22 min and the longest one 91 min. All interviews were recorded with the permission of the interviewees and transcribed by us.

4.2. Data analysis

The interviews were analyzed by the content analysis technique (Mayring, 2014). Our data analysis started with a free reading of all interview transcripts, seeking greater familiarity and a general view of the dada. After that, we inserted all transcript files into the Atlas ti software to facilitate the coding process. Pieces of information were codified from the transcription when they referred to social opportunities and challenges dimensions related to the entry of alternative meats in Brazil. Afterward, we revised the codification to improve the codes, merge those that address similar issues, or exclude unrepresentative codes with few mentions in the entire set of interviews.

5. Results and discussion

The study results are divided into two parts. The first involves nine elements of social opportunities and the second involves five social challenges expected by the interviewed specialists with the entry of the alternative meats in the Brazilian scenario. Fig. 1 shows these opportunities and challenges and their details from the qualitative data analysis framework proposed by Gioia et al.

5.1. Social opportunities

5.1.1. Opportunities for agricultural producers

The interviewed experts (88.6 % of them) considered that Brazil has large potential to become one of the world's leading suppliers of plant-based meat ingredients and vegetable substances for various uses in cultivated meat production. Recent data indicate Brazil is the leading exporter of soybeans and maize, and appears on the top positions for several other types of crops (FAO, 2021b). Whether due to the existing natural resources, such as the availability of land and water, the weather conditions, or the experience with agriculture in the country, the consulted experts considered that Brazil holds the necessary conditions to be one of the leading players in the production and marketing of vegetable ingredients. Similarly, the increased demand for crop producers was also pointed out by Newton and Blaustein-Rejto (2021) as a relevant advantage of the alternative meat chains in the United States. In addition, our data indicate the possibility of finding plant species that are not yet part of the list of ingredients in use for the existing plant-based products or for the expected diverse requirements for cultivated meat production. The experts believed that Brazil's rich biodiversity in its various biomes may shelter plants with high protein potential or other

Table 1
Interviews conducted with experts in Brazil, between March and April 2021.

Sector	Type of organization	Respondent number	Job title
Government	Ministry of Agriculture, Livestock and Supply - Federal Government	R1	Director
	Ministry of Agriculture, Livestock and Supply - Federal Government	R2	Plant-based specialist
	Secretariat for Economic Development - State Government	R3	Head of Startup Ecosystem
	Public financer of research projects - Federal Government	R4	Superintendent
Private sector	Ingredients industry	R5	Regional Manager
	Ingredients industry	R6	Coordinator of Sales
	Ingredients industry	R7	Head of Innovation
	Cattle farm	R8	Farmer
	Cultivated meat start-up	R9	Director and Founder
	Cultivated meat start-up	R10	Vice President of Product & Market Development
	Cultivated meat start-up	R11	Scientific Director
	Chemical and pharmaceutical industry for animal production	R12	Sales Executive
	Chemical and pharmaceutical industry for animal production	R13	Product manager for the health of farm animals
	Chemical industry in the food industry	R14	Regional Business Director
	Dairy industry	R15	Research and Development Director
	Meat Processor Company	R16	Director of Innovation and New Business
	Meat Processor Company	R17	Researcher
	Meat Processor Company	R18	Innovation and New Business Global Director
	Plant-based industry	R19	International Marketing Director
	Plant-based industry	R20	Research and Development Manager
	Plant-based start-up	R21	Research and Development Director
	Plant-based start-up	R22	Director and Founder
	Plant-based start-up	R23	Marketing Director
	Resale of alternative food products	R24	Owner
	Sustainable agribusiness consultant	R25	Director
Research	Public Research Institute in Economics	R26	Program Director
	Public Research Institute in Agriculture and Livestock	R27	Researcher
	Public Research Institute in Agriculture and Livestock	R28	Researcher
	Public Research Institute in Agriculture and Livestock	R29	Researcher
	Public University	R30	Professor and researcher in cultivated meat
	Public University	R31	Researcher and professor in protein innovation chain
Non-profit organizations	Association in the field of bio-innovation industries	R32	Director
	Association in the field of food innovation	R33	Managing Director and Founder
	NGO in sustainable food production	R34	Director of Public Policy
	NGO in sustainable livestock	R35	Sustainable Agribusiness Specialist

uses in the alternative meat industry. The following quote from one of our responses helps to exemplify this finding: *How many more protein plants do we have here in Brazil? A lot. So, you have to get it, link with co-operatives, help the small farms to understand that this is an aggregated product. We are going to export; the idea is to export* (R33).

Plant ingredients are intuitive in plant-based meat production; however, their use for cultivated meat production may be less evident. For the cultivated meat industry to become an alternative to conventional meat, it must rely on plant-based ingredients, with an explicit requirement to avoid animal-sourced components such as fetal bovine serum (Kolkmann et al., 2020), for example. Some experts (11.4 % of them) mentioned the potential use of plant ingredients as culture media and scaffolds in cultivated meat production. With these opportunities in both alternative chains, plant producers may see increases in demand for their products, improve their income and quality of life, and offer new job positions on their farms. One of the interviewees mentioned that *Brazil has to stop being the world's barn to be the world's supermarket. This means providing value-added food.* […] *So, I see an 'Eldorado'* [popular term for wealth] *for new Brazilian grains and new pulses, ok?* (R32).

Respondents added further details on how these opportunities may be used, considering the size of the farms and their main activities. Larger producers may meet the specific needs of this new market more quickly due to their financial and technological resources. However, this market opportunity may be extended to small farms through inclusive policies and cooperative initiatives. According to the Nacional Agricultural Census (IBGE, 2018), cooperatives comprise around 579.5 thousand farms in Brazil, representing around 11.4 % of all farms. In addition, about 70.5 % of the associated farms are smaller, with units ranging from 1 to 50 ha. Thus, animal producers that eventually lose their market share because of reductions in demand for conventional meats in the future may also attempt to offer plant ingredients.

Nevertheless, experts also predicted the need for some changes in Brazilian plant production chain to meet the requirements of the new industries. The first requirement mentioned is to include other plants in the list of commodities produced in Brazil. Peas and chickpeas, protein sources widely used in the plant-based meat industry, may be produced in the country in larger quantities as compared to current production. Official Brazilian data on agriculture show that 9.2 tons of peas were produced in 2020 (IBGE, 2022); while chickpea production was incipient, but with an upward trend as there has been increased interest in its production in recent years (Embrapa, 2019). Changes may also be necessary regarding the extensive use of pesticides in Brazilian agriculture (FAO, 2021c; Lopes and Nascimento, 2021), which may not be well accepted in the alternative meat market and may negatively impact consumer purchasing behavior. The improvements in the use of technology for processing plants into appropriate ingredients for industry use will likely also be necessary. Currently, most ingredients for the industry are imported, as referred by some of the members of Brazilian start-ups.

5.1.2. New job opportunities

Several employment opportunities that may occur in the production chain of cultivated and plant-based meats were also mentioned by 57.1 % of experts. In the initial stages, regarding ingredients, new jobs in rural areas are expected, mainly in the cultivation of specific plants to meet the demands of the alternative meat chains. In the processing stage, new jobs are expected to be created, within the specificities of each alternative chain. Experts involved in the plant-based meat production chain explained that this type of product is made in a typical food factory. Thus, job opportunities for people with lower and higher qualifications are expected, mainly in agronomy, biotechnology, food engineering and chemical engineering. Regarding cultivated meat, as

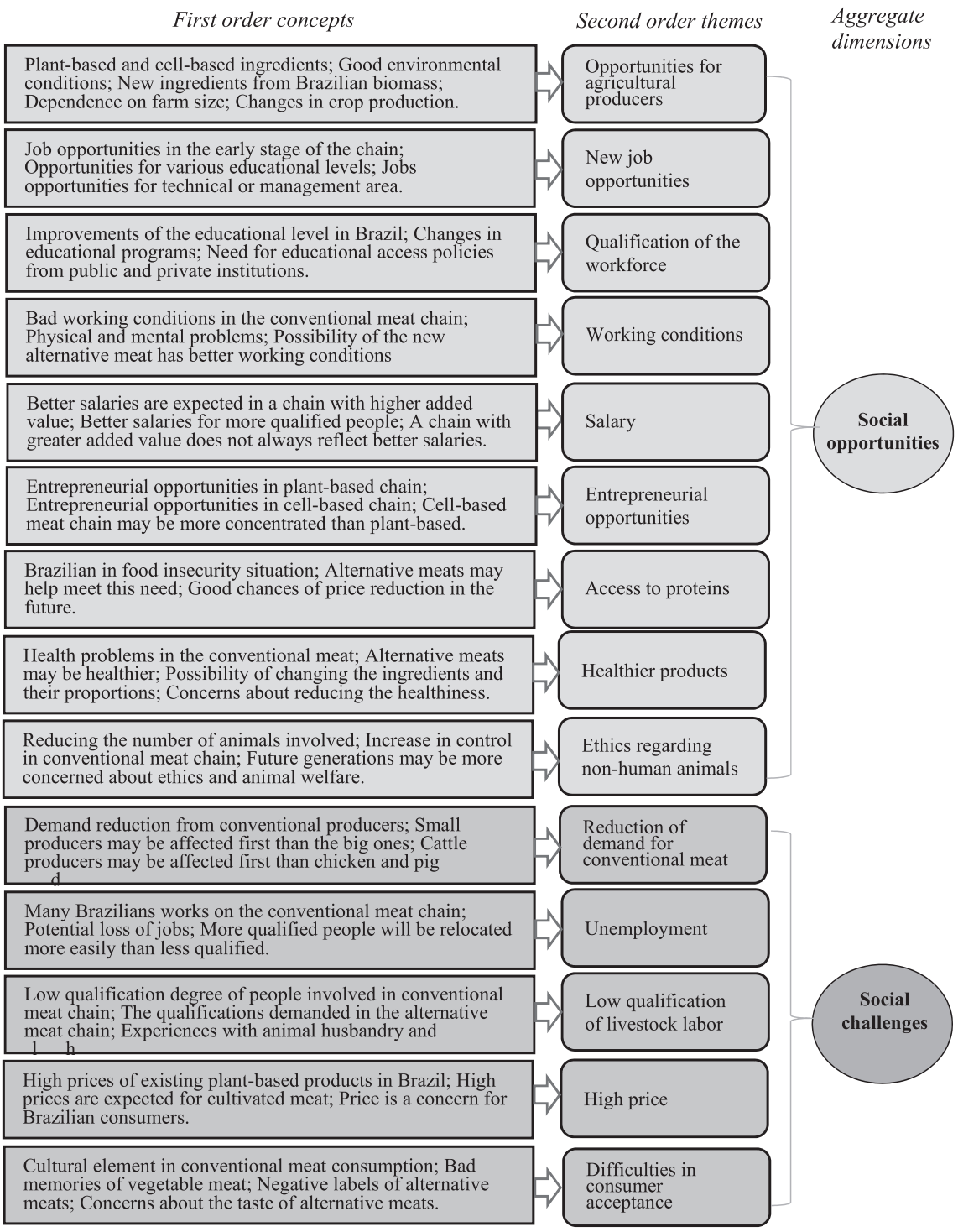

Fig. 1. Data analysis structure, based on Gioia et al. (2013), showing social opportunities in light gray and social challenges in dark gray.

the process is more innovative and the production developed within bioreactors, with less requirement for handling by people, job opportunities may lean towards more qualified people.

In the packaging, distribution and marketing stages of both chains, new job opportunities are expected at all levels of education. Job opportunities are also expected in the management area, such as managing research and development processes, marketing and advertising, and technical support areas, such as data specialist, automated process control, and other areas mainly related to the field of technology and information. Thus, the specialists believe that new jobs may be created throughout the entire production process of alternative meats, from ingredients to marketing. One of the interviewees argued *I think there will be jobs for every-one. I think it's only the format of the jobs that will be a little different, but it's a matter of adaptation and adjustment. We will create more jobs across the entire new chain* (R20).

5.1.3. Qualification of the workforce

Our findings suggest that the new production may help raise worker qualification, as mentioned by 51.4 % of the experts. According to OECD data, only 21.3 % of people aged up to 34 have a university degree,

compared to the average for OECD countries, of 44.9 % (OECD, 2021). Most respondents felt that the likely demand for more qualified workers for plant-based and cultivated meat chains may encourage people to seek improvements of their educational levels. However, requirement increases for qualified positions beyond university degrees are expected. According to the experts, technical courses are currently rare in Brazil, but this type of degree may be requested in the new production chains. The following quote from the interviews exemplify these findings: *Every technology and every innovation always bring with them an increase in the quality of labor* (R1). *So, I think there is still a lot of opportunities and I think it needs a lot of qualified professionals* (R20).

However, to increase the qualification of the workforce, the participation of educational institutions, both public and private, is requested. For this, policies to encourage the offering of specific programs at all levels will be necessary, to meet the needs for increasing the workforce in Brazil. Some of the respondents considered that the University programs currently available in Brazil, such as animal science, veterinary medicine and biotechnology, are sufficient to qualify professionals for the different roles necessary for the new industries, requiring only adjustments. Others commented on the need for more specific courses, such as tissue engineering and regenerative engineering.

5.1.4. Salary

The average salary in Brazil is different when comparing rural and urban workers. Official data (IBGE, 2021) indicate that the average monthly salary of a person working in rural areas is US$ 266, while the national average is US$ 461, using approximate values based on the Brazilian real to American dollar exchange rate in May 2021. The following quote illustrates this point: *People who work in the countryside live poorly, the salary is small for the worker, but it is high for the small employer, it is difficult to pay* (R26). In addition, some farms in the countryside are accused of employing people with a value lower than the legal minimum wage or in conditions analogous to slavery (Phillips and Sakamoto, 2012). These working conditions without payments or with values below the national minimum may also be known as indentured servitude or debt bondage, in which people work to liquidate a debt, but usually without a precise end date (Figueira and Esterci, 2017). This information helps understanding how low the salaries paid to rural workers are, especially those working in the early stages of the conventional meat chain.

Considering this scenario, a production chain with greater added value in the country, such as that of alternative proteins, has the potential to increase the average salary of its employees, as agreed by 42.9 % of the respondents. However, two interviewees emphasized that a chain that captures more economic value does not necessarily pay better wages to its employees. Thus, wage increases are expected to occur, but mainly for more qualified people.

5.1.5. Working conditions

To work for the conventional meat chain is considered high risk, especially in the animal raising and slaughter phases. Official data from 674 economic activities in Brazil show that the work in a cattle slaughterhouse ranks as the fourth-highest number of occupational accidents per thousand employees; the slaughter of pigs, chickens and other small animals occupies the twenty-fifth position in all functions (DataPrev, 2021). The main risks involve using sharp objects, working in low-temperature conditions, excessive noise, repetitive work, contact with potentially infectious substances and chemical products, amongst others (Marzoque et al., 2021). Besides, the activity of slaughtering an animal, in particular, has a series of psychological implications related to depression, anxiety and mental maladjustments (Hutz et al., 2013). One of the interviewees said that: *Industry is made of people. There is no one here who looks at the slaughter and claps hands. This does not exist. Nobody likes it"* (R18).

With the introduction of alternative meats, fewer people may be exposed to such poor working conditions. These people may work in other activities related to the meat processing stage, such as packaging and distribution, in both the plant-based and cultivated meat chains. The respondents (68.6 % of them) argued that working in alternative meat chains should provide better conditions for the employees. The following quote illustrate this finding: *Working in an alternative meat factory will be much better than working in a slaughterhouse* (R34). *We don't need people who slaughter cows. They'll do other things, but they won't kill cows for us anymore* (R10).

5.1.6. Entrepreneurial opportunities

The new alternative meat production chains may open several opportunities for entrepreneurs in Brazil, as mentioned by 71.4 % of the experts. In the case of plant-based products, the experts interviewed mentioned that these opportunities may arise mainly in relation to the ingredients that this industry requires, such as different plant protein sources, as well as plant ingredients to provide adequate aroma and flavor to the new products. As the plant-based market in Brazil is already a reality, the number of industries that produce plant products is extensive, including smaller companies, to serve different audiences. One of the interviewees pointed out that *there are so many plant-based brands on the market that I have never heard of them, and I know the market very well. […] So, I think the trend is to have smaller players, and this is a need, as the market is vast with many different consumers preferences* (E-20). Three of our experts also expected the plant-based market to be less centralized than the conventional protein market, especially when comparing the number of plant-based product brands with the few traditional meat product brands in the country.

In the case of cultivated meat products, experts' opinions varied in two directions. Some believed (57.1 % of them) that entrepreneurial opportunities already exist in the country and involve the need to supply medium ingredients for cell culturing, as well as molecules to provide flavor, aroma, vitamins, scaffolding, and various types of cell-based food products to the market. In this line of thinking, the Brazilian cultivated meat industry may follow the international scenario, with several ingredients suppliers or meat producers working as relatively independent start-ups. The other group of experts (28.6 % of them) believed that Brazil is not in an advanced stage in technological development and investments via start-ups; thus, this new industry may develop much more at the hands of the large conventional meat processing industries. For this group of experts, the technological sophistication and the high costs involved in cultivated meat production process may keep the market concentrated on few large established companies, with room for start-ups mostly in supplying ingredients, as one of the experts said: *The protein-processing actor will have a much greater relevance in this chain because it already has an established processing structure, […] which makes them have a huge advantage over start-ups that will launch in this sector. What will remain for the start-ups are the ingredients* (R34).

The Newton and Blaustein-Rejto (2021) study considered the possibility of having bioreactors on farms, for decentralized and smaller-scale production. Van der Weele and Drissen (2013) also report the possibility of bioreactors on farms and even at homes, which was proposed under the title "the pig in the backyard". Specialists in Brazil were more reluctant to consider this possibility because they believe that the technology is too complex for such a scenario and that it is still too costly for production outside the industrial context.

5.1.7. Access to proteins

Access to food is a significant challenge in Brazil, as well as in other low- and middle-income countries. Recent FAO (2020) data show that undernourishment affects almost 50 million people in Latin America and the Caribbean and that this number is likely to reach 66.9 million by 2030. Poverty, one of the leading causes of undernourishment, reaches almost 50 million people (24.7 % of the population), who live on less than 5.5 dollars a day in Brazil (IBGE, 2020). On the other hand, the price of meat has increased strongly in recent years. Data show that the price per kilogram of chicken and beef more than doubled, comparing

2015 with 2021 (CEPEA, 2021a). Considering this scenario, all the interviewed experts believed that alternative proteins may help solve the challenge of accessing proteins in Brazil. The main idea behind these responses was that the higher the availability of proteins, the better for people. One of the respondents concluded: *It doesn't matter whether the protein is embedded in chickpeas, beans, lentils, peas, or in a picanha steak, a chicken breast fillet, or a fish steak. Whoever is hungry is in a hurry! We need more protein for people* (R1).

Despite the greater supply of proteins, alternative proteins retail at a price that is still high by Brazilian standards. Considering the current plant-based meats available in the Brazilian market, conventional meats remain cheaper, especially secondary products such as sausages, chicken nuggets and hamburgers. However, there is an expectation for a reduction in prices as the inputs and production time of the plant-based chain are shorter than that of conventional meat products. One of the experts stated that *By definition, less resources are used to produce plant-based meat than to produce conventional animal protein. So, at some point it will have to become a cheaper protein […]. So, I think so, it will become cheaper* (E-15). Some experts highlighted that investment in research on new national ingredients for plant-based products, as well as the improvement of technological production processes, may help reduce the prices for consumers.

Regarding cultivated meat, most respondents (85.7 % of them) believed that the price to consumers tends to decrease in the future. This price reduction may help cultivated meet to participate in a considerable share of the Brazilian market. The announcement by the BRF-Aleph Farms partnership that cultivated meat will be available in 2024 at a price similar to conventional meat may suggest that parity will be achieved in the coming years (Reuters, 2021). Price parity may also consider the historical increase in conventional meat prices. One interviewee believed that this parity may be achieved soon: *I believe that yes, it will have a compatible cost. […]. We need to consider that conventional meat price is going significantly up in Brazil. So, I believe we will soon have a compatible price* (R11).

Thus, access to alternative proteins remains a challenge, especially for people with lower purchasing power. Experts (57.1 % of them) believed that there will be reduced prices for plant-based meat, as new local ingredients are researched and production processes are improved, and for cultivated meat, as technological advances are achieved. Thus, alternative meats may represent a potential advancement for access to proteins, as prices become lower.

5.1.8. Healthier products

Excessive consumption of conventional meat, especially beef, is linked to obesity, heart disease and diabetes, among other illnesses (Papier et al., 2021). Most experts used arguments related to the negative aspects of conventional meat to justify the consideration of plant-based meats as healthier. However, others pointed out that this justification is not valid for all plant-based products. Concerns about the potential use of low-quality ingredients to ensure lower prices and the ultra-processed label that consumers may perceive are likely problematic. Nonetheless, food processing is considered essential for food to be good for consumption, safe and to offer nutrients for consumers (Sadler et al., 2021). On this topic, one of the experts interviewed, member of a public food regulatory body, stated that labeling plant-based meat as ultra-processed and linking it to something harmful to health is miscommunication and related to the low consumer knowledge about what makes a food good or bad.

Regarding cultivated meat, most experts (54.3 % of them) believed that healthiness may be better as the ingredients and processes can be tailored for human health, as opposed to the more rigid aspects of conventional meat. The removal of excess saturated fat or the inclusion of vitamins, for example, are important differentials for cultivated meat compared to conventional meat. One expert argued that: *Cultivated meat is openly engineered and you may include more or less sodium, vitamin D, calcium, whatever you want for people's health.* (R34). However, as with plant-based meat, the safety of cultured products needs to be verified and, at some level, guaranteed by regulations.

Our experts generally believed that alternative products may be healthier than conventional ones, which tends to be both a positive market competitiveness factor and a relevant social gain. Healthiness is considered a fundamental element for the choice of Brazilian consumers. The study by Goméz-Luciano et al. (2019) compared the preferences of alternative meat consumers in the United Kingdom, Spain, Brazil and the Dominican Republic. Brazil was the country in which more people (86.8 % of respondents) considered increasing their probability of buying cultivated meat if health, safety and nutritional content were guaranteed. Consuming healthy foods improves people's quality of life since unhealthy diets are one of the main global health risks (World Health Organization, 2020).

5.1.9. Ethics regarding non-human animals

Brazil is one of the world's leading producers and exporters of conventional meat (FAO, 2021a). Official data show that 6 billion chickens, 49.4 million pigs and 29.9 million cattle were slaughtered in Brazil in 2020 (IBGE, 2021). In addition to the death of these animals, which is an issue from an ethical point of view, the meat production chain in intensive systems is marked by severe animal welfare problems. Animal production practices, which are especially aimed at productivity gains and cost reduction, generally negatively interfere with the well-being of non-human animals (Lymbery and Oakeshott, 2014; Narayanan, 2016; Tarazona et al., 2020). In the case of a considerable growth in the production of alternative meats, to the point of impacting the production of conventional meats, the number of animals may be considerably reduced, as mentioned by 65.7 % of the experts. In addition, three experts indicated that animals may benefit indirectly as new alternative products become available. These alternative industry advertisements, combined with an expected greater ethical awareness of society, stronger performance of animal protection organizations and stricter legislation, may benefit animals within food production systems. The following quote illustrates this indirect impact that alternative meats may have on farm animals: *When these new meats actually hit the market, you're going to have a lot of marketing on top of it. They will touch this wound, this other dark side, which is the animals. They will attack […]. And that will be good for the animals* (R27).

Even though this reduction may not occur in the coming years, according to experts, the long-term impact tends to benefit animals by decreasing the number of individuals sent to be slaughtered. The Newton and Blaustein-Rejto (2021) study showed that alternative meats may help improve the position of animals in the future, even that of animals raised for food production through slaughter. The new positioning tends to require less suffering for the animals, which will likely be maintained on pastures and with organic food. The study by Heidemann et al. (2020) indicated that uncoupling meat consumption from animal slaughter may bring even more exceptional gains to animals, as slaughter sets the debate about what is acceptable to do to animals at an extremely low bar. Thus, the results of alternative meats regarding animal ethics may go well beyond the protection of farmed animals, as there may be a reconfiguration of the whole debate on the consideration of animals as subjects with fundamental rights.

5.2. Social challenges

5.2.1. Reduction of the demand for conventional meat producers

Demand reduction for conventional meat producers was the social challenge pointed out by all the interviewed experts. Even if this reduction does not occur in the short term, it is expected that alternative meats will become more competitive in price and consumer acceptance will increase in the coming decades. Most experts consulted argued that smaller producers will suffer first and more intensely if there is a reduction in demand for conventional meats. The main reasons for small conventional producers to be affected first, according to the experts,

include characteristics of this group such as low scale gains, low productivity, less use of technology, high production costs, in addition to insufficient availability of financial credit and increasing regulatory requirements. Such characteristics can negatively influence the performance of small producers in a scenario of a more restricted market for conventional products. The following quote illustrate the relevance of scale gains in meat production: *So, the question of scale is of enormous importance. Looking at the data from the agricultural census […], the larger the farm, the greater its capacity to sell its products at a higher price and its costs are lower per unit produced, ok* (R26).

However, Newton and Blaustein-Rejto (2021) study brought a different prediction for small producers in the United States. For them, small producers are expected to be little impacted, as most do not have animal products as their primary source of income; on the other hand, large producers would be more affected by a significant drop in demand for conventional meat. Thus, the findings from the United States differ from those reported here for Brazil, which indicates that smaller farms may suffer more and first than other farm sizes. The perception of likely greater disadvantages for the smaller farms in Brazil may relate to a lower diversification of activities and the low qualification and technical knowledge of the people involved (CEPEA-CNA, 2021). Nonetheless, a potential exclusion of smallscale producers may not be a direct and exclusive consequence of the entry of alternative meats. Some of our interviewees (45.7 % of them) argued that such an exclusion process has been active for many decades in rural areas in Brazil, and this is not related to alternative meats. Some discussed underlying drivers of this process relate to the emphasis on large-scale monocultures in Brazilian agricultural production systems (Lapola et al., 2014). The last agricultural census showed an increase in the areas of large farms (more than 1000 ha) and a decrease in the total area occupied by small farms (less than 10 ha) (IBGE, 2017). Besides, high production costs, low scale gains and low adherence to new technologies help explain the challenges historically faced by Brazilian small-scale farmers.

Some experts (40 % of them) also mentioned that the beef production chain may be the first to suffer from the entry of alternative products. The reasons for this are varied and include the high prices of beef for consumers, its environmental footprint, the high costs to farmers, the time required from birth to slaughter and the low carcass yield. On the other hand, chicken and pig production chains are less expensive for the producer, their products are cheaper for consumers, the animals require less space on farms, which tend to be operated in an integrated manner with the processing companies. Chicken and pig production units also tend to use more advanced technology, require less time from birth to slaughter and have higher carcass yields.

In this scenario, all types of Brazilian animal farms, especially the smaller and dedicated to cattle raising, may be affected in the case of a significant global transition to alternative proteins, which is one of the biggest socioeconomic problems mentioned by our interviewees. The reduction in demand from conventional farmers has been identified as a significant social challenge in a transition to alternative proteins (Treich, 2021; Verbeke et al., 2015) and has raised fears of a dark and ultra-technological future (van der Weele & Driessen, 2013). A survey in the United States showed that the loss of market for products from conventional farmers was one of the unintended social consequences of a transition to alternative proteins (Wilks & Phillips, 2017), showing that this challenge is not seen as relevant only by producers. To overcome this challenge, public policies are regarded as essential to support conventional farmers in adapting to a transition in the global protein chain (Bryant and van der Weele, 2021; Mancini and Antonioli, 2022; Newton and Blaustein-Rejto, 2021).

5.2.2. Unemployment

Along with the drop in demand from conventional meat producers, unemployment could be a significant challenge according to the interviewed experts. The number of workers involved in Brazilian animal production systems reached 3.52 million people in 2020, with 117,665 involved in animal feed production and veterinary services, 2,879,130 in animal husbandry activities and 521,537 in the slaughter of animals (CEPEA, 2021b). Even though the replacement of conventional meat by the alternative may be partial, progressive and less intense in the near future, a concern with job losses was constantly reminded by all specialists.

More qualified workers, such as veterinarians, may be relocated to other positions and areas, including the cultivated meat chain, but the specialists' most significant concern was for the less qualified workers. Although some of them may be absorbed in other agricultural activities, such as crops, unemployment may be a problem. However, some interviewed (34.3 % of them) argued that the reallocation of employment opportunities is typical with the entry of new technologies. This has already occurred and is occurring in other industries. The following quote illustrate this explanation: *The same is happening in other industries, such as street shops vs e-commerce. People will have to rethink themselves and governments should help* (R9). *I think there is no use in fighting technology… it's counterproductive to do that. We have to think about accommodating these people in other activities, as it's already happening in several sectors, not just meat.* (R30). Thus, although unemployment is a challenge with the entry of alternative meats, this is not an isolated process of loss or reorganization of working positions.

5.2.3. Low qualification of livestock labor

The low qualification of the Brazilian workforce is another relevant social problem. Data show that only 11 % of the people who work in the slaughter and processing stage, 9 % of those who work in raising chickens, 4 % of those who work in raising cattle and 3 % of those who work in raising pigs have a university degree (CEPEA-CNA, 2021). The percentage of people who failed to complete the first cycle of formal education in Brazil (nine years of schooling) was 60 % for raising cattle and pigs and 44 % for the chicken chain. The number of people without any formal education to raise cattle is 7 %, 11 % for poultry and 3 % for pig production (CEPEA-CNA, 2021).

These data reveal a great challenge for the modernization of the meat production chain or for these people to be relocated to new jobs. Most experts (71.4 % of them) stated that the low qualification of the labor on animal production chain may be a significant social problem in the event of a profound change in the meat production chain in Brazil. Although part of these people may be relocated to work on other agricultural activities, such as crops as ingredients for the new alternative meat chains, most labor opportunities will be for workers with the highest qualifications. The following quote illustrate the problem with poorly qualified labor or with experience restricted to the conventional meat chain: *So, I think there will be a lot of opportunities, but we need qualified workers for the more strategic area and research, and even to work in the more technological factories* (R21). *We need nobody who has experience slaughtering cows. We don't need people who slaughter cows* (R10).

5.2.4. High price

The price of alternative meats was a frequent theme in the discourse of the interviewed experts (94.3 % of them). Most of them are wary of the promise of short-term price cuts. Plant-based products analogous to conventional meat available in Brazil are concerning as their costs are generally higher than the average for products of animal origin. Even in the medium term, most specialists do not believe that there will be a reduction in the prices of these products. However, some experts pointed out that the larger-scale production of plant-based meat, technological advances and domestically-sourced ingredients may make the products cheaper. *So, we hardly use Brazilian proteins, so 90 % of the ingredients are imported. And if they are not imported, they use imported raw materials. And this makes the product too expensive […] We need to develop our own national ingredients* (R21).

For cultivated meats, the challenge is more significant. Some of our respondents believed that the expected price reduction for cultivated meat is overestimated. For them, the price of cultivated meat,

considering the technology used and the underdeveloped ingredients, will be high and should not focus on all consumer groups. *I do not believe that cultivated meat will be cheaper than regular meat. Perhaps in the long term, it may change but not now* (R9). Although some people with the availability of resources and concerns on sustainability and animal ethics may consume cultivated meat even with a price disadvantage, most of the Brazilian population will likely follow the price. Literature has also been showing that price may be a significant barrier to the consumption of alternative meats in Brazil (GFI, 2020), as well as in many other countries around the world (Bryant and Barnett, 2020; Grasso et al., 2019; Onwezen et al., 2021; Verbeke et al., 2015; Wilks and Phillips, 2017).

5.2.5. Difficulties in consumer acceptance

In addition to the price, all the experts cited other barriers to the acceptance of the Brazilian consumer to alternative proteins. The first is the cultural element, in which the "barbecue country" may take longer to adopt alternative meats. *If you're going to celebrate your wedding anniversary, you're going to buy a mature steak from a young calf […]. So, realize that this is in the collective consciousness of Brazilians, it is ours* (R1). Thus, the cultural aspect may be an initial barrier for the acceptance of alternative meats in the country. The study by Michel et al. (2021) revealed a greater self-declared intention of consumers when imagining eating alternative meats alone than eating in a group, which may bring judgments considering the cultural roots of conventional meat consumption.

For the specific case of plant-based meats, many experts pointed out that the older Brazilian consumer has memories of "soy meat" sold in the past. It was a little processed product with an intense soy flavor that hardly resembled the new plant-based products or the conventional meats. The ultra-processed label, which groups different types of processed foods receiving a negative image due to potentially related health problems, was also a potential barrier to plant-based meat. Experts mentioned the taste and texture of current products as possible barriers for consumers used to conventional meat. Other studies have also revealed that flavor and texture that are very different from traditional meats may still be a barrier to alternative products (Tucker, 2014; Verbeke et al., 2015). Some experts also mentioned that the switch from conventional beef to plant-based products is little expected for traditional consumers because other cheaper meat products are of animal origin. *The individual switches from red meat to chicken, but then for them to switch to soy meat. The soy meat must be much cheaper than chicken, because Brazilian consumers still prefer chicken* (R4).

For cultivated meat, in addition to price concerns, labels such as "unnatural", "laboratory", "fake meat" and potentially disease-causing were barriers frequently raised by respondents concerning Brazilian consumers. *I imagine that this population today will hardly change from an animal protein in natura, let's say, to something artificial* (R8). *Plant-based products can be seen in the ultra-processed group* (R2). Other studies that debate consumer acceptance have also discussed the classification between natural and artificial and the fear of new food products (Bekker et al., 2017; Laestadius, 2015; Siegrist and Hartmann, 2020). The concern of Brazilian consumers with health was also revealed in the research by Goméz-Luciano et al. (2019) in which consumers in Brazil were the ones who most agreed to accept alternative products if they were healthier than conventional meat. Nevertheless, even after a list of potential barriers, auto declared intention to consume alternative meat in Brazil is high, of 63.6% (de Valente et al., 2019) or 65,6% (Bryant and Krelling, 2020) for cultivated meat, and 72,1% for plant-based meat (Bryant and Krelling, 2020). These numbers express the significance the alternative proteins may reach in Brazil, considering consumer acceptance.

5.3. Implications and contributions

5.3.1. Implications according to the level of stakeholder engagement

Considering the nine opportunities and five social challenges expected with the entry of alternative meats in Brazil, some implications may be conceived. Most challenges are set to occur as alternative meats assume an increasing share of the total global meat market. Leaders of conventional meat, such as Brazil, tend to be affected by the drop in demand for traditional animal products and an eventual decrease in exports. Domestic consumption may also decrease as Brazilian's gain access to alternative products, even if from imports. If the forecasts are considered (Gerhardt et al., 2020; Tubb and Seba, 2021), a drop in the conventional meat market is predicted for the coming decades, which contrasts with the current steady growth of the traditional industry. Should this prediction be right, challenges seem likely to occur independently from national level decisions, as the scenario depicts an imminent change in the global consumption pattern, which tends to be significant.

In the case of opportunities, most of them seem to be related to the engagement with the global production chain of alternative meats. This engagement seems necessary, for example, to offer ingredients of plant origin, produced on Brazilian farms and processed by the national industry. To better discuss this situation, the concept of stakeholder engagement was adopted. In a broad view, stakeholders may be understood as people, individuals or groups, and even organizations affected by or that may affect a referred issue (Schmidt et al., 2020). Stakeholder engagement, as per the business literature, is understood as "practices the organization undertakes to involve stakeholders in a positive manner in organizational activities" (Greenwood, 2007, p. 315). Adapting those concepts to our study, by stakeholder engagement we mean the commitment of various actors, such as governments, the conventional animal industry, alternative meat startups, regulatory bodies, consumers, civil society organizations, etc., in supporting the advancement of the alternative protein agenda.

Therefore, we argue that most of the social opportunities that the alternative meat chain may bring to Brazil depend on a higher level of stakeholder engagement with the new chains. On the other hand, challenges seem to remain even in the case of a low level of engagement, as the technology tends to advance in the international context, threatening the market of conventional protein-producing countries. Based on that, Fig. 2 presents a two-scenario analysis, considering the experts' opinions regarding opportunities and challenges due to the entry of alternative meats in Brazil and the perspective of engagement level.

As shown in Fig. 2, our study suggests that outcomes may vary considerably depending on the level of stakeholder engagement. The more the country engages with alternative meats, the higher the chances of taking advantage of the opportunities that may arise in this new sector. The less a country engages, the greater the difficulties for taking advantage of these opportunities. The challenges, however, vary less. This variation in outcomes occurs because the social impacts of new technologies are different from environmental impacts, for example, which are assessed causally. Thus, social impacts can vary strongly as behaviors and attitudes change (Dreyer et al., 2010). These findings highlight the importance of joint action amongst the multi-stakeholders involved to make the country's transition from a complete reliance on conventional meat to include alternative proteins as fast and as efficient as possible. The higher the success, the better for all social issues involved.

5.3.2. Implications for policy

For the advancement of alternative meats to generate opportunities for a country, the engagement of stakeholders seems crucial; however, it may be hindered by the absence of adequate food policies. Directing the market transition may be key to better appropriate the opportunities that may arise and mitigate the challenges. Policymakers may take

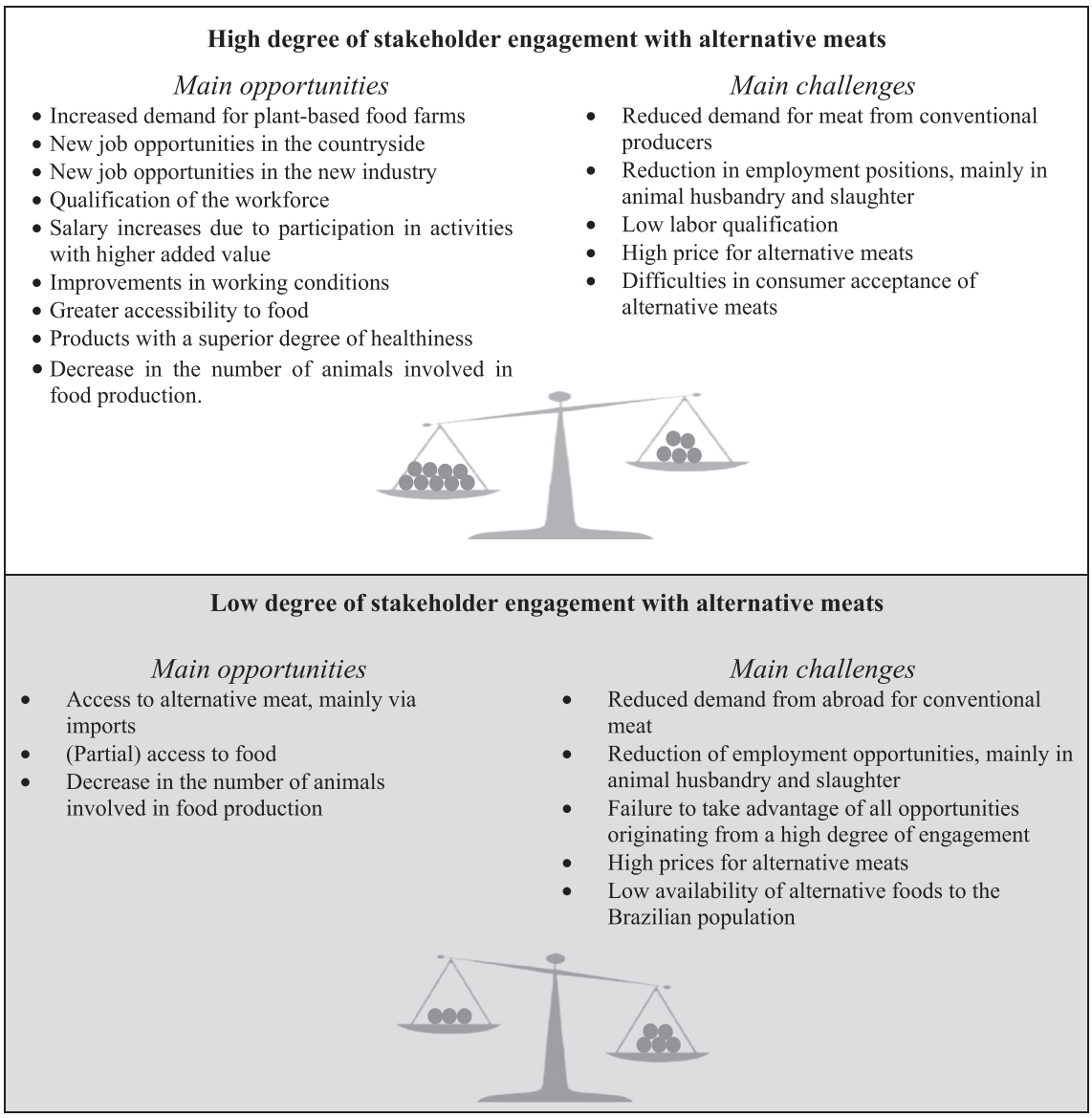

Fig. 2. Expected outcomes according to scenarios of high and low levels of stakeholder engagement with alternative meats in Brazil, as per relevant literature and the opinion of 35 experts interviewed between March and April 2021.

advantage of the results presented in this study to better plan food policies, which may guide strategies to the progress of the field prioritizing social benefits for all. Other studies (e.g. Bryant and van der Weele, 2021; Mancini and Antonioli, 2022; Newton and Blaustein-Rejt, 2021) have also emphasized the need for public policies to help guide a transition process towards a significant participation of alternative proteins, mainly to maximize benefits and mitigate challenges.

Based on the results of our research, we envision recommendations for new food policies that consider alternative meats. The first recommendation is to build national and regional plans to better take advantage of the country's regional potential. Thus, the opportunities may be better managed considering the existing vocations in each geographic region. The second recommendation is to develop a national workforce to meet the demands for positions in the new chain and offer jobs to people. Incrementing the content of educational programs and creating new ones in the area may contribute to this goal. The third recommendation is related to the need to create regulations that guarantee the healthiness of alternative products, ensuring safe and nutritious food to the population. The fourth recommendation refers to the need to develop options to include people who work in the conventional meat chains, such as employees and farmers, so that they may transit to the new chain. Employing specific public policies to facilitate a transition may be important to help incorporate the social opportunities that are about to arise, as well as to reduce the negative impact of the challenges. Further policy recommendations related to the socioeconomic aspects and other areas are presented by organization as The Good Food Institute (GFI, 2022) and the European Commission (2020).

5.3.3. *Contribution to previous literature*

The literature on alternative proteins has focused mainly on technological advances (Kolkmann et al., 2020; O'Neill et al., 2021; Post et al., 2020) and consumer acceptance (Bryant and Sanctorum, 2021; GFI, 2020; de Valente et al., 2019). However, social impacts have received little attention. Only small mentions of socioeconomic factors were found, as consumers' concerns about farmers in the case of the entry of alternative meats (Verbeke et al., 2015; Wilks and Phillips, 2017) or fears about the highly technological future (van der Weele and Driessen, 2013). Only one study focused on social and economic issues (Newton and Blaustein-Rejto, 2021); their results reveal opportunities and threats for crop producers, animal farms and rural communities in

the United States. Thus, the original contribution of our work stems from a wider perspective which allowed for some different discoveries, as in the case of jobs, the qualification of the workforce, the improvement of working conditions and wages, in addition to the difficulties in acceptance and the high prices of alternative foods so far.

In addition, our study advances the discussion by proposing that, in order to take advantage of the opportunities that may arise, a higher degree of stakeholder engagement is necessary, while threats tend to vary less. Specific policies to guide a transition are also presented. Thus, our research contributes to potential solutions for the unclear future scenario in animal-producing countries that has been indicated by the main reports on the topic (Gerhardt et al., 2020; Tubb and Seba, 2021), with an emphasis on social issues.

6. Conclusion

The necessary changes in food systems to improve environmental sustainability, food security, animal welfare and public health may have positive and negative social consequences. Our study showed that nine opportunities and five challenges are expected with the introduction of alternative meats in Brazil. We also analyze these results from a variation in the level of stakeholder engagement and suggested policies for an active Brazilian participation within the new meat chains, which in turn seems the best approach for the country to collect net social benefits. Although data collection was carried out in Brazil, our results may be relevant for other countries with a similar profile, identified as large producers of conventional meats and highly dependent on agribusiness. Thus, one contribution of this article is to present in detail social opportunities and challenges arising from the development of alternative proteins. We hope that this initial contribution may serve as a starting point for more specific analyses in other countries.

Our study also showed differences between cultured and plant-based meats in terms of opportunities and challenges. Overall, it seems that both may have a significant impact for the Brazilian context, as they tend to change the meat global supply chain. The opportunities of the plant-based chain seem to be more easily accessible to the country, as the degree of technological sophistication required is lower. For example, several national brands of plant-based products are available in Brazil, and some are exporting food to other countries. On the other hand, cultivated meat may have a more significant impact on the country as the technical requirement is more advanced, requiring more qualified people and a more developed innovation ecosystem to produce ingredients and equipment.

As suggestions for further research, we propose studies in other countries to understand which findings may be generalized and which are likely more country-specific. Future studies with a quantitative approach may also be developed to better identify which opportunities and challenges are indicated as most likely to occur. We also suggest studies regarding jobs and possibilities for small farms, as they are likely to be more affected by the advancement of alternative proteins and the decrease of conventional animal proteins. From the point of view of animals, although our results indicate a better position for them, much remains to be studied, for instance, how they would still be part of the human food chain through cultivated meat production. Even though this is an important question, the magnitude of the gain for animals is blatant. There are opportunities for many other pieces of research dedicated to studying the diverse impacts that a likely change in the food production chain may bring to countries.

Funding

This work was supported by the Global Action in the Interest of Animals (GAIA Belgium).

CRediT authorship contribution statement

Rodrigo Luiz Morais-da-Silva: Conceptualization, Methodology, Writing – original draft. **Germano Glufke Reis:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration. **Hermes Sanctorum:** Conceptualization, Writing – review & editing, Project administration. **Carla Forte Maiolino Molento:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration.

Declaration of Competing Interest

This research was funded by GAIA - Global Action in the Interest of Animals (Belgium) and the author H.S. 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 and interpretation of data, or in the writing and revision of the manuscript. The other authors declare no competing interests.

References

Barrow, C.J., 2010. How is environmental conflict addressed by SIA? Environ. Impact Assess. Rev. 30, 293–301.
Bekker, G.A., Fischer, A.R.H., Tobi, H., van Trijp, H.C.M., 2017. Explicit and implicit attitude toward an emerging food technology: the case of cultured meat. Appetite 108, 245–254.
Béné, C., Lamotte, L., Prager, S.D., Khoury, C.K., Oosterveer, P., Brouwer, I.D., Talsma, E. F., de Haan, S., 2019. When food systems meet sustainability – current narratives and implications for actions. World Dev. 116–130.
Bogner, A., Menz, W., 2009. The Theory-Generating Expert Interview: Epistemological Interest, Forms of Knowledge, Interaction, in: A., B., B., L., W., M. (Eds.), Interviewing Experts. Palgrave Macmillan UK, London, pp. 43–80.
Boni, M.F., Lemey, P., Jiang, X., Lam, T.T.Y., Perry, B., Castoe, T., Rambaut, A., Robertson, D.L., 2020. Evolutionary origins of the SARS-CoV-2 sarbecovirus lineage responsible for the COVID-19 pandemic. Nat. Microbiol. 5, 1408–1417.
Bozzo, G., Corrente, M., Testa, G., Casalino, G., Dimuccio, M.M., Circella, E., Brescia, N., Barrasso, R., Celentano, F.E., 2021. Animal welfare, health and the fight against climate change: One solution for global objectives. Agric. 11.
Broad, G.M., 2020. Making meat, better: the metaphors of plant-based and cell-based meat innovation. Environ. Commun. 14, 919–932.
Bryant, C., Krelling, F., 2020. Proteínas Alternativas No Brasil: Um Estudo De Nomenclatura Sobre Carnes Vegetais E Carnes Cultivadas 20.
Bryant, C.J., van der Weele, C., 2021. The farmers' dilemma: Meat, means, and morality. Appetite 167.
Bryant, C., Barnett, J., 2020. Consumer acceptance of cultured meat: An updated review (2018-2020). Appl. Sci. 10.
Bryant, C., Sanctorum, H., 2021. Alternative proteins, evolving attitudes: Comparing consumer attitudes to plant-based and cultured meat in Belgium in two consecutive years. Appetite 161.
CEPEA, 2021a. Indicador do boi gordo CEPEA/B3 [WWW Document]. URL https://www.cepea.esalq.usp.br/br/indicador/boi-gordo.aspx (accessed 3.5.21).
CEPEA, 2021b. Mercado de trabalho do agronegócio brasileiro: 4 trimestre de 2020. Piracicaba.
CEPEA-CNA, 2021. PIB do agronegócio alcança participação de 26,6% no PIB brasileiro em 2020. Piracicaba.
European Commission, 2020. FOOD 2030 Pathways for Action: alternative proteins and dietary shift [WWW Document]. URL https://ec.europa.eu/info/sites/default/files/research_and_innovation/research_by_area/documents/2020.2057_en_05.pdf.
DataPrev, 2021. Infologo AEAT - Base de dados históricos de acidentes do trabalho [WWW Document]. URL http://www3.dataprev.gov.br/aeat/ (accessed 4.1.21).
de Krom, M.P.M.M., Muilwijk, H., 2019. Multiplicity of perspectives on sustainable food: Moving beyond discursive path dependency in food policy. Sustain. 11.
Pereira, E.J. de A.L., Ribeiro, L.C. de S., Freitas, L.F. da S., Pereira, H.B. de B., 2020. Brazilian policy and agribusiness damage the Amazon rainforest. Land use policy 92, 1–6.
De Schutter, O., Jacobs, N., Clément, C., 2020. A 'Common Food Policy' for Europe: How governance reforms can spark a shift to healthy diets and sustainable food systems. Food Policy 96.
Valente, J. de P.S., Fiedler, R.A., Sucha Heidemann, M., Molento, C.F.M., 2019. First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil. PLoS One 14, 1–12.
Detzel, A., Krüger, M., Busch, M., Blanco-Gutiérrez, I., Varela, C., Manners, R., Bez, J., Zannini, E., 2021. Life cycle assessment of animal-based foods and plant-based protein-rich alternatives: an environmental perspective. J. Sci. Food Agric.
Dietz, T., 1987. Theory and method in social impact assessment. Sociol. Inq. 57, 54–69.
Dreyer, M., Renn, O., Cope, S., Frewer, L.J., 2010. Including social impact assessment in food safety governance. Food Control 21, 1620–1628.
Eisen, M.B., Brown, P.O., 2022. Rapid global phaseout of animal agriculture has the potential to stabilize greenhouse gas levels for 30 years and offset 68 percent of CO2 emissions this century. PLOS Clim. 1.

Embrapa, 2019. Pulses e o grão-de-bico: importante mercado mundial para o Brasil [WWW Document]. Embrapa - Empres. Bras. Pesqui. Agropecuária. URL https://www.embrapa.br/busca-de-noticias/-/noticia/48714778/artigo—pulses-e-o-grao-de-bico-importante-mercado-mundial-para-o-brasil (accessed 7.27.22).
Espinosa, R., Tago, D., Treich, N., 2020. Infectious Diseases and Meat Production. Environ. Resour. Econ. 76, 1019–1044.
Fao, 2020. The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diet, Rome.
FAO, 2021c. Pesticides Use [WWW Document]. Food Agric. Organ. United Nations. URL http://www.fao.org/faostat/en/#data/RP/visualize (accessed 9.30.21).
FAO, 2022. Animal Production [WWW Document]. Food Agric. Organ. United Nations. URL https://www.fao.org/animal-production/en/ (accessed 5.27.22).
FAO, 2019. Five practical actions towards low-carbon livestock.
FAO, 2021a. Livestock Primary [WWW Document]. URL http://www.fao.org/faostat/en/#data/QL (accessed 6.2.21).
FAO, 2021b. Major commodities exporters [WWW Document]. URL http://www.fao.org/faostat/en/#rankings/major_commodities_exports (accessed 5.20.21).
Figueira, R.R., Esterci, N., 2017. Slavery in Today's Brazil: Law and Public Policy. Lat. Am. Perspect. 44, 77–89.
Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., Tempio, G., 2013. Tackling climate change through livestock - A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome.
Gerhardt, C., Suhlmann, G., Ziemßen, F., Donnan, D., Warschun, M., Kühnle, H.J., 2020. How Will Cultured Meat and Meat Alternatives Disrupt the Agricultural and Food Industry? Ind. Biotechnol. 16, 262–270.
GFI, 2020. O consumidor brasileiro e o mercado plant-based. São Paulo.
GFI, 2022. Policy [WWW Document]. URL https://gfi.org/policy/ (accessed 5.28.22).
Gioia, D.A., Corley, K.G., Hamilton, A.L., 2013. Seeking Qualitative Rigor in Inductive Research. Organ. Res. Methods 16, 15–31.
Gómez-Luciano, C.A., de Aguiar, L.K., Vriesekoop, F., Urbano, B., 2019. Consumers' willingness to purchase three alternatives to meat proteins in the United Kingdom, Spain, Brazil and the Dominican Republic. Food Qual. Prefer. 78.
Grasso, A.C., Hung, Y., Olthof, M.R., Verbeke, W., Brouwer, I.A., 2019. Older consumers' readiness to accept alternative, more sustainable protein sources in. the European Union, Nutrients 11.
Greenwood, M., 2007. Stakeholder engagement: Beyond the myth of corporate responsibility. J. Bus. Ethics 74, 315–327.
Haleem, A., Mannan, B., Luthra, S., Kumar, S., Khurana, S., 2019. Technology forecasting (TF) and technology assessment (TA) methodologies: a conceptual review. Benchmarking 26, 48–72.
He, J., Evans, N.M., Liu, H., Shao, S., 2020. A review of research on plant-based meat alternatives: Driving forces, history, manufacturing, and consumer attitudes. Compr. Rev. Food Sci. Food Saf. 19, 2639–2656.
Heidemann, M.S., Molento, C.F.M., Reis, G.G., Phillips, C.J.C., 2020. Uncoupling meat from animal slaughter and its impacts on human-animal relationships. Front. Psychol. 11, 1–20.
Hervieux, C., Voltan, A., 2019. Toward a systems approach to social impact assessment. Soc. Enterp. J. 15, 264–286.
Hutz, C.S., Zanon, C., Neto, H.B., 2013. Adverse working conditions and mental illness in poultry slaughterhouses in southern Brazil. Psicol. Reflex. e Crit. 26, 296–304.
Ibge, 2017. Censo agropecuário. Rio de Janeiro.
Ibge, 2020. Síntese dos indicadores sociais: uma análise das condições de vida da população brasileira. Rio de Janeiro.
IBGE, 2022. Produção Agropecuária [WWW Document]. Inst. Bras. Geogr. e Estatística. URL https://www.ibge.gov.br/explica/producao-agropecuaria/ (accessed 5.27.22).
IBGE, 2018. Nacional Agricultural Census - Cooperatives [WWW Document]. URL https://censos.ibge.gov.br/agro/2017/templates/censo_agro/resultadosagro/pdf/cooperativas.pdf (accessed 9.30.21).
IBGE, 2021. Sistema de Recuperação Automática do Instituto Brasileiro de Geografia e Estatística (SIDRA - IBGE) [WWW Document]. URL https://sidra.ibge.gov.br/home/cnt/brasil (accessed 3.3.21).
IPCC, 2020. Climate Change and Land.
Kolkmann, A.M., Post, M.J., Rutjens, M.A.M., van Essen, A.L.M., Moutsatsou, P., 2020. Serum-free media for the growth of primary bovine myoblasts. Cytotechnology 72, 111–120.
Laestadius, L.I., 2015. Public Perceptions of the Ethics of In-vitro Meat: Determining an Appropriate Course of Action. J. Agric. Environ. Ethics 28, 991–1009.
Lapola, D.M., Martinelli, L.A., Peres, C.A., Ometto, J.P.H.B., Ferreira, M.E., Nobre, C.A., Aguiar, A.P.D., Bustamante, M.M.C., Cardoso, M.F., Costa, M.H., Joly, C.A., Leite, C. C., Moutinho, P., Sampaio, G., Strassburg, B.B.N., Vieira, I.C.G., 2014. Pervasive transition of the Brazilian land-use system. Nat. Clim. Chang. 4, 27–35.
Lopes, V.G., Nascimento, G.N.L., 2021. Food safety: Relation between pesticides and poisoning. Food Sci. Technol. 41, 174–179.
Lopez, V., Teufel, J., Gensch, C.O., 2020. How a transformation towards sustainable community catering can succeed. Sustain. 12, 1–16.
Loughnan, S., Haslam, N., Bastian, B., 2010. The role of meat consumption in the denial of moral status and mind to meat animals. Appetite 55, 156–159.
Lusk, J.L., Blaustein-Rejto, D., Shah, S., Tonsor, G.T., 2022. Impact of plant-based meat alternatives on cattle inventories and greenhouse gas emissions. Environ. Res. Lett. 17.
Lymbery, P., Oakeshott, I., 2014. Farmageddon: The True Cost of Cheap Meat, Canadian Food Studies / La Revue canadienne des études sur l'alimentation. Bloomsbury Publishing.
Mancini, M.C., Antonioli, F., 2022. The future of cultured meat between sustainability expectations and socio-economic challenges. In: Bhat, R. (Ed.), Future Foods: Global Trends, Opportunities, and Sustainability Challenges. Academic Press - Elsevier, London, pp. 331–350. https://doi.org/10.1016/b978-0-323-91001-9.00024-4.
Marzoque, H.J., Cunha, R.F. da, Lima, C.M.G., Nogueira, R.L., Machado, V.E. de A., De Alencar Nääs, I., 2021. Work Safety in slaughterhouses: general aspects. Res. Soc. Dev. 10, 1–10.
Mayring, P., 2014. Qualitative Content Analysis. Theoretical Foundation, Basic Procedures and Software Solution, 143. Beltz, Klagenfurt.
Messmann, L., Zender, V., Thorenz, A., Tuma, A., 2020. How to quantify social impacts in strategic supply chain optimization: State of the art. J. Clean. Prod. 257.
Moragues-Faus, A., Battersby, J., 2021. Urban food policies for a sustainable and just future: Concepts and tools for a renewed agenda. Food Policy.
Narayanan, Y., 2016. Where are the Animals in Sustainable Development? Religion and the Case for Ethical Stewardship in Animal Husbandry. Sustain. Dev. 24, 172–180.
Newton, P., Blaustein-Rejto, D., 2021. Social and Economic Opportunities and Challenges of Plant-Based and Cultured Meat for Rural Producers in the US. Front. Sustain. Food Syst. 5.
O'Neill, E.N., Cosenza, Z.A., Baar, K., Block, D.E., 2021. Considerations for the development of cost-effective cell culture media for cultivated meat production. Compr. Rev. Food Sci. Food Saf. 20, 686–709.
OECD, 2021. Population with tertiary education [WWW Document]. URL https://data.oecd.org/eduatt/population-with-tertiary-education.htm (accessed 8.10.21).
OECD-FAO, 2020. Agricultural Outlook 2020-2029. Paris.
Oleschuk, M., Johnston, J., Baumann, S., 2019. Maintaining meat: cultural repertoires and the meat paradox in a diverse sociocultural context. Sociol. Forum 34, 337–360.
Onwezen, M.C., Bouwman, E.P., Reinders, M.J., Dagevos, H., 2021. A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. Appetite 159.
Palhares, J.C.P., Morelli, M., Novelli, T.I., 2021. Water footprint of a tropical beef cattle production system: The impact of individual-animal and feed management. Adv. Water Resour. 149.
Papier, K., Fensom, G.K., Knuppel, A., Appleby, P.N., Tong, T.Y.N., Schmidt, J.A., Travis, R.C., Key, T.J., Perez-Cornago, A., 2021. Meat consumption and risk of 25 common conditions: outcome-wide analyses in 475,000 men and women in the UK Biobank study. BMC Med. 19.
Phillips, N., Sakamoto, L., 2012. Global Production Networks, Chronic Poverty and "Slave Labour" in Brazil. Stud. Comp. Int. Dev. 47, 287–315.
Post, M.J., Levenberg, S., Kaplan, D.L., Genovese, N., Fu, J., Bryant, C.J., Negowetti, N., Verzijden, K., Moutsatsou, P., 2020. Scientific, sustainability and regulatory challenges of cultured meat. Nat. Food 1, 403–415.
Reis, G.G., Heidemann, M.S., Borini, F.M., Molento, C.F.M., 2020. Livestock value chain in transition: Cultivated (cell-based) meat and the need for breakthrough capabilities. Technol. Soc. 62, 101286.
Reuters, 2021. Brazil's BRF makes $2.5 million bet on Israel's Aleph Farms [WWW Document]. URL https://www.reuters.com/article/brf-investment-idUSL2N2OJ15M (accessed 8.1.21).
Rubio, N.R., Xiang, N., Kaplan, D.L., 2020. Plant-based and cell-based approaches to meat production. Nat. Commun. 11.
Sadler, C.R., Grassby, T., Hart, K., Raats, M., Sokolović, M., Timotijevic, L., 2021. Processed food classification: Conceptualisation and challenges. Trends Food Sci. Technol. 112, 149–162.
Schmidt, L., Falk, T., Siegmund-Schultze, M., Spangenberg, J.H., 2020. The Objectives of Stakeholder Involvement in Transdisciplinary Research. A Conceptual Framework for a Reflective and Reflexive Practise. Ecol. Econ. 176.
Serwecińska, L., 2020. Antimicrobials and antibiotic-resistant bacteria: A risk to the environment and to public health. Water (Switzerland) 12.
Siegrist, M., Hartmann, C., 2020. Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. Appetite 155.
Sinke, P., Odegard, I., 2021. LCA of cultivated meat Future projections for different scenarios.
Soriano, V.S., Phillips, C.J.C., Taconeli, C.A., Fragoso, A.A.H., Molento, C.F.M., 2021. Mind the gap: Animal protection law and opinion of sheep farmers and lay citizens regarding animal maltreatment in sheep farming in southern brazil. Animals 11.
Stanford, C.B., Bunn, H.T., 2001. Meat-eating and human evolution. Oxford University Press, Oxford.
Tarazona, A.M., Ceballos, M.C., Broom, D.M., 2020. Human relationships with domestic and other animals: One health, one welfare, one biology. Animals 10.
Tello, M.A., 2020. Conceptualizing social impact: A geographic perspective. J. Bus. Res. 119, 562–571.
Treich, N., 2021. Cultured Meat: Promises and Challenges. Environ. Resour. Econ. 79, 33–61.
Tubb, C., Seba, T., 2021. Rethinking Food and Agriculture 2020–2030: The Second Domestication of Plants and Animals, the Disruption of the Cow, and the Collapse of Industrial Livestock Farming. Ind. Biotechnol. 17, 57–72.
Tuomisto, H.L., Teixeira De Mattos, M.J., 2011. Environmental impacts of cultured meat production. Environ. Sci. Technol. 45, 6117–6123.
United Nations, 2015. The 2030 Agenda for Sustainable Development [WWW Document]. URL https://sustainabledevelopment.un.org/content/documents/21252030 Agenda for Sustainable Development web.pdf (accessed 8.31.21).
van der Weele, C., Driessen, C., 2013. Emerging profiles for cultured meat; ethics through and as design. Animals 3, 647–662.
van der Weele, C., Driessen, C., 2019. How Normal Meat Becomes Stranger as Cultured Meat Becomes More Normal; Ambivalence and Ambiguity Below the Surface of Behavior. Front. Sustain. Food Syst. 3, 2571–2581.
van der Weele, C., Feindt, P., Jan van der Goot, A., van Mierlo, B., van Boekel, M., 2019. Meat alternatives: an integrative comparison. Trends Food Sci. Technol. 88, 505–512.

Vanclay, F., 2002. Conceptualising social impacts. Environ. Impact Assess. Rev. 22, 183–211. https://doi.org/10.1016/S0195-9255(01)00105-6.
Vanclay, F., Esteves, A.M., Aucamp, I., Franks, D.M., 2015. Social Impact Assessment: Guidance for assessing and managing the social impacts of projects. International Association for Impact Assessment.
Verbeke, W., Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., Barnett, J., 2015. "Would you eat cultured meat?": Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. Meat Sci. 102, 49–58.
Wilks, M., Phillips, C.J.C., 2017. Attitudes to in vitro meat: A survey of potential consumers in the United States. PLoS ONE 12.
Witte, B., Obloj, P., Koktenturk, S., Morach, B., Brig, M., Rogg, J., Schulze, U., Walker, D., Koeller, E. Von, Dehnert, N., Grosse-Holz, F., 2021. Food for Thought: The Protein Transformation.
World Health Organization, 2020. Healthy diet [WWW Document]. URL https://www.who.int/news-room/fact-sheets/detail/healthy-diet (accessed 10.3.21).
Yin, R.K., 2009. Case Study Research: Design and Methods. Sage Publications, Thousand Oaks.