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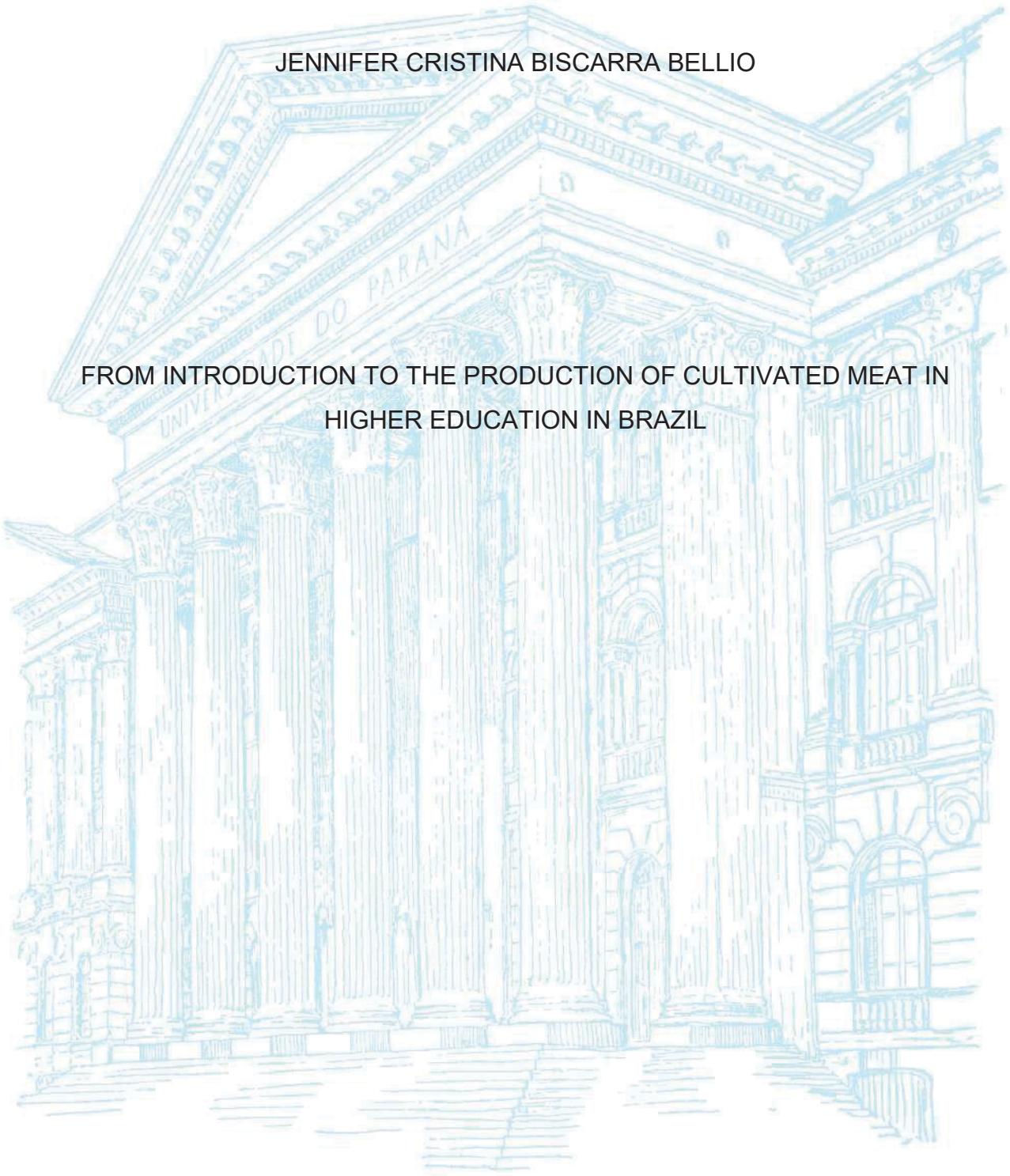

FROM INTRODUCTION TO THE PRODUCTION OF CULTIVATED MEAT IN HIGHER EDUCATION IN BRAZIL

CURITIBA

2024

JENNIFER CRISTINA BISCARRA BELLIO

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Tese apresentada ao Programa de Pós-Graduação em Ciências Veterinárias, no Setor de Ciências Agrárias, Universidade Federal do Paraná, como requisito parcial à obtenção do título de Doutora em Ciências Veterinárias.
Orientadora: Profª. Drª. Carla Forte Maiolino Molento.

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TERMO DE APROVAÇÃO

Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação CIÊNCIAS VETERINÁRIAS da Universidade Federal do Paraná foram convocados para realizar a arguição da tese de Doutorado de **JENNIFER CRISTINA BISCARRA BELLIO** intitulada: **FROM INTRODUCTION TO THE PRODUCTION OF CULTIVATED MEAT IN HIGHER EDUCATION IN BRAZIL**, sob orientação da Profa. Dra. CARLA FORTE MAIOLINO MOLENTO, que após terem inquirido a aluna e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.

A outorga do título de doutora está sujeita à homologação pelo colegiado, ao atendimento de todas as indicações e correções solicitadas pela banca e ao pleno atendimento das demandas regimentais do Programa de Pós-Graduação.

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RESUMO

Projeções indicam que a população mundial ultrapassará 9,7 bilhões até 2025, aumentando o consumo global de carne e gerando preocupações ambientais e sociais, como uso excessivo de recursos, emissões de gases, degradação ambiental e bem-estar animal. A agricultura celular oferece uma alternativa sustentável, produzindo carne, leite e ovos sem abate, por meio do cultivo de células e tecnologias avançadas. Para atender ao crescimento desse setor, é essencial investir no desenvolvimento de mão de obra qualificada. Assim, esta tese trata da implementação do ensino sobre proteínas alternativas em instituições de ensino superior no Brasil, abordando aspectos como a demanda por carne, a intenção de consumo de carne cultivada e o interesse pela agricultura celular, o histórico do ensino dessa área no país e os avanços no Estado do Paraná, bem como a investigação de disciplinas relacionadas à agricultura celular atualmente existentes nos currículos de cursos de graduação relativos à produção de alimentos. Nos capítulos desta tese, foram apresentadas mudanças nas demandas por carne, as diferentes opiniões e intenção de consumo de carne cultivada nas regiões Sudeste e Nordeste do Brasil, assim como o interesse de estudantes e profissionais em aprender sobre agricultura celular, os avanços no ensino dessa área do conhecimento na UFPR e a existência de tópicos relacionados à agricultura celular já existentes em programas de graduação. As reflexões evidenciam demanda por proteínas alternativas e assim a importância de adaptar a formação acadêmica para atender às necessidades de um mercado em crescimento e garantir a qualificação de profissionais que contribuirão para o desenvolvimento da agricultura celular no Brasil.

Palavras-chave: Agricultura celular. Educação. Proteínas alternativas. Zootecnia celular.

ABSTRACT

Projections indicate that the global population will surpass 9.7 billion by 2025, driving increased global meat consumption and raising environmental and social concerns, such as excessive resource use, greenhouse gas emissions, environmental degradation, and animal welfare issues. Cellular agriculture presents a sustainable alternative, producing meat, milk, and eggs without slaughter through cell cultivation and advanced technologies. To support the growth of this sector, investing in the development of a qualified workforce is essential. This thesis focuses on implementing education on alternative proteins in higher education institutions in Brazil, addressing topics such as meat demand, consumer intentions for cultivated meat, and interest in cellular agriculture. It also explores the history of teaching in this field in the country, advancements in Parana state, and the presence of cellular agriculture-related subjects in the curricula of food production-related undergraduate programs. The chapters of this thesis present change in meat demand, differing opinions, and consumer intentions regarding cultivated meat in Brazil's Southeast and Northeast regions, as well as the interest of students and professionals in learning about cellular agriculture. It also highlights advancements in teaching this area at UFPR and the inclusion of cellular agriculture-related topics in undergraduate programs. The findings underscore the demand for alternative proteins and the importance of adapting academic training to meet the needs of a growing market, ensuring the qualification of professionals who will contribute to the development of cellular agriculture in Brazil.

Key-words: Alternative proteins. Cellular agriculture. Cellular animal science. Education.

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1 PRESENTATION

United Nations projections (2022) indicate that the world population is expected to surpass 9.7 billion by 2025, and meat consumption will likely rise accordingly. The impact of population growth on meat consumption is amplified by the "meatification" of diets (Hansen et al., 2021), meaning the explosive rise in global meat consumption, coupled with the increasing industrialization of livestock production, which places meat at the center of human diets, in which it was previously peripheral (Weis, 2015; Garbin et al., 2024). In light of the growing demand for meat, there are increasing concerns about the problems associated with animal production. Such problems have been called "elephants in the room" as they are disproportionately discussed. Recently, eight "elephants" were identified: (1) the absurd reality that food for over 80 billion farm animals is produced to feed eight billion humans; (2) deforestation for grazing and crops intended to feed livestock; (3) greenhouse gas emissions; (4) excessive water use and waste management problems; (5) the mistreatment of animals in intensive production systems; (6) inefficiencies of current animal production systems compared to new technologies; (7) public health risks of new pandemics and antibiotic resistance; and (8) the predominant use of Earth's carbon atoms by human bodies and, primarily, farm animals (Phillips et al., 2024).

Cellular agriculture, also known as cellular animal science, consists of producing proteins as an alternative to the raising and slaughtering of animals. In a stricter sense, it involves methods for cultivating animal cells *ex vivo*; in a broader sense, it includes other techniques such as combining plant molecules, using fungi and algae, mass fermentation, and precision fermentation, among others, to produce meat, milk, eggs, or their substitutes (Garbin et al., 2024).There are reasons to believe that such production methods may become common. According to Tubb and Seba (2020), we are witnessing a "second domestication", the domestication of microorganisms and animal cells for food production, with exponentially higher productivity potential. To accelerate the development of this new market in Brazil, the engagement of food production chain stakeholders will be crucial (Morais-da-Silva, 2022). It requires skilled labor in addition to other dimensions of this new food chain, making the development of teaching strategies to train potential professionals essential (Newell & Glaros, 2024).

The aim of this thesis was to reflect on the teaching of alternative proteins in an academic context, covering topics from basic concepts to the production of cultivated meat in higher education institutions in Brazil. Specific objectives included to further understand the demand for meat, investigate the intention to consume cultivated meat, analyze people's willingness to learn about cellular agriculture, describe the history of cellular agriculture education, gather opinions from participants in educational initiatives on the subject, report advances related to cellular agriculture in the State of Parana, and investigate the curricula of various undergraduate programs focused on training professionals in animal-derived food production to identify a basic structure that may drive their entry into the new market. These topics are addressed in Chapters II, III, IV, V and VI of this thesis.

In Chapter II, the changes in meat demand, influenced by the increasing availability of alternative meats along with the challenges associated with conventional meat, were discussed with an emphasis on the Brazilian context. This study was published by the scientific journal Meat Science on November 17, 2023, titled "Demand changes meat as changing meat reshapes demand: The great meat revolution" (ANNEX 1).

In Chapter III, a questionnaire was applied to investigate different opinions on conventional and cultivated meat, as well as to analyze the consumption intention of residents from two distinct regions of Brazil. The study is published as an article titled "How much do opinions regarding cultivated meat vary within the same country? The cases of Salvador and São Paulo, Brazil" at Plos One Journal.

In Chapter IV people's willingness to learn about cellular agriculture in higher education was investigated through a questionnaire circulated on social media from March to October 2022. The study led to the submission of an article titled "Should cellular agriculture be taught in undergraduate programs in Brazil?" to the Archives of Veterinary Science journal at UFPR.

In Chapter V, a partial view of the history of cellular agriculture education in Brazil is described, with a focus on the "Introduction to Cellular Livestock Farming" course offered in the Graduate Program in Veterinary Sciences and in the undergraduate programs in Veterinary Medicine and Animal Science at UFPR as an elective course. The opinions of the participants about these initiatives are also presented, along with the advancements in the implementation of cellular agriculture in the State of Parana between 2021 and 2024. Notably, in August 2021, the

planning for the NAPI (New Arrangements for Research and Innovation - Alternative Proteins) began , which consists of a working group formed by a multidisciplinary team supported by the Fundação Araucária and the Parana State Department of Science, Technology, and Higher Education (SETI). The results and discussion regarding such initiatives are presented in the article titled "Teaching, Research and Extension in Cellular Animal Science at the Federal University of Parana," submitted to the Brazilian Journal of Graduate Studies, published by CAPES.

Chapter VI presents a list of courses offered in undergraduate programs in Veterinary Medicine, Animal Science, Bioprocess Engineering, Biotechnology, and Food Engineering that may relate to cellular agriculture. The information is discussed in an article submitted to the Brazilian Journal of Science and Technology Education, titled "Cellular Agriculture Education in Brazilian Undergraduate Programs: not as far as it seems".

The thesis presents data and strategies to suggest foundation for new curricular proposals in undergraduate programs ensuring the qualification of professionals who will contribute to the development of cellular agriculture in Brazil.

REFERENCES

GARBIN, V. P., PINTO, P. T., LUZ-FREITAS, M. S., MOLENTO, C. F. M. (2024). Ética animal e proteínas alternativas: questões atuais em terminologia da língua portuguesa. **Archives of Veterinary Science**, 29 (1). http://dx.doi.org/10.5380/avs.v29i1.

HANSEN, A., JAKOBSEN, J., &WETHAL, U. (2021). **New geographies of global meatification: The BRICS in the industrial meat complex** (chapter 3). In A. Hansen, & K. L. Syse (Eds.), Changing meat cultures: Food practices, global capitalism, and the consumption of animals (pp. 35–59).

MORAIS-DA-SILVA, R. L., VILLAR, E. G., REIS, G. G., et al. (2022). The expected impact of cultivated and plant-based meats on jobs: The views of experts from Brazil, the United States, and Europe. **Humanities and Social Sciences Communications***,* 9, 297. https://doi.org/10.1057/s41599-022-01316-z

NEWELL, R., &GLAROS, A. (2024). Chapter 3 - **Sustainable food systems, development paths, and scenarios for cellular agriculture**. In E. D. G. Fraser, D. L. Kaplan, L. Newman, & R. Y. Yada (Eds.), Cellular agriculture (pp. 29-45). Academic Press. https://doi.org/10.1016/B978-0-443-18767-4.00022-6

PHILLIPS, C., MOLENTO, C., BOGUEVA, D., MARINOVA, D. (2024). **Planetary health and animal and plant dietary proteins**, in Preedy, V. R. (ed.) Plant and

Animal Proteins in Health and Disease Prevention, Taylor and Francis, Milton Park, UK. Unpublished results.

TUBB, C., &SEBA, T. (2020). Rethinking food and agriculture 2020–2030: The second domestication of the cow, and the collapse of industrial livestock farming. *Rethink X*. Retrieved from https://www.rethinkx.com/food-and-agriculture. http://dx.doi.org/10.1089/ind.2021.29240.ctu. Accessed June 13, 2024.

United Nations – DESA (2022). World population prospects 2022. Retrieved from: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf. Accessed June 13, 2024.

WEIS, T. SFSGEC. Meatification and the madness of the doubling narrative. **Canadian Food Studie/La Revue canadiennedes éstudes sur l'alimentacion**, 2(2), 296-303, 2015. https://doi.org/10.15353/CFS-RCEA.V2I2.105.

2 DEMAND CHANGES MEAT AS CHANGING MEAT RESHAPES DEMAND: THE GREAT MEAT REVOLUTION.

ABSTRACT

As consumer acceptance and overall demand for the different types of meat are important determinants of the new balance between conventional and alternative meats, our goal was to approach the changes in meat demand, as affected by the increasingly available alternative meats coupled to the problems of conventional meat including the meat paradox, with emphasis on the Brazilian scenario. Then, some aspects of the demand for alternative meats are presented, with a brief historical background. As the decisions taken in the present shape this unprecedented revolution in the way we produce and choose whether to eat meat and, if so, which one, the details of the transition to alternative meat chains in Brazil are yet to be written. It seems even more difficult to predict which food protein items will be in higher demand in the next decades, as new products will likely present themselves for their quality as food items as well as for their ethical and environmental attributes.

Keywords: Alternative protein, Brazil, cultivated meat, veganism, vegetarianism

2.1 INTRODUCTION

The global human population is constantly increasing and developing, and along with these processes some additional challenges may arise. An example of a related challenge is the steady increase in meat demand, a contributor to environmental degradation (Sanchez-Sabate et al., 2019) and biodiversity loss over the world (Benton et al., 2021). Animal production contributes to gas emissions deriving from land-use changes – especially deforestation – caused by expansion of pastures and arable land for feed crops. According to the World Economic Forum (2019), agriculture is responsible for 10-12% of greenhouse gas emissions, with meat, poultry and dairy farming producing nearly three quarters of that percentage. Other concerns are related to welfare conditions for most animals raised under industrialized farming conditions and the scale of their slaughter (Webster, 2013). In 2018, an estimated 68.8 billion chickens, 1.5 billion pigs and 302 million cattle were slaughtered for meat production (Ritchie & Roser, 2019). In Brazil, 29,7 million cattle, 6 billion chickens and 49,3 million pigs were slaughtered in 2020 (IBGE, 2021). In addition, the number of aquatic animals involved is difficult to estimate, although the dimension of the industry may be perceived by the 150 million tones of seafood which were used for human consumption in 2016 (FAO, 2018). Animal production activities are such that the total biomass of terrestrial animals used for food

production is one order of magnitude higher than that of human beings and two orders of magnitude higher than all wild mammals combined (Bar-On et al., 2018).

Regardless of the challenges associated to conventional meat, the fact is that many people like to eat it, while simultaneously many people care for animals and are concerned with the environmental impacts of meat production. In Brazil, consumer research on opinions and demand for conventional meat have traditionally shown the importance of taste and price; however, recent research suggests that the order of importance of meat attributes may be changing. For example, Marques et al. (2022) reported that the most important meat attributes were healthiness, safety, animal welfare, environmental impact and support of the local economy, with attributes such as price and taste ranking lower.

Generally, the decisions about eating meat are complex and consumer attitudes seem constantly reshaping with the changes in underlying factors. Examples of such factors are the amount of information accessed by consumers on the practices involved in conventional meat production, e.g., animal suffering and environmental impacts, increases in consumer purchase power, and the availability, quality and comparative price of conventional meat substitutes. In fact, concerns about the ethics and environmental consequences of conventional meat consumption have led to a rapid expansion in the development of substitutes (Godfray et al., 2018). Such meat substitutes, denominated alternative proteins, include (1) meat cultivated from the multiplication of relevant animal cells in bioreactors, (2) meat analogues produced by molecular combinations of plant ingredients to mimic conventional meat characteristics, and (3) fermentation processes.

The study, development and field work related to the technologies to produce alternative meats and other food proteins uncoupled from animal raising and slaughtering may be denominated Cellular Animal Science which is based on cultivated animal cells and additional alternative methods. As such, the products of Cellular Animal Science will likely increase their participation in the global meat chain and generate a new balance in the worldwide demand for meat, especially between conventional and alternative meats. In fact, it has been estimated that by the year 2040, 35% of the market will be cellular and 25% plant-based meat alternatives, with 40% remaining conventional meat (Gerhardt et al., 2020). This forecast seems of the utmost importance, perhaps especially for countries that rely heavily on meat

production, as is the case of Brazil. Considering such predictions allows for planning strategies to maximize benefits and mitigate disadvantages.

As an important determinant of the new balance is consumer acceptance and overall demand for the different types of meat, our goal is to approach the changes in meat demand, as affected by the increasingly available alternative meats coupled to the challenges related to conventional meat, with emphasis on the Brazilian scenario.

2.2 KNOWN PROBLEMS

The steady trend for higher global meat consumption is a critical issue, in terms of sustainability, food security and safety, public health and animal ethics. Meatification, describing that meat has moved from the periphery to the center of human diets, relates to the fact that daily meat consumption has expanded from richer countries to become a global phenomenon (Hansen, Jakobsen & Wethal, 2021). In 2018, 320 million tons of meat have been consumed worldwide and the global meat production has more than quadrupled since the 60’ (Ritchie & Roser, 2019). The Food and Agriculture Organization (FAO) has forecasted that, by 2050, 70% more food will be required to meet the demands of the growing human population, which in turn poses a major challenge due to limited arable land and water resources (Whitnall & Pitts, 2019; Chriki et al., 2021). The picture thus suggests that we either change our appetite for meat or the way meat is produced, or else we are left in a situation where part of the world population will not have their meat demands provided for, while the planet resources become scarcer to cater for the demands of only the other part of the human population.

On the other hand, the demand for specific types of food is neither static nor deterministic. There are many motivations that shape demand, such as demographic factors, income, tradition, price, flavor, perception of nutritional properties, religious beliefs, health, environmental concerns, and animal ethics. With such complexity, consumer preferences tend to be both resistant to changes and at the same time constantly shifting, depending on the combination of motivations in each point in time as well as on different consumer segments (Chen et al., 2020; OECD/FAO, 2021). As such, there is room for changes in perception and attitudes towards meat, with consequent changes in purchase behavior, as observed by the increasing adoption of diets and lifestyles that aim to reduce meat from the menu in the world. According

to Poore and Nemecek (2018), today and probably into the future, dietary change can deliver environmental benefits on a scale not achievable by producers; their study suggests that the impacts of the lowest-impact animal products exceed average impacts of substitute vegetable proteins across GHG emissions, eutrophication, acidification (excluding nuts), and frequently land use. In addition, Humpenöder et al. (2022) projected that substituting 20% of per-capita ruminant meat consumption with microbial protein globally by 2050, on a protein basis, may offset future increases in global pasture area, cutting annual deforestation and related CO2 emissions roughly in half, while also lowering methane emissions. On the other hand, such dietary changes can only happen if new food items are available.

To further our understanding of the problems related to conventional meat production, it seems worth to consider the context with more detail. Considering terrestrial animals, the main types of meat in the world are those originating from the slaughter of cattle, pigs and birds, followed by sheep and goats. Although absolute world meat production has increased steadily, there have been changes in animal production systems and in consumption patterns (Ritchie & Roser, 2019). For example, chicken consumption has increased its share of the total meat consumption to represent, in 2019, 39% of global meat production (FAO, 2022). Between 2010 and 2020, the world per capita consumption of beef and veal presented a reduction from 6.6 to 6.4 kg/capita, pork from 12.2 to 10.7 kg/capita, while the consumption of poultry increased from 12.7 to 14.9 kg/capita (OECD, 2022). However, the decrease in per capita consumption is more than compensated for by the increase in absolute number of consumers.

Brazil is the third largest meat producer in the world (OECD/FAO, 2019). Due to price differences, Brazilian domestic market tends to intensify the consumption of poultry meat, while increases in Brazilian pig production are mostly destined to the foreign market (CONAB, 2022). In addition, a survey commissioned by the Brazilian Vegetarian Society (SVB) and performed by IPEC (Intelligence in Research and Consulting) was carried out in February 2021, with 2002 respondents from all regions of Brazil, showed that 46% of Brazilians have reduced their meat consumption, cutting it from the menu at least once a week; this information reveals opportunities for the flourishing of plant-based brands (SVB, 2021). Yet, animal production in Brazil

remains strong in both political and economic terms, with billions of birds slaughtered per year and more cattle than humans in the country's territory.

The relevance of considering the problems with conventional meat is supported by the magnitude of the numeric descriptors of both global and Brazilian animal production. Such magnitude relates to the intensification of animal production systems, which exacerbates the main harms of conventional meat production to the environment, animals, public health and food security. As for environmental problems, impacts of the lowest-impact animal products exceed those of plant substitutes, providing evidence for the importance of dietary changes (Poore and Nemecek, 2018). Despite the importance of protecting the environment, studies have shown that a minority of consumers is aware of the environmental impact of conventional meat, is willing to halt or reduce meat intake for ecological reasons or has already stopped or reduced meat consumption because of environmental concerns (Sanchez-Sabate et al., 2019). Another central issue, the discussion on the suffering and slaughter of animals for food is not new, with perhaps a turning point when Harrison (1964) exposed the problems related to animal conditions in intensive animal production in her seminal book Animal Machines. The naturalization of systematic animal slaughter is likely related to the manner that animals are treated in other scenarios, as it sets the debate about what is acceptable to do to animals at an extremely low bar (Heidemann et al., 2020). In addition, the welfare conditions in which animals are maintained in intensive production systems is likely related to the emergence of new diseases, including zoonotic pathogens. This understanding has led the United Nations Environment Programme to publish a report stating that amongst the seven human-mediated factors which are most likely driving the emergence of zoonotic diseases, the top two drivers are related to animal production: 1) increasing human demand for animal protein, and 2) unsustainable agricultural intensification (UNEP, 2020).

As the recognition of conventional meat problems becomes more prominent in social media as well as in everyday conversation among our groups of family and friends, how can a new relationship with our diets be built? There is literature studying the mechanisms in place to deal with the incongruences attached to conventional meat consumption, which may be either conscious or subconscious. With the example of the concern with animal ethics, which appears in 21% of the respondents of a survey with more than 9000 Brazilians participants performed by

GFI (2018). Some of these mechanisms are discussed, as their consideration seems essential to understand both the contemporary meat demand patterns and the possibilities for change.

2.2.1 The meat paradox

Meat is central to most western people's diets and frequently a focus of culinary enjoyment. Yet most people also like animals and wish to protect them. This inconsistency between a love for animals and enjoyment of meat creates a paradox. According to Loughnan, Haslam and Bastian (2010), it is necessary to provide a novel perspective for everyday naturalized actions like eating meat, which are not commonly conceptualized as moral choices, to deal with the meat paradox. In the case of meat, appetite, culture and culinary practices tend to dictate what people choose to eat. Thus, mentally disengaging from the origins of meat serves an important function for meat eaters, reducing the dissonance aroused by enjoying meat but disliking the harm that animals suffer for its production. It follows that people rarely enjoy thinking about where conventional meat comes from (Loughnan, Haslam and Bastian, 2010; Bastian et al., 2012). Thus, although consumers may be unaware of the impacts of their meat-eating behavior, they may be actively avoiding thinking about it. As people may vary in the willpower, they can summon to avoid meat consumption (Bryant et al., 2022), perhaps not thinking about its impacts is a convenient temporary solution. People may keep a light attitude towards eating meat as long as it remains possible to avoid thinking of the animals they eat as sentient beings (Bastian et al., 2012; Onwezen and van der Weele, 2016). According to Joy (2025), relational dysfunctions stem from relational illiteracy, and relational literacy is essential for social transformation, especially when reflecting on the human-animal relationship. These dysfunctions, however, seem to be deliberately invisibilized and systematically ignored due to the lack of this awareness and healthy practice of relating. Coherently, Leach et al. (2022) have reported that the desire to eat meat is associated with strategies to avoid information that is likely to challenge meat consumption. An interesting hypothesis is that these avoidance strategies are released as it becomes possible to replace the consumption of conventional meat with alternative options. This may be one reason for the high percentages of acceptance of cell-based meat in many countries. In Brazil, for instance, the first

study on the intention of cell-based meat consumption showed that 63.6% of respondents were willing to try cultivated meat alternatives, with the major perceived benefits related to animal welfare and environmental issues (Valente et al., 2019). In addition, the main motivations for reducing meat consumption reported by Brazilians were health-related concerns and concerns with animals (GFI, 2018). Research on the reasons why people choose not eating meat in other countries also suggests that human health, environmental issues and animal rights are the main drivers (Rosenfeld, 2019; Hopwood et al., 2019).

In summary, the decisions about eating conventional meat are complex and, on the other hand, the discussion of the problems related to it is increasingly common. Then, as stated by Piazza et al. (2015), meat eating is a practice that in recent years has become subject to increasing criticism. Within such a scenario, new food protein options tend to become relevant.

2.3 THE ARRIVAL OF MEAT ALTERNATIVES

Consuming plant-based protein is nothing new to us. Pythagoras, Gandhi and Paul McCartney may be interesting patrons to escort us across different times and cultures, showing the presence of vegetarianism. The first official reports on a vegetarian diet relate to ancient Egypt and India, and they describe mainly spiritual reasons (Hargreaves et al., 2020). In Asia, vegetarian diets have been affiliated with Buddhism, Hinduism, Jainism and I-Kuan Tao. The common ground amongst these religions is the fact that they encourage avoidance of meat through the concept of non-violence, meaning that being vegetarian equals to having compassion, and this is beneficial for spiritual cultivation (Orlich et al., 2019). Despite its long history, it was only in the twentieth century that vegetarianism became a worldwide common practice, significantly growing in numbers each year. According to Leahy et al. (2010), about 1.5 billion people in the world population is currently vegetarian.

The percentage of the Brazilian population that self-identifies as vegetarians has increased from 8% to 14%, from 2012 to 2018 (IBOPE, 2018). The data regarding vegetarianism in Brazil may cause some puzzlement, as it is traditionally viewed as a meat-eating culture, known as the barbecue or the picanha country. In fact, the high percentage of self-declared vegetarians may relate to differences in the understanding of the concept of vegetarianism. Perhaps many respondents consider

themselves vegetarians if they do not eat cattle meat, thus allowing for a diet including fish and other aquatic animals to be reported as vegetarian. This may explain high percentages of self-declared vegetarians by residents of Brazilian coastal regions, where there is high consumption of fish, lobster and shrimp, amongst other aquatic animals. It is also likely that the image of Brazil as a meat-eating culture is exaggerated, due to a high visibility of this specific segment of Brazilian consumers. Recent surveys with population subgroups show great variation. For example, vegetarianism among first-year students at a public university in Southern Brazil was reported by 6.4% respondents (Barros et al., 2020). Specifically for veganism, percentages are much lower; however, it is difficult to measure the size of their influence in society. A study on vegan restaurants and their consumers in the city of Porto Alegre, South of Brazil, concluded that these actors develop several practices that contribute to shape more sustainable models of food production, distribution, and consumption (Niederle & Schuber, 2020). More research on vegetarianism and veganism in Brazil is welcome, especially considering the size of the country and the diversity of Brazilian culture across geographical regions.

Even though there are indications of increasing numbers of people adopting vegetarian and vegan diets, there are at least two reasons to celebrate the fact that meat-eaters show interest in alternative meats. The first one is that most people in Brazil and abroad do eat meat, and the second is the continued meatification phenomenon globally. The provision of such current and future meat demand may be aided by alternative meats, in a way that the urgent problems with conventional meat can be by-passed or at least significantly reduced through completely novel systems for the production of meat.

However, it is essential to remember that choices regarding diet are strongly determined by social and economic conditions.

2.3.1 Cell-based and plant-based meat alternatives

Much research is currently dedicated to creating novel ways to produce meat alternatives. Such efforts are so relevant that the disruption of conventional meat production seems comparable to the changes obtained when humanity first started the domestication processes which allowed for the initial agrarian developments more than ten thousand years ago. According to Tubb and Seba (2019), we are

going through the second domestication, the domestication of microorganisms and animal cells for the production of food, with exponentially higher possibilities for productivity. Cultivated or cell-based meat alternatives are products made by isolating stem cells from a sample collected from an animal and proliferating these cells in an environment which provides all the required nutrients and conditions for cell growth. This process involves practices of cell culture and tissue engineering for the production of muscle for consumption as food; it is an emergent technology which operates as part of the wider field of cellular agriculture (Stephens et al., 2018; Post, 2012). Several start-ups around the world have been finessing the technology required to use this process to create meat alternatives (Hocquette, 2016), and last year cell-based chicken became available in restaurants in Singapore, the first country approve the selling of cultivated meat alternatives. In Brazil, the Ministry of Agriculture is working on a National Plan for Alternative Proteins and the funding for research and development is rising, with new possibilities at the federal and state levels, as well as robust private investments, including those by major Brazilian meat industries. Plant-based products, which have now been available for consumers for years, are gaining space in the retailer gondolas, which may be pragmatically understood as a sign of its growing acceptance by consumers. In this case Brazil is also moving forward, with brands of plant-based meat alternatives both as part of important traditional meat industries and as stand-alone business, with major success cases such as the Future Farm brand with its ever-broadening export branch.

The drivers for the great efforts towards the development of meat alternatives are basically the perceived problems with conventional meats. For instance, avoiding animal suffering and slaughter was a major perceived benefit of cell-based meat alternatives (Bryant and Barnett, 2018; Valente et al., 2019; Bryant and Barnett 2020). Cell-based meat alternatives are also considered to be environmentally sounder, as their production emits less GHG, uses less land and water per unit of meat produced and may consume less energy than most traditional animal production systems, except poultry (Tuomisto, 2018). If we consider plant-based meat alternatives, these gains are even more marked.

Until recently, alternative products have been mainly targeted toward vegetarians and vegans, and only occasionally for meat eaters. Vegetarians and vegans tend not to prioritize that plant proteins show similar textures and tastes as

compared to conventional meat. However, the latest products from the new generation of plant-based alternative proteins aim to be indistinguishable from traditional meat products, so that those with mild to high meat diets will become target consumers (He et al., 2020). Apparently, the limits between vegetarianism and consumption of meat alternatives are becoming a blurred line. The consumer segment most interested in meat alternatives is currently composed of meat eaters, and not of vegans and vegetarians. This trend has been observed specifically for Brazilian consumers (Valente et al., 2019, Nezlek et al., 2022). Additional data are needed to see a clearer picture on this issue, and it seems relevant to note that the intention of alternative meat consumption among vegetarians and vegans is not zero and may actually increase with time. This context seems to describe a turning point in the history of the general demand for meat, as an important line is crossed. From the point of view of reducing animal production, the division between meat-eaters and non-meat eaters may fade away.

Percentages of Brazilian interviewees intending to consume cell-based meat alternatives are amongst the highest. Valente et al. (2019) argued that the awareness of cultivated meat alternatives by highly educated Southern Brazilians was low in a survey with 626 respondents; however, after watching an explanatory video, 63.6% of the participants declared they would eat cell-based meat alternatives; among vegetarians and vegans, 24% and 8% stated they would do so. A later survey with 225 respondents confirms that southeastern Brazilians are willing to consume cultivated meat alternatives: 80.9% of the respondents were willing to try it, 61.3% to eat it regularly, and 56.9% to eat cell-based meat alternatives as a replacement for conventionally produced beef (de Oliveira et al., 2021). Gomez-Luciano et al. (2019) in their survey with 216 respondents reported that the probability of willingness to purchase cell-based meat alternatives in Brazil may increase 86.8%, if the perception of its healthiness, safety and nutritiousness increases. In Porto Alegre (Rio Grande do Sul), a Brazilian state that is characterized by its strong cultural identity and social practices where barbecue is a typical dish, a survey with 538 respondents demonstrated that six of ten people were willing to try cultivated meat alternatives (Fernandes et al., 2021). According to a survey carried out by Chriki et al. (2021) with 4471 respondents, 46.6% of Brazilians consider cell-based meat alternatives as a promising and acceptable option and 66% are willing to try it, with an important observation that most respondents are not willing to pay a higher price for cultivated

meat alternatives. This finding may be influenced by consumer purchase power. A recent survey with 1545 respondents reports that 90% of Brazilians are willing to consume plant-based foods and 89% of those who already do so do not consider themselves vegans or vegetarians (PortaldoAgronegócio, 2020; Plant-Based BR, 2022). Overall, research is showing a positive scenario for cultivated and plant-based meat alternatives amongst Brazilian consumers (Figure 1).

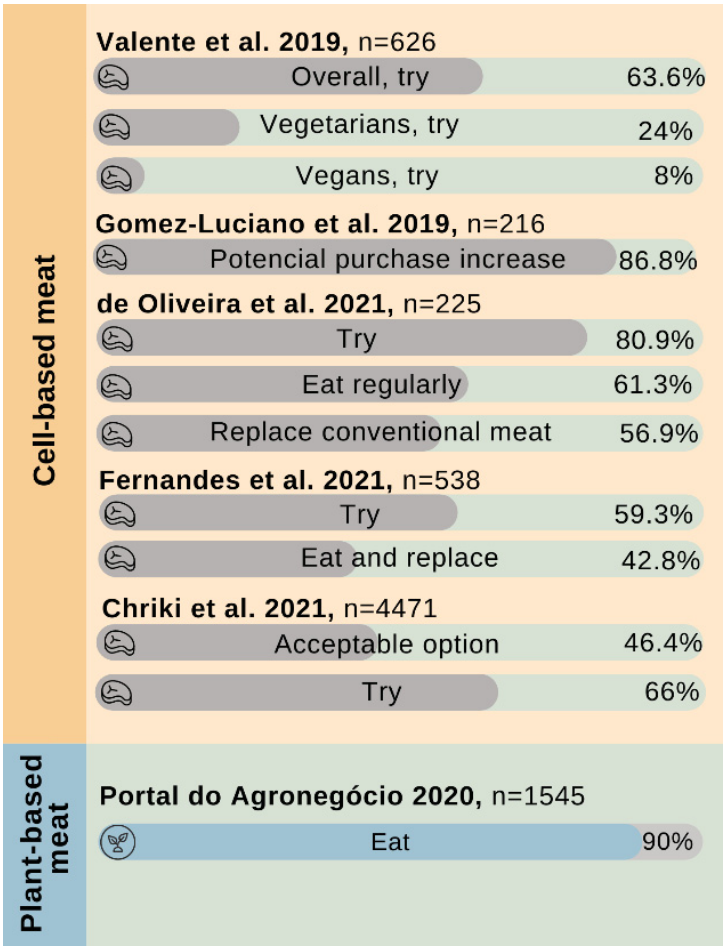


FIGURE 1. CONSUMPTION INTENTION AND ATTITUDES TOWARDS MEAT ALTERNATIVES IN BRAZIL.

As for cell-based meat alternatives, many consumers have mixed feelings about conventional meat, and often recognize the benefits of cultivated meat alternatives, especially for animals and the environment. The potential safety improvements, advantages for food security and nutritional enhancements are additional benefits; however, their recognition by the public in general is modest. Some consumers currently tend to sense risks regarding cell-based meat alternatives due to the perception of unnaturalness and violation of norms (Bryant and Barnett, 2020). Unnaturalness is a common citation by Brazilian respondents as well (Valente

et al., 2019). This may relate to neophobia, i.e., the fear of the new and unknown, since conventional meat production is filled with unnatural aspects and procedures. Neophobia tends to decrease with time as cell-based meat alternatives become more familiar to society at large: as put by van der Weele and Driessen (2019), “normal meat may become stranger as cultivated meat becomes more normal”.

2.4 THE FUTURE IS YET TO BE WRITTEN

Some forecasts have been published regarding the percentage of the global meat chain to be provided for by meat alternatives in the future, of which that by Gerhardt et al. (2020) is frequently cited. Although the predictions seem supported by the recent developments in the plant-based industry, the forecast is less straightforward for cell-based meat alternatives. This is so because, unlike plant-based products, cell-based items are yet to become available to final consumers, with the single exception of Singapore. An additional difficulty for such estimates is that the size of the global meat market to be seized by meat alternatives is not pre-determined and depends on decisions which may be difficult to predict. Finally, there is high complexity in such decisions, with many facets to be locally studied, as they may differ significantly across geographical regions and countries.

An important factor influencing the size of the alternative product chains, which may vary across countries, is how society first learns about new meat alternatives and which attributes become attached to them. Marketing issues are relevant and methodological directions are necessary for shaping decisions and practices regarding alternative proteins (Nguyen et al., 2022). In a survey to examine the view of German consumers on cultivated meat, food technology neophobia was the strongest negative, and green consumption values were the strongest positive predictors of general attitudes (Dupont, Harms & Fiebelkorn, 2022). Such knowledge may contribute to marketing strategies, which may present increased efficiency by encouraging the natural perception of cultivated meat alternatives, using a less technological product name, enabling transparency about the production and creating a dialogue about both the fears and the benefits of the new technology. Applying the same rationale to the positive aspects related to animal welfare in surveys with Brazilian consumers, it seems logical to make reference to animal ethics as well when marketing meat alternatives in Brazil.

An important component affecting the decisions is the potential social impact of the new chains, especially for countries highly involved in conventional meat production such as Brazil. Tomiyama et al. (2020) approached a moral objection raised against cell-based meat alternatives as they may increase unemployment for producers, suggesting that new policies may be necessary to neutralize the negative impacts. In a study by Morais-da-Silva et al. (2022a), a significant proportion of interviewed experts agreed with the statement that cell-based and plant-based meats will bring challenges to producers, with the greatest impact for small Brazilian farms, since they do not have scale gains and, thus, are less competitive (Morais-da-Silva et al., 2022a). On the other hand, according to Newton & Blaustein-Rejto (2021), smaller American farms were identified as lower risk situations, since they have other sources of income besides animal production. Additionally, challenges may arise from barriers to make the transition, with American contracts and funding mostly linked to conventional animal production (Newton & Blaustein-Rejto, 2021). Overall, results by Morais-da-Silva et al. (2022a) suggest that the experts from Brazil and the USA are more optimistic than European ones in relation to the social impacts of alternative meats. All such contrasts support the need for local studies.

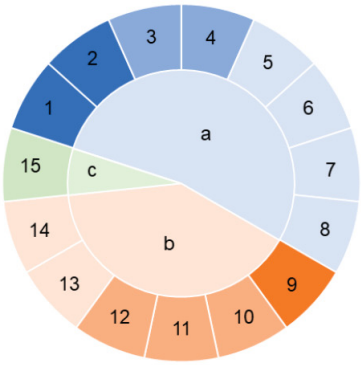
In Brazil, nine social opportunities and five threats were identified in relation to the transition to alternative proteins (Morais-da-Silva et al., 2022b). One threat listed by the interviewees was a potential difficulty in consumer acceptance, since Brazilians have a cultural self-perception as the “barbecue country” (Morais-da-Silva et al., 2022b). As evident by the expansion of vegetarianism and results on plant- and cell-based meat demands in Brazil, this issue does not seem straightforward. In addition, the fading line between meat-eating and vegetarianism further complicates the issue and perhaps the concept of barbecuing will transition to alternative meats more smoothly than initially thought. A major conclusion of the study by Morais-da-Silva et al. (2022b) was that opportunities can better seized if there is a higher level of engagement of stakeholders in the new alternative protein chains; the challenges, in turn, tend to occur regardless, since habits are changing, and alternative proteins are likely to advance in the world.

Convergent with recent findings regarding the benefits of engaging with the new meat chains, Herrero et al. (2020) have previously proposed some action points that may accelerate the transition to a more sustainable food system. Some action points are related to the development of a societal dialogue, others are changes in

policies and regulations as well as designing market incentives, which may be considered three basic domains. Some of such actions have been initiated in Brazil. For instance, the National Plan for Alternative Proteins by the Brazilian Ministry of Agriculture (Becker, 2021) is currently under development with the participation of several stakeholders of the new alternative protein chain and counts with the result of a public consultation held in 2021. Besides that, there are research initiatives that include universities, government agencies, NGOs and the private sector, as well as other stakeholders. However, the development of public policies and private and public funding to the alternative protein chain seem essential for the country to become able to participate in the new meat chains in a meaningful way.

As the market and opportunities in alternative proteins increase, they tend to receive more attention from the private sector as well. Big stakeholders such as JBS and BRF, Brazilian companies recognized in the world as major protein industries, have already invested in plant-based meat products and more recently in the cell-based products as well. The JBS group announced the investment of USD $ 100 million in developments regarding cultivated meat, including the acquisition of the Spanish startup BioTech Foods in 2021. The company is also developing a technological and research center in Brazil (Teixeira, 2021). The BRF group invested USD $ 2.5 million in the startup Aleph Farms and states that the company's 2030 vision is to have healthy and sustainable food, with the alternative proteins as the pillar for such achievement (Forbes, 2021).

The future of the demand for alternative proteins relates to the availability of the final products at retail level. The three domains based on Herrero et al. (2020), if convergent, may accelerate the development of the alternative protein production. In Figure 2, 15 relevant actions are presented, each linked to a domain, and their relative degree of implementation in Brazil is classified. Such organization of relevant actions may contribute to a clear view of possibilities and provide a framework to help their monitoring across time. The framework allows for a rapid understanding of the status of development of the alternative protein production chains, which may be used for organizing actions within a country or to visualize local conditions to be used for investment decisions. Such understanding may directly impact the production of alternative protein items, which are essential for supplying the changing meat demands.



a	SOCIETAL DIALOGUE
b	CHANGES IN POLICIES AND REGULATIONS
c	DESIGNING MARKET INITIATIVES
	IN DEVELOPMENT
	IN PLANNING
	NO ACTION AS YET

1. RESEARCH & TEACHING: Develop scientific research and graduation teaching
2. DIALOGUE: Promote interaction between experts and opinion leaders on alternative proteins
3. TRANSPARENCY: Prioritize transparency in all stages for the promotion of trust
4. AWARENESS: Estabilish a dialogue to increase awareness of benefits and challenges of alternative proteins
5. INCLUSION: Leave no one behind: include farmers and workers of traditional meat
6. BASIC EDUCATION: Include teaching content and meal options at schools to promote alternative proteins
7. DIFFERENTIATE STRATEGIES: Anticipate the impact of different strategies
8. DIFFERENTIATE COUNTRIES: Anticipate the impact of existing different scenarios in each country
9. INCLUSION AS PRIVATE GOALS: Promote the inclusion of alternative proteins in the strategies of private companies
10. POLICIES FOR TRANSITION: Develop public policies as a way to drive the transition
11. FUNDING PROGRAMS: Develop public and private funding programs
12. MARKETING REGULATIONS: Approve regulations for quality control and commercialization
13. INCLUSION OF EXTERNALITIES: Promote the inclusion of externalities on the financial analyses
14. TAX BENEFITS: Develop public programs for tax benefits
15. MARKET INCENTIVES: Develop market and incentives to alternative protein products

FIGURE 2. THE THREE DOMAINS (A, B AND C) AND RESPECTIVE ACTION POINTS TO DRIVE THE DEVELOPMENT OF THE ALTERNATIVE PROTEIN CHAINS; ACTION POINTS ARE CLASSIFIED ACCORDING TO THEIR RELATIVE DEGREE OF IMPLEMENTATION IN BRAZIL, IN MARCH 2022, WITH DARKER COLORS INDICATING MORE ADVANCED STAGES.

Thus, how the new chains of meat alternatives will develop is a complex issue, with important differences across countries. Nevertheless, considering that the alternative protein market is growing fast and has started attracting attention of governments, society and private sector, most changes are expected to occur in the near future. Probably, an important factor for the success in the alternative protein chain is a good ability to adequately drive the required initiatives. Brazil, as other countries, seems to be writing its own future in the domestic and global meat market by the decisions to be taken within the next few years.

2.5 CONCLUSION

Even though vegetarianism and veganism are increasing in Brazil and elsewhere, a scenario of a predominantly meatless society does not seem likely in the foreseeable future. In other words, meat demand may be decreasing when measured as a percentage of total population; however, it is not showing signs of a

significant decrease in absolute numbers. On the contrary, Brazilian demand for meat may be increasing, with the increase in the absolute number of Brazilian citizens in the future and with potential increases in purchasing power. This, however, may not be understood as a stagnant picture where society will maintain their conventional meat purchasing regardless of all the associated problems. As the many benefits of meat alternatives become clearer and the paradoxes coupled to conventional meat consumption are relieved, it is likely that the trend for acceptance of alternative meat products will soar. This trend seems increasingly strong as meat alternatives approach conventional meats in terms of flavor and price, with the potential to generate a revolution in the worldwide meat scenario. Thus, from a solid demand for meat and an increasing recognition of the problems with its conventional type, a great revolution seems to be gaining momentum, and it is based on a disruption in the way meat is produced.

It is difficult to predict what type of food protein will be in high demand in the next decades, as novel products tend to become more abundant as well as more original. Because we are living through one of the major changes in the way we produce food since the domestication of animals more than ten thousand years ago, it is a risky exercise to imagine what kind of foods will be preferred in the future. This is true for disruptive innovations: just as at present the demand for better computers make it awkward to imagine a demand for better typewriters, or car engines made it obsolete to dream with better horse carts, so will completely new food protein products likely present themselves for their quality as food items as well as for their ethical and environmental attributes.

REFERENCES

BAR-ON, Y. M., PHILLIPS, R., & MILO, R. (2018). The biomass distribution on earth. **Proc. Natl. Acad. Sci. U. S. A**., 115, 6506–6511. http://doi.org/10.1073/pnas.1711842115.

BARROS, K. S., BIERHALS, I. O. & ASSUNÇÃO, M. C. F. (2020). Vegetarianismo entre ingressantes de uma universidade pública no sul do Brasil, 2018. **Epidemiologia e Serviços de Saúde**, 29 (4), Article e2019378. https://doi.org/10.5123/S1679-49742020000400009.

BASTIAN, B., LOUGHNAN, S., HASLAM, N., & RADKE, H. R. M. (2012). Don't Mind Meat? The Denial of Mind to Animals Used for Human Consumption. **Personality**

and Social Psychology Bulletin, 38(2), 247–256. https://doi.org/10.1177/0146167211424291.

BECKER, L. (2021). **Ministério da Agricultura prepara plano nacional de proteínas alternativas.** Retrieved from https://revistagloborural.globo.com/Noticias/Politica/noticia/2021/01/ministerio-da-agricultura-prepara-plano-nacional-de-proteinas-alternativas.html. Accessed March 25, 2022.

BENTON, Tim G.; BIEG, Carling; HARWATT, Helen; PUDASAINI, Roshan; WELLESLEY, Laura. *Food system impacts on biodiversity loss*. Chatham House, 2021. Disponível em: <2021-02-03-food-system-biodiversity-loss-benton-et-al.pdf>. Acesso em: 3 fev. 2025.

BRYANT, C. J., PROSSER, A., & BARNETT, J. (2022). Going veggie: Identifying and overcoming the social and psychological barriers to veganism. **Appetite**, 169, Article 105812. https://doi.org/10.1016/j.appet.2021.105812.

BRYANT, C., & BARNETT, J. (2020). Consumer Acceptance of Cultured Meat: An Updated Review (2018–2020). **Applied Sciences**, 10(15), Article 5201. https://doi.org/10.3390/app10155201.

BRYANT, C., & BARNETT, J. (2018). Consumer acceptance of cultured meat: A systematic review. **Meat Science**, 143, 8-17. https://doi.org/10.1016/j.meatsci.2018.04.008.

CHEN, P.-J., & ANTONELLI, M. (2020). Conceptual Models of Food Choice: Influential Factors Related to Foods, Individual Differences, and Society. **Foods**, 9(12), 1898. https://doi.org/10.3390/foods9121898.

CHRIKI, S., PAYET, V., PFLANZER, S. B., ELLIES-OURY, M. P., LIU, J., HOCQUETTE, É., REZENDE-DE-SOUZA, J. H., & HOCQUETTE, J. F. (2021). Brazilian Consumers' Attitudes towards So-Called "Cell-Based Meat." **Foods**, 10(11), Article 2588. https://doi.org/10.3390/foods10112588.

CONAB. (2022). **AgroConab** Janeiro-Fevereiro/2022. Retrieved from http://www.conab.gov.br. Accessed March 18, 2022.

DE OLIVEIRA, G.A., DOMINGUES C. H. d. F., & BORGES, J. A. R. (2021). Analyzing the importance of attributes for Brazilian consumers to replace conventional beef with cultured meat. **PLoS ONE**, 16(5), Article e0251432. https://doi.org/10.1371/journal.pone.0251432.

DUPONT, J., HARMS, T., & FIEBELKORN, F. (2022). Acceptance of Cultured Meat in Germany—Application of an Extended Theory of Planned Behaviour. **Foods**, 11(3), Article 424. https://doi.org/10.3390/foods11030424.

FAO. (2018). **The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals**. Rome. License: CC BY-NC-SA 3.0 IGO.

FAO. (2022). **Gateway to poultry production and products**. Retrieved from https://www.fao.org/poultry-production-products/production/en/. Accessed March 17, 2022.

FERNANDES, A., COSTA, L., TEIXEIRA, O., SANTOS, F., REVILLION, J. P., & SOUZA, A. (2021). Consumption behavior and purchase intention of cultured meat in the capital of the "state of barbecue," Brazil. **British Food Journal**, 123(9), 3032-3055. https://doi.org/10.1108/BFJ-08-2020-0698.

FORBES. (2021). **BRF faz aporte de US$ 2,5 milhões na Aleph Farms para produzir carne cultivada**. Retrieved from https://forbes.com.br/forbes-money/2021/07/brf-faz-aporte-de-us-25-milhoes-na-aleph-farms-para-produzir-carne-cultivada/. Accessed February 6, 2022.

GERHARDT, C., SUHLMANN, G., ZIEMSSEN, F., DONNAN, D., WARSHUN, M., & KÜHNLE, H. J. (2020). How will cultured meat and meat alternatives disrupt the agricultural and food industry? **Industrial Biotechnology**, 16(5), 262-270. https://doi.org/10.1089/ind.2020.29227.cge.

GFI. (2018). **Pesquisa de consumidor: mercado de proteínas alternativas no Brasil.** Retrieved from https://gfi.org.br/2018/10/02/mercado-de-alternativas-vegetais-pesquisa-exclusiva-no-brasil/. Accessed March 24, 2022.

GODFRAY, H., AVEYARD, P., GARNETT, T., HALL, J. W., KEY, T. J., LORIMER, J., PIERREHUMBERT, R. T., SCARBOROUGH, P., SPRINGMANN, M., & JEBB, S. A. (2018). Meat consumption, health, and the environment. **Science** (New York, N.Y.), 361(6399), Article eaam5324. https://doi.org/10.1126/science.aam5324.

GÓMEZ-LUCIANO, C. A., DE AGUIAR, L. K., URBANO, B., & VRIESEKOOP, F. (2019). Consumers' willingness to purchase three alternatives to meat proteins in the United Kingdom, Spain, Brazil and the Dominican Republic. **Food Quality and Preference**, 78, Article 103732. https://doi.org/10.1016/j.foodqual.2019.103732.

HANSEN, A., JAKOBSEN, J. & WETHAL, U. (2021). New Geographies of Global Meatification: the BRICS in the Industrial Meat Complex (Chapter 3). In A. Hansen, & K. L. Syse (Eds.), **Changing Meat Cultures: Food Practices, Global Capitalism, and the Consumption of Animals** (pp. 35-59).

HARGREAVES, S. M., NAKANO, E. Y., & ZANDONADI, R. P. (2020). Brazilian Vegetarian Population-Influence of Type of Diet, Motivation and Sociodemographic Variables on Quality of Life Measured by Specific Tool (VEGQOL). **Nutrients**, 12(5), 1406. https://doi.org/10.3390/nu12051406.

HARRISON, R. (1964). **Animal machines**. London, UK: Vincent Stuart Ltd.

HE, J, EVANS, NM, LIU, H, SHAO, S. (2020). A review of research on plant-based meat alternatives: Driving forces, history, manufacturing, and consumer attitudes. **Comprehensive Reviews in Food Science and Food Safety**, 19, 2639-2656. https://doi.org/10.1111/1541-4337.12610.

HEIDEMANN, M. S., MOLENTO, C. F. M., REIS, G. G., PHILIPS, C. J. C. (2020). Uncoupling meat from animal slaughter and its impacts on human-animal relationships. **Frontiers in Psychology**, 11, Article 1824. https://doi.org/10.3389/fpsyg.2020.01824.

HERRERO, M., THORNTON, P. K., MASON-D'CROZ, D. et al. (2020) Innovation can accelerate the transition towards a sustainable food system. **Nature Food**, 1, 266–272. https://doi.org/10.1038/s43016-020-0074-1.

HOCQUETTE, J. F. (2016). Is in vitro meat the solution for the future? **Meat Science**, 120, 167-176. https://doi.org/10.1016/j.meatsci.2016.04.036.

HOPWOOD, C. J., & BLEIDORN, W. (2019). Psychological profiles of people who justify eating meat as natural, necessary, normal, or nice**. Food Quality and Preference**, 75, 10-14. https://doi.org/10.1016/j.foodqual.2019.02.004.

HUMPENÖDER, F., BODIRSKY, B.L., WEINDL, LOTZE-CAMPEN, H., LINDER, T., POPP, A. (2022). Projected environmental benefits of replacing beef with microbial protein. **Nature** 605, 90–96 https://doi.org/10.1038/s41586-022-04629-w.

IBGE. (2021). **Instituto Brasileiro de Geografia e Estatística** (Brazilian Institute of Geography and Statistics). Retrieved from https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/21119-primeiros-resultados-2abate.html?edicao=21092&t=publicacoes. Accessed April 16, 2022.

IBOPE Inteligência. (2018). **Pesquisa de opinião pública sobre vegetarianismo.** JOB0416. Retrieved from https://www.svb.org.br/images/Documentos/JOB_0416_VEGETARIANISMO.pdf. Accessed March 24, 2022.

JOY, M. Retrieved from https://www.melaniejoy.org/. Accessed February 11, 2025.

LEACH, S., PIAZZA, J., LOUGHNAN, S., SUTTON, R. M., KAPANTAI, I., DHONT, K., & DOUGLAS, K. M. (2022). Unpalatable truths: Commitment to eating meat is associated with strategic ignorance of food-animal minds. **Appetite**, 171, Article 105935. https://doi.org/10.1016/j.appet.2022.105935.

LEAHY, E., LYONS, S., & TOL, R. S. J. (2010). **An Estimate of the Number of Vegetarians in the World.** ESRI Working Papers, 340. https://www.researchgate.net/publication/254412281_An_Estimate_of_the_Number_of_Vegetarians_in_the_World.

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(1), 156–159. https://doi.org/10.1016/j.appet.2010.05.043.

MARQUES, S. C. D. C., MAUAD, J. R. C., DOMINGUES, C. H. D. F., BORGES, J. A. R., & DA SILVA, J. R. (2022). The importance of local food products attributes in

Brazil consumer's preferences. **Future Foods**, 5, Article 100125. https://doi.org/10.1016/j.fufo.2022.100125.

MORAIS-DA-SILVA, R. L., REIS, G. G., SANCTORUM, H., & MOLENTO, C. F. M. (2022a). The social impact of cultivated and plant-based meats as radical innovations in the food production chain: the view of specialists from Brazil, the United States and Europe. Submitted.

MORAIS-DA-SILVA, R. L., REIS, G. G., SANCTORUM, H., & MOLENTO, C. F. M. (2022b). The social impact of the transition from conventional to cultivated and plant-based meats: evidence from Brazil. Submitted.

NEWTON, P., & BLAUSTEIN-REJTO, D. (2021). Social and Economic Opportunities and Challenges of Plant-Based and Cultured Meat for Rural Producers in the US. **Frontiers in Sustainable Food Systems**, 5, Article 624270. https://doi.org/10.3389/fsufs.2021.624270.

NEZLEK, J. B., TOMCZYK, J., PIMENTEL, T. C., CYPRYANSKA, M., DA CRUZ, A. G., & ALMEIDA, E. (2022). **Evaluations of Meat Substitutes in Brazil: Differences between Vegetarians and Omnivores and the Role of Vegetarian Threat**. https://doi.org/10.31219/osf.io/2vyjb.

NGUYEN, J., FERRARO, C., FERRARO, C., SANDS, S., & LUXTON, S. (2022). Alternative protein consumption: A systematic review and future research directions. **International Journal of Consumer Studies**, 00, 1–27. https://doi.org/10.1111/ijcs.12797.

NIEDERLE, P., & SCHUBERT, M. N. (2020). HOW does veganism contribute to shape sustainable food systems? Practices, meanings and identities of vegan restaurants in Porto Alegre, Brazil. **Journal of Rural Studies**, 78, 304-313. https://doi.org/10.1016/j.jrurstud.2020.06.021.

OECD. (2022). **Meat consumption (indicator**). https://doi.org/10.1787/fa290fd0-en. Accessed March 24, 2022.

OECD/FAO. (2021). OECD-FAO **Agricultural Outlook 2021-2030**. OECD Publishing, Paris. https://doi.org/10.1787/19428846-en.

OECD/FAO. (2019). OECD-FAO **Agricultural Outlook 2019-2028**. OECD Publishing, Paris. https://doi.org/10.1787/agr_outlook-2019-en.

ONWEZEN, M. C., & VAN DER WEELE, C. N. (2016). When indifference is ambivalence: Strategic ignorance about meat consumption. **Food Quality and Preference**, 52, 96-105. https://doi.org/10.1016/j.foodqual.2016.04.001.

ORLICH, M. J., CHIU, T., DHILLON, P. K., KEY, T. J., FRASER, G. E., SHRIDHAR, K., AGRAWAL, S., & KINRA, S. (2019). Vegetarian Epidemiology: Review and Discussion of Findings from Geographically Diverse Cohorts. **Advances in nutrition**, 10(Suppl_4), S284–S295. https://doi.org/10.1093/advances/nmy109.

PIAZZA, J., RUBY, M. B., LOUGHNAN, S., LUONG, M., KULIK J., WATKINS, H. M., & SEIGERMAN M. (2015). Rationalizing meat consumption. The 4Ns. **Appetite**, 91, 114–128. http://dx.doi.org/10.1016/j.appet.2015.04.011.

PLANT-BASED BR. (2022). **Os desafios e as oportunidades do mercado plant-based**. Retrieved from https://plantbasedfoods.com.br/revistas/pb-ed01/#p=10. Accessed March 24, 2022.

POORE, J., & NEMECEK, T. (2018). Reducing food's environmental impacts through producers and consumers. **Science**, 360(6392), 987–992. https://doi.org/10.1126/science.aaq0216.

PORTAL DO AGRONEGÓCIO. (2020). **Pesquisa mostra que 90% dos brasileiros têm interesse em alimentos vegetais**. Retrieved from https://www.portaldoagronegocio.com.br/gestao-rural/analise-de-mercado/noticias/pesquisa-mostra-que-90-dos-brasileiros-tem-interesse-em-alimentos-vegetais-consumir-produtos-saudaveis-e-principal-fator-de-atracao. Accessed March 31, 2022.

POST, M. J. (2012). Cultured meat from stem cells: Challenges and prospects. **Meat Science**, 92(3), 297–301. https://doi.org/10.1016/j.meatsci.2012.04.008.

RITCHIE, H., & ROSER, M. (2019). **Meat and Dairy Production**. Retrieved from https://ourworldindata.org/meat-production. Accessed March 24, 2022.

ROSENFELD, D. L. (2019). A **comparison of dietarian identity profiles between vegetarians and vegans. Food Quality and Preference,** 72, 40-44. https://doi.org/10.1016/j.foodqual.2018.09.008.

SANCHEZ-SABATE, R., BADILLA-BRIONES Y., & SABATÉ J. (2019). Understanding Attitudes towards Reducing Meat Consumption for Environmental Reasons. A Qualitative Synthesis Review. **Sustainability**, 11(22), Article 6295. https://doi.org/10.3390/su11226295.

STEPHENS, N., DI SILVIO, L., DUNSFORD, I., ELLIS, M., GLENCROSS, A., & SEXTON, A. (2018). Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. **Trends in Food Science & Technology,** 78, 155–166. https://doi.org/10.1016/j.tifs.2018.04.010.

SVB. Sociedade Vegetariana Brasileira. (2021). **Nova pesquisa Ipec 2021 revela: brasileiros reduzem, por vontade própria, consumo de carne e impactam estabelecimentos**. Retrieved from https://www.svb.org.br/2649-nova-pesquisa-ipec-2021-revela. Accessed March 18, 2022.

TEIXEIRA, S. J. (2021). JBS faz a maior aposta de frigoríficos brasileiros na carne de laboratório. Retrieved from https://www.capitalreset.com/jbs-faz-a-maior-aposta-de-frigorificos-brasileiros-na-carne-de-laboratorio/. Accessed March 27, 2022.

TOMIYAMA, A., KAWECKI, N., ROSENFELD, D., JAY, J., RAJAGOPAL, D., & ROWAT, A. (2020). Bridging the gap between the science of cultured meat and

public perceptions. **Trends in Food Science & Technology**, 104, 144-152. https://doi.org/10.1016/j.tifs.2020.07.019.

TUOMISTO, H. L. (2018). The eco-friendly burger. **EMBO reports**, 20(1), Article e47395. https://doi.org/10.15252/embr.201847395.

TUBB, C., & SEBA, T. (2019). R**ethinking food and agriculture 2020–2030: the second domestication of the cow, and the collapse of industrial livestock farming.** Retrieved from https://www.rethinkx.com/food-and-agriculture. Accessed March 24, 2022.

UNEP - United Nations Environment Programme and International Livestock Research Institute. (2020). **Preventing the Next Pandemic: Zoonotic diseases and how to break the chain of transmission.** Nairobi, Kenya. https://www.unep.org/resources/report/preventing-future-zoonotic-disease-outbreaks-protecting-environment-animals-and.

VALENTE, J. D. 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(8), Article e0221129. https://doi.org/10.1371/journal.pone.0221129.

VAN DER WEELE, C. N., & DRIESSEN, C. (2019). How Normal Meat Becomes Stranger as Cultured Meat Becomes More Normal, Ambivalence and Ambiguity Below the Surface of Behavior. **Frontiers in Sustainable Food Systems**, 3 (69), Article 69. https://doi.org/10.3389/fsufs.2019.00069.

WEBSTER, J. (2013). **Animal Husbandry Regained: The Place of Farm Animals in Sustainable Agriculture** (1st ed.). New York, USA, Routledge.

WHITNALL, T., & PITTS, N. (2019). Global trends in meat consumption. **Agricultural Commodities**, 9(1), 96–99. https://search.informit.org/doi/10.3316/informit.309517990386547.

WORLD ECONOMIC FORUM. (2019). **Meat: the Future series Alternative Proteins.** Switzerland. https://www.weforum.org/whitepapers/meat-the-future-series-alternative-proteins. Accessed April 16, 2022.

3 HOW MUCH DO OPINIONS REGARDING CULTIVATED MEAT VARY WITHIN THE SAME COUNTRY? THE CASES OF SALVADOR AND SÃO PAULO, BRAZIL.

ABSTRACT

The problems related to conventional meat production have been widely discussed globally and alternative proteins emerge as more sustainable and ethical options. Thus, understanding the intention to consume cultivated meat is key. This work aimed to study the intention to consume cultivated meat by residents of São Paulo and Salvador, Brazil, studying demographic differences. An online questionnaire with 17 multiple-choice and open questions regarding opinions on conventional and cultivated meat was used and the results were analyzed both quantitatively and qualitatively. With 809 participants, 419 (51.8%) from São Paulo and 390 (48.2%) from Salvador, 265 (32.8%, of which 170 (64.2%) from São Paulo and 95 (35.8%) from Salvador) respondents stated they would eat cultivated meat. Residents of São Paulo demonstrated higher familiarity with cultivated meat (187 (44.6%) had heard of it compared to 123 (31.5%) in Salvador).Such disparity in awareness seems coherent with differences in access to information and educational levels. Our results suggest that the acceptance of cultivated meat varies significantly across different regions of Brazil, likely related to the country's continental size, uneven economic and educational status and rich cultural diversity. We conclude that the acceptance of cultivated meat correlates with knowledge about it and that efforts to raise such knowledge require the consideration of cultural and socioeconomic aspects on a regional rather than national level, especially for geographically big and culturally diverse countries. Future research seems warranted as additional reasons for different acceptance levels likely play key roles and may be investigated in target groups less diverse in educational levels. Continued research is also essential due to dynamics of acceptance and its entanglement with familiarity and knowledge regarding cultivated meat, both of which tend to significantly increase with time.

Key-words: Alternative proteins. Awareness. Consumer behavior. Demographic differences.

3.1 INTRODUCTION

The projections by the United Nations, in 2022, suggest that the global population is likely to grow to around 8.5 billion in 2030, 9.7 billion in 2050 and 10.4 billion in 2100 (United Nations, 2022). The effect of this overall human population growth on meat consumption is amplified by the progressive meatification of diets (Hansen et al., 2021) in highly populated areas. Coherently, the demand for meat remains on the rise globally, leading to increased societal concerns about intensified animal production and, consequently, environmental and animal welfare issues (Bryant & Barnett, 2020). The problems related to animal production have been called 'elephants in the room', as they are disproportionately discussed. Recently, eight elephants were reported in the room: (1) the absurd reality that food for more

than 80 billion farm animals is produced in an effort to feed 8 billion humans, (2) forest destruction for pasture and crops to feed farm animals, (3) greenhouse gas emissions, (4) water use and waste management problems, (5) the unfair treatment of animals in intensive production systems, (6) the inefficiency of the current animal production systems as compared to new technologies, (7) public health risks of novel pandemics and antibiotic resistance, and (8) the predominant use of Earth's carbon atoms by human and, mostly, farm animal bodies (Phillips et al., 2024).

In this sense, the problems involved in the current scenario of animal production indicate a need to adapt to more sustainable systems that also value aspects related to animal welfare (Godfray et al., 2018), with concerns about such topics growing among consumers (Pakseresht et al., 2022). Coherently, concerns about the ethics and environmental impacts of traditional meat consumption have stimulated the development of alternatives (Godfray et al., 2018), and protein source diversification emerges as a promising option, with the potential to generate environmental benefits (Poore & Nemecek, 2018) and higher standards regarding animal suffering (Pakseresht et al., 2022). Furthermore, alternative proteins address issues related to public health, food safety, and animal welfare (Godfray et al., 2018; Pakseresht et al., 2022; Tuomisto et al., 2024; van der Weele & Driessen, 2019; Nobre, 2022). However, there are challenges for their development. For instance, although cultivated meat uses significantly less land and water than conventional production, it may require higher energy inputs, depending on which specific chains are compared (Tuomisto et al., 2014). The climate effects of cultivated meat can also vary depending on the energy source used (Tuomisto et al., 2024). Biotechnological challenges for scaling up cultivated meat production in a cost-effective way remain (Soccol et al., 2024), while the use of animal-free inputs presents its own set of research questions (Bryant & Barnett, 2019). Yet another example is the need to understand consumer demands and intention to purchase cultivated meat products (Biscarra-Bellio et al., 2023), as an evident essential part for the success of the new food production systems. Considering the remaining difficulties, the robust and multidimensional perceived benefits of cultivated meat and other alternative proteins boost increasing private and public investments for the resolution of the remaining challenges.

As a response to the need for science-based solutions, a new field of research, education, outreach activities and production systems conceived to

develop and deliver alternative proteins, commonly denominated cellular agriculture, is currently under development (GFI, 2022). In turn, alternative proteins are foods produced through the cultivation of animal cells ex vivo (i.e. out of the body), fermentation processes such as biomass and precision fermentation, or a combination of plant ingredients, with the goal of offering animal products or their analogues without the need for animal farming and slaughter (Garbin et al., 2024). Cultivated meat is a product of the culture of muscle tissue from a collection of cells from a live animal (Pandurangan & Kim, 2015).

Some analogues to products of animal origin, such as those from plants, have been in human meals for decades. Whereas plant-based products are already commercialized, there are increasing levels of investment in cellular agriculture to improve knowledge regarding the existing technical, regulatory, and commercial challenges before all sorts of alternative proteins become widely available in the market (Nezlek & Forestell, 2019), with price parity with their conventional counterparts. This price-parity seems particularly difficult to achieve unless fundamental shifts in subsidies currently available for conventional meat are enacted (Pasitka et al., 2024).

It is known that price is a major driving force for consumer buying decisions (Liu et al., 2023). Would then price-parity between alternative proteins and conventional animal products suffice for a major market shift towards alternative proteins? Maybe not. Meat consumers are reported to be resistant to alternative proteins due to a variety of reasons. An important reason seems to be their perception of risks in novel foods (Nezlek & Forestell, 2019). For instance, consumer preferences and risk perceptions influence the intention to try alternative proteins, and the greater the risk perceived the less likely consumers are to try them (Begho & Zhu, 2023). In addition, consumers who are skeptical when it comes to the decision of consuming cultivated meat report feelings of disgust, lack of naturalness, and negative sensory expectations (Wilks & Phillips, 2017; Onwezen et al., 2021; Bryant & Barnett, 2018; Siegrist et al., 2018; Egolf et al., 2019; Septiano et al., 2023). Food neophobia, defined as an individual's reluctance to consume new foods (Nezlek & Forestell, 2019), is a general reason for rejecting any food item on the basis of its novelty and unfamiliarity which also plays a role for rejecting alternative proteins.

An approach related to social sciences brings additional understanding to the potential acceptance of cultivated meat and other alternative proteins. Dietary

behaviors are intrinsically linked to the social and economic expression of identities and preferences, playing a crucial role in nutritional status and health. Such links include the cultural context, which influences the place that different foods occupy within local culinary traditions and the perception of specific food technologies (Nguyen et al., 2021; Giacalone & Jaeger, 2023). Within this complex multifactorial scenario composing food choices, it seems necessary to gain a more nuanced understanding of the psychological mechanisms that contribute to attitudes to and engagement with cultivated meat (Wilks et al., 2019). It is perceived that consumer acceptance will dictate its success (Pakseresht et al., 2022; Wilks et al., 2019) in addition to being a determinant of the new balance between conventional and cultivated meat production chains. In this sense, whether cellular agriculture will become more than just a niche market (Valente et al., 2019) depends critically on the percentage of consumers that buy its products.

It is logical, then, that the intention to purchase cultivated meat is a relevant research topic. In fact, the intention to consume cultivated meat has been the focus of scientific studies over the past decade, with the first publications appearing in 2015 (Boscardin & Dorr, 2023). The levels of acceptance of cultivated meat vary among different research results worldwide (Wilks & Phillips, 2017; Weinrich et al., 2020; Mancini & Antonioli, 2019; Chriki & Hocquette, 2020), as in Brazil (Valente et al., 2019; Fernandes et al., 2021; de Oliveira et al., 2021; Chriki et al., 2021). However, treating consumption intention on a country basis seems an oversimplification that may hinder advancements in the field. This is especially relevant for countries with diverse cultural characteristics, which may be exacerbated by extensive territorial area and large human population sizes, as can be epitomized by the case of Brazil.

Brazil hosts around half the South American population and around half its geographical area. In addition, Brazil is the largest exporter of beef and the second largest producer of meat in the world (USDA, 2021), being arguably considered a country with a barbecue culture (Fernandes et al., 2021). As agriculture and animal production constitute a major component of the country's Gross Domestic Product (GDP), the introduction of meat alternatives nationally, e.g. cultivated meat seems essential to maintain its market share in the future, requiring careful planning to maximize the benefits and mitigate the disadvantages (Morais-da-Silva et al., 2022). Thus, a more detailed regional understanding of Brazilians' perceptions of and intention to consume alternative proteins, with their underlying reasons, seems both

relevant and a rich study case scenario. Brazilian regions differ significantly in geographic, socioeconomic, food culture, and media exposure aspects and it is likely that such differences significantly influence consumer acceptance of new foods. Indeed, in a previous study comparing two Brazilian cities within the same geographical region of Brazil, the South, significant differences in consumption intention were observed (Valente et al., 2019), raising interesting scientific questions regarding the magnitude of differences which may appear when the comparison is expanded to include cities from other regions in the country.

To address such knowledge gaps, this study compared consumption intention and related perceptions between residents of the biggest cities in Northeastern and Southeastern regions in Brazil. More specifically, we studied the knowledge of and willingness to eat cultivated meat, general perceptions about conventional and cultivated meat, as well as about the relationship between each type of meat and environmental, human health, and animal welfare issues. Thus, goal of our study was to further investigate the intention of Brazilians to consume cultivated meat and related issues, focusing on residents in the cities of São Paulo and Salvador. The two cities were chosen for their representativeness of each region, due to their population sizes and the fact that they are both State capitals, as well as due to the strong contrasts between them.

Salvador, the largest urban center in the Northeast region and the capital of the State of Bahia, with a population of 2,417,678 inhabitants (IBGE, 2022), is currently ranked with the weakest economic and employment indicators among Brazilian State capitals (ICE, 2023). In contrast, the city of São Paulo, capital of the Southeastern State of São Paulo, is the most populous city in Brazil, with a population of 11,451,99 inhabitants (IBGE, 2022), and stands out as the most economically developed center in the country (ICE, 2023).

This paper is structured to provide a demographic characterization of our participants, followed by descriptive and qualitative data obtained from their responses, which were later summarized and prepared for comparative and explanatory analyses, according to appropriate methodology for each case. Results were then statistically compared between cities and also analyzed considering relevant demographic data as potential explanatory factors. There follows a discussion section, organized from general to more specific issues, which includes the limitations of our study and potential priorities for further research in the field.

3.2 MATERIAL AND METHODS

Residents of the cities of São Paulo and Salvador were invited to participate in an online survey. A consumer survey start-up (Opinion Box®) was hired to apply the questionnaire to individuals over 18 years-old, from September 5th to 23rd, 2019.This work was approved by the Ethics Committee on Research with Humans, of Health Sciences Sector of the Federal University of Parana, Brazil, and is registered under number 3.040.865/2018. To proceed with the questionnaire, participants were required to check a box indicating that they had read and agreed with the Informed Consent Form. This procedure ensured that they understood the study's objectives and nature before continuing. The explanation provided included details about the risks and benefits involved. They were also informed that they could withdraw from participation at any time, without the need to justify their decision and without any penalties, thus expressing their voluntary consent to participate in the study. The survey was elaborated based on a previous study of consumers in Southern Brazil (Valente et al., 2019) and composed of 15 multiple-choice and two open-ended questions. Questions 1 to 7 were related to sociodemographic data (gender, income, age, region, city, education, frequency of meat consumption). In addition to questions specifically about cultivated meat acceptance, we selected related issues that may provide insights into respondents' acceptance levels. The degree of familiarity with cultivated meat is likely a key factor in understanding consumer interest. Similarly, capturing respondents' perceptions of the positive and negative impacts of conventional meat on environmental, human health, and animal welfare issues may help interpreting their motivations for accepting or rejecting meat alternatives. Thereby, questions 8 to 17 (Table 1) explore participants' level of knowledge about conventional and cultivated meat, their intention to consume cultivated meat, and their perceptions of how the production of either one affects the environment, human health, and animal welfare. Questions 8 and 10 featured an image depicting conventional and cultivated meat chains. Questions from 12 to 17 presented the following response categories: very negative, negative, neutral, positive, and very positive.

TABLE 1. QUESTIONS COMPOSING THE ONLINE QUESTIONNAIRE ADMINISTERED FROM SEPTEMBER 5TH TO 23RD, 2019, TO RESIDENTS OF SÃO PAULO AND SALVADOR, BRAZIL.

Number	Question

8	What comes to your mind when you think of this conventional meat production system? Mention the first three words that come to your mind.
9	Have you heard about cultivated meat?
10	What comes to your mind when you think of this cultivated meat production system? Mention the first three words that come to your mind.
11	Would you eat cultivated meat? Justify
12	Regarding the environment, conventional meat is very negative/negative/neutral/positive/very positive
13	Regarding the environment, cultivated meat is very negative/negative/neutral/positive/very positive
14	Regarding human health, conventional meat is very negative/negative/neutral/positive/very positive
15	Regarding human health, cultivated meat is very negative/negative/neutral/positive/very positive
16	Regarding animal welfare, conventional meat is very negative/negative/neutral/positive/very positive
17	Regarding animal welfare, cultivated meat is very negative/negative/neutral/positive/very positive

Sociodemographic data (questions 1 to 7) were compared with census results by the Brazilian Institute of Geography and Statistics (IBGE, 2022), to verify whether the sample was representative of the population of the cities where the questionnaire was applied. Question 7 intended to identify respondents in terms of meat consumption, a factor likely related to their opinions regarding alternative proteins.

The answers to the open-ended questions were analyzed by two researchers, who initially synthesized the phrases individually into preliminary central ideas using the Collective Subject Discourse (CSD) method (Duarte et al., 2009). First, each researcher conducted their own independent data analysis, selecting the terms that, in their view, best represented the central themes. Subsequently, both researchers met to compare and discuss the selected terminology, evaluating each term to decide which best represented the respondent ideas. During these discussions, a 90.0% agreement rate was achieved between the analyses. In cases of divergence, the reasons behind each term's proposal were thoroughly examined. The researchers then consulted an online Portuguese dictionary and, afterwards, an online English dictionary (Michaelis Moderno Dicionário, 2024) to ensure translation accuracy and the semantic precision of the terms. Finally, these terms were incorporated into the word clouds, where the most frequent terms appear in proportionally larger sizes. The justifications for answers to question 11 were also analyzed by the two different researchers, grouping them by similarity, using the same methodology.

The following factors were considered as explanatory variables: city, income, education, and frequency of meat consumption, as per categories in Table 2.

Knowledge about cultivated meat, consumption intention, and the relationships between cultivated and conventional meat with the environment, human health and animal welfare were the subjects addressed in the questions. For the binary responses (yes or no) we fitted binary logistic regression models, and the results are presented through the odds ratios of a positive response and corresponding confidence intervals (95%), whereas the ordinal response variables (very negative, negative, neutral, positive, very positive) were analyzed by fitting proportional odds regression models, and the results are presented by means of the odds ratios for a more favorable (positive) response. The ordinal scale variables were grouped before fitting the regression models, by combining the two less favorable options as a negative response, and the two more favorable as a positive response. In this case, each ordinal variable presents three categories: negative, neutral, and positive. All questions contained the "I do not know" answer option. Thus, an examination was also carried out on how demographic factors influenced knowledge, or lack thereof, in relation to each of the questions. We present the non-adjusted results, based on univariate regression models, as well as the adjusted results, provided by multiple regression models. All conclusions are based on a 5% significance level. All analyses were carried out using the R software (R Core Team, 2023) for statistical computation, version 4.3.1. The R library ordinal was used to fit the ordinal regression models.

3.3 RESULTS

The questionnaire was filled by a total of 809 respondents, 419 from São Paulo and 390 from Salvador. The demographic results are presented in Table 2. The income range varied between the two cities: in São Paulo the most frequently declared income was from R$1,997.00 to R$4,990.00 (44.8%), while in Salvador, it was up to R$1,996.00 (42.5%). Respondents from São Paulo most frequently claimed complete or incomplete higher education (42.4%), and from Salvador, partial or complete elementary or high school (48.7%). Most respondents from São Paulo stated that they consumed meat 4 to 7 days a week (51.0%), while in Salvador it is 1 to 3 days a week (54.3%).

TABLE 2.DEMOGRAPHIC RESULTS BY RESPONSE CATEGORIES OF THE 809 RESPONDENTS FROM AN ONLINE QUESTIONNAIRE ADMINISTERED FROM

SEPTEMBER 5 TO 23, 2019, TO RESIDENTS OF SÃO PAULO AND SALVADOR, BRAZIL.

Variables	Categories	Results
City	São Paulo	419 (51.8%)
	Salvador	390 (48.2%)
Gender	Men	345 (42.6%)
	Women	464 (57.4%)
Age	18 to 29 years old	260 (32.1%)
	30 to 49 years old	424 (52.4%)
	50 or older	125 (15.5%)
Income	Up to R$1996.00	273 (33.7%)
	R$1997.00 to R$4990.00	344 (42.5%)
	More than R$4990.00	192 (23.8%)
Education	Elementary or high school	341 (42.2%)
	Higher education	394 (48.7%)
	Postgraduate degree	74 (9.1%)
Frequency of meat consumption	Does not eat meat	22 (2.7%)
	1 to 3 days a week	402 (49.7%)
	4 to 7 days a week	385 (47.6%)

When respondents were asked whether they had already heard about cultivated meat, of the 809 respondents, 310 (38.3%) answered yes (Figure 1). The results of the responses related to the question by demographic variable are presented in Table 3.

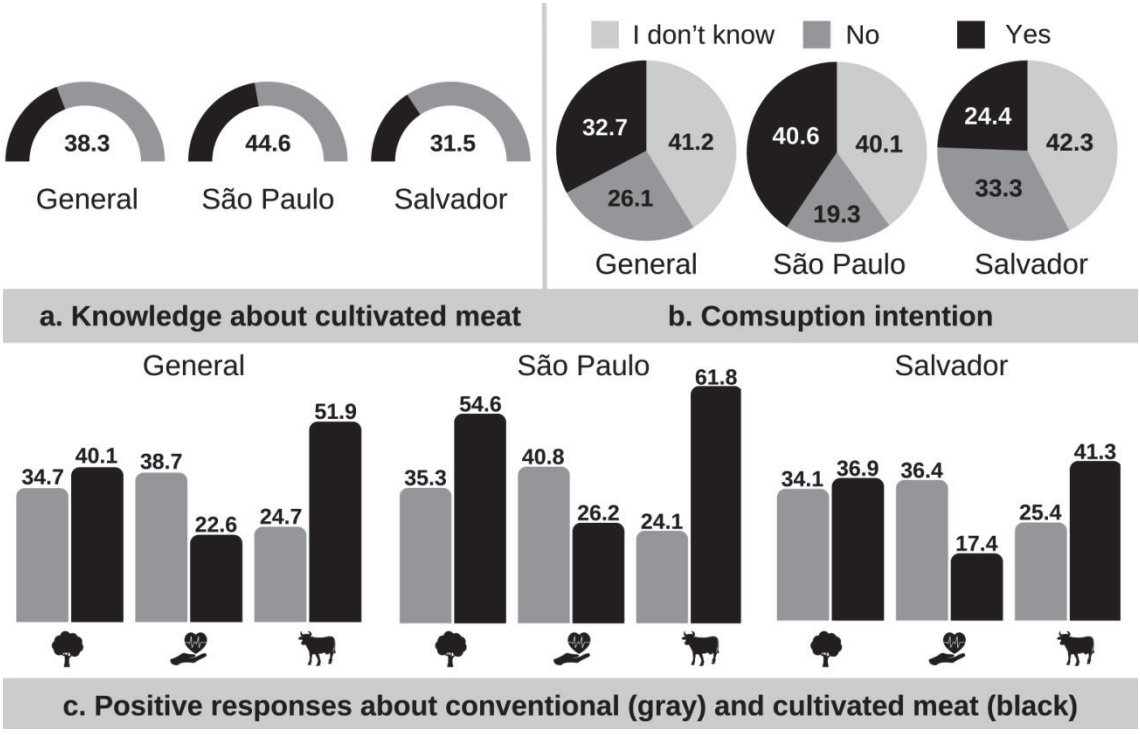


FIGURE 1. GENERAL AND BY CITY PERCENTAGES REGARDING KNOWLEDGE ABOUT CULTIVATED MEAT (A); THE INTENTION TO CONSUME CULTIVATED

MEAT (B); POSITIVE RESPONSES REGARDING THE INFLUENCE OF CONVENTIONAL MEAT AND CULTIVATED MEAT ON THE ENVIRONMENT, HUMAN HEALTH AND ANIMAL WELFARE (C).

TABLE 3. ANSWERS TO THE QUESTION “HAVE YOU HEARD ABOUT CULTIVATED MEAT?”, GIVEN BY 809 RESPONDENTS FROM SÃO PAULO AND SALVADOR, BRAZIL, IN AN ONLINE QUESTIONNAIRE FROM SEPTEMBER 5 TO 23, 2019.

Variables	Categories	Have you heard about cultivated meat?	
		Yes	No
City	São Paulo	187 (44.6%)	232 (55.4%)
	Salvador	123 (31.5%)	267 (68.5%)
Gender	Men	146 (42.3%)	199 (57.7%)
	Women	164 (35.3%)	300 (64.7%)
Age	18 to 29	114 (43.8%)	146 (56.2%)
	30 to 49	151 (35.6%)	273 (64.4%)
	50 or older	45 (36.0%)	80 (64.0%)
Income	Up to R$1996.00	100 (36.6%)	173 (63.4%)
	R$1997.00 to R$4990.00	120 (34.9%)	224 (65.1%)
	More than R$4990.00	90 (46.9%)	102 (53.1%)
Education	Elementary or high school	113 (33.1%)	228 (66.9%)
	Higher education	161 (40.9%)	233 (59.1%)
	Postgraduate degree	36 (48.6%)	38 (51.4%)
Frequency of meat consumption	Does not eat meat	9 (40.9%)	13 (59.1%)
	1 to 3 days a week	139 (34.6%)	263 (65.4%)
	4 to 7 days a week	162 (42.1%)	223 (57.9%)

Overall, 265 (32.8%) participants expressed interest in eating cultivated meat, 211 (26.0%) stated that they would not consume it, and 333 (41.2%) replied “I do not know” (Figure 1). The results of the responses related to the question by demographic variable are presented in Table 4.

TABLE 4. ANSWERS TO THE QUESTION “WOULD YOU EAT CULTIVATED MEAT”, GIVEN BY 809 RESPONDENTS FROM SÃO PAULO AND SALVADOR, BRAZIL, IN AN ONLINE QUESTIONNAIRE FROM SEPTEMBER 5 TO 23, 2019.

Variables	Categories	Would you eat cultivated meat?		
		Yes	No	I do not know
City	São Paulo	170 (40.6%)	81 (19.3%)	168 (40.1%)
	Salvador	95 (24.4%)	130 (33.3%)	165 (42.3%)
Gender	Men	128 (37.1%)	79 (22.9%)	138 (40.0%)
	Women	137 (29.5%)	132 (28.5%)	195 (42.0%)
Age	18 to 29	100 (38.5%)	58 (22.3%)	102 (39.2%)
	30 to 49	137 (32.3%)	110 (25.9%)	177 (41.8%)
	50 or older	28 (22.4%)	43 (34.4%)	54 (43.2%)

Income	Up to R$1996.00	86 (31.5%)	80 (29.3%)	107 (39.2%)
	R$1997.00 to R$4990.00	104 (30.2%)	92 (26.8%)	148 (43.0%)
	More than R$4990.00	75 (39.1%)	39 (20.3%)	78 (40.6%)
Education	Elementary or high school	109 (32.0%)	101 (29.6%)	131 (38.4%)
	Higher education	131 (33.2%)	93 (23.6%)	170 (43.2%)
	Postgraduate degree	25 (33.8%)	17 (23.0%)	32 (43.2%)
Frequency of meat consumption	Does not eat meat	2 (9.1%)	15 (68.2%)	5 (22.7%)
	1 to 3 days a week	115 (28.6%)	116 (28.9%)	171 (42.5%)
	4 to 7 days a week	148 (38.4%)	80 (20.8%)	157 (40.8%)

Among the 265 who showed interest in consuming cultivated meat, the main justifications were related to curiosity (32.0%), reporting verbs such as to try, to taste, to know; animal welfare (26.0%), with phrases such as to spare the lives of animals, to reduce slaughter, to avoid the killing of animals; human health (9.0%), with justifications such as it seems healthy, it would not be harmful to human health, it seems more nutritious.

Regarding the justification of the 211 respondents who answered that they would not eat cultivated meat, the main ideas were grouped into i) neophobia (26.0%), with phrases such as I am afraid, dubious process, strange; ii) artificiality (21.0%), containing justifications such as not natural, too artificial, something modified; iii) lack of knowledge (15.0%), with ideas such as I do not know, lack of information about the product, I do not understand the process; and iv) human health (15.0%), involving responses such as it is bad for our health, it is not healthy, it can cause disease.

The results of the most positive responses regarding the relationships between conventional meat and cultivated meat with the environment, human health, and animal welfare are represented in Figure 1.

Among the 310 respondents who had heard of cultivated meat, 156 (50.3%) said they would eat it, 64 (20.7%) said they would not, and 90 (29.0%) said they didn't know. Of the 499 respondents who were unfamiliar with cultivated meat, 109 (21.8%) said they would eat it, 147 (29.5%) said they would not, and 243 (48.7%) said they didn't know (Table 5).

TABLE 5. RESPONSES TO QUESTIONS ABOUT THE RELATIONSHIP BETWEEN CULTIVATED MEAT AND THE ENVIRONMENT, HUMAN HEALTH, AND ANIMAL WELFARE, BASED ON RESPONDENTS' FAMILIARITY OF CULTIVATED MEAT,

COLLECTED FROM 809 PARTICIPANTS IN SÃO PAULO AND SALVADOR, BRAZIL, IN AN ONLINE QUESTIONNAIRE CONDUCTED FROM SEPTEMBER 5 TO 23, 2019.

Have heard about	How cultivated meat relates to	Responses			
		Beneficial	Neutral	Harmful	I do not know
Yes	Environment	174 (56.1%)	67 (21.6%)	42 (13.6%)	27 (8.7%)
	Human Health	108 (34.8%)	77 (24.9%)	62 (20.0%)	63 (20.3%)
	Animal Welfare	205 (66.1%)	54 (17.4%)	33 (10.7%)	18 (5.8%)
No	Environment	199 (39.9%)	123 (24.7%)	82 (16.4%)	95 (19.0%)
	Human Health	75 (15.0%)	144 (28.9%)	114 (22.8%)	166 (33.3%)
	Animal Welfare	215 (43.1%)	114 (22.9%)	84 (16.8%)	86 (17.2%)

Regarding the odds ratios of providing a response other than "I don't know" response for each question, only those with statistical significance (95% CI, $p<0.05$* or $p<0.001$**) will be highlighted. Greater knowledge was observed among respondents from São Paulo compared to those from Salvador on the following questions: question 12 (OR=1.95* in the bivariate analysis and OR=1.79* in the multivariate analysis), question 13 (OR=1.67* in the bivariate analysis and OR=1.73* in the multivariate analysis), question 16 (OR=3.16** in the bivariate analysis and OR=3.10** in the multivariate analysis), and question 17 (OR=1.69* in the bivariate analysis and OR=1.77* in the multivariate analysis). Additional results are available in Table 6.

TABLE 6. DATA SET OF ODDS RATIOS OF RESPONSES FOR EACH QUESTION, COMPARING THE VARIABLES GENDER, AGE, INCOME, EDUCATION, AND MEAT CONSUMPTION AMONG RESPONDENTS FROM SÃO PAULO AND SALVADOR, FROM SEPTEMBER 5TH TO 23RD, 2019.

Question	Variable	Odds ratio definition	Bivariate analysis	Multiple analysis
9	Gender	Men / Women	1.34*	1.23
	Age	30 to 49 / 18 to 29	0.70*	0.62*
		50 or older / 18 to 29	0.72	0.60*
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	0.92	0.81
		Greater than 4990.00 / Up to 1996.00	1.52*	1.25
	Education	University/ Elementary or High School	1.39*	1.33
		Postgraduate / Elementary or High School	1.91*	1.65
	Meat Consumption	Did not consume / 4 to 7	0.95	0.83
		1 to 3 / 4 to 7	0.72*	0.86
11	Gender	Men / Women	1.56*	1.56*
	Age	30 to 49 / 18 to 29	0.72	0.54
		50 or older / 18 to 29	0.37*	0.23**
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	1.05	0.81
		Greater than 4990.00 / Up to 1996.00	1.78*	1.46
	Education	University/ Elementary or High School	1.30	1.24
		Postgraduate / Elementary or High	1.36	1.00

		School		
	Meat Consumption	Did not consume / 4 to 7	0.07*	0.04**
		1 to 3 / 4 to 7	0.53*	0.67
12	Gender	Men / Women	1.35*	1.35*
	Age	30 to 49 / 18 to 29	1.28	1.24
		50 or older / 18 to 29	1.17	1.19
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	.1.08	1.12
		Greater than 4990.00 / Up to 1996.00	0.85	0.91
	Education	University/ Elementary or High School	0.93	0.99
		Postgraduate / Elementary or High School	0.97	1.07
	Meat Consumption	Did not consume / 4 to 7	1.17*	0.17*
		1 to 3 / 4 to 7	1.21	1.19
13	Gender	Men / Women	1.10	1.06
	Age	30 to 49 / 18 to 29	0.81	0.75
		50 or older / 18 to 29	0.56*	0.45*
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	1.51*	1.42*
		Greater than 4990.00 / Up to 1996.00	1.87*	1.76*
	Education	University/ Elementary or High School	1.26	1.00
		Postgraduate / Elementary or High School	1.44	1.04
	Meat Consumption	Did not consume / 4 to 7	0.78	0.76
		1 to 3 / 4 to 7	0.67*	0.83
14	Gender	Men / Women	1.62*	1.48*
	Age	30 to 49 / 18 to 29	1.47*	1.46*
		50 or older / 18 to 29	1.37	1.45
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	0.92	0.85
		Greater than 4990.00 / Up to 1996.00	1.34	1.11
	Education	University/ Elementary or High School	1.17	1.16
		Postgraduate / Elementary or High School	0.93	0.79
	Meat Consumption	Did not consume / 4 to 7	0.20**	0.20**
		1 to 3 / 4 to 7	0.66*	0.67*
15	Gender	Men / Women	1.03	0.96
	Age	30 to 49 / 18 to 29	0.86	0.87
		50 or older / 18 to 29	0.70	0.68
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	1.28	1.15
		Greater than 4990.00 / Up to 1996.00	1.45	1.32
	Education	University/ Elementary or High School	1.30	1.14
		Postgraduate / Elementary or High School	0.85	0.71
	Meat Consumption	Did not consume / 4 to 7	0.50	0.52
		1 to 3 / 4 to 7	0.66*	0.75
16	Gender	Men / Women	1.52*	1.55*
	Age	30 to 49 / 18 to 29	1.26	1.30
		50 or older / 18 to 29	1.39	1.58*
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	0.75	0.79
		Greater than 4990.00 / Up to 1996.00	0.64*	0.68
	Education	University/ Elementary or High School	0.84	0.98
		Postgraduate / Elementary or High School	0.61*	0.73
	Meat Consumption	Did not consume / 4 to 7	0.14*	0.14*
		1 to 3 / 4 to 7	1.18	1.07
17	Gender	Men / Women	1.14	1.02
	Age	30 to 49 / 18 to 29	0.92	0.84
		50 or older / 18 to 29	0.55*	0.46*
	Income (R$)	1997.00 to 4990.00 / Up to 1996.00	1.55*	1.37

	Greater than 4990.00 / Up to 1996.00	2.19**	1.88*
Education	University/ Elementary or High School	1.39*	1.15
	Postgraduate / Elementary or High School	1.81*	1.26
Meat Consumption	Did not consume / 4 to 7	0.29*	0.29*
	1 to 3 / 4 to 7	0.56**	0.71*

The odds ratios of providing a more positive response for each question, comparing respondents from São Paulo to those from Salvador, are represented in Figure 2.

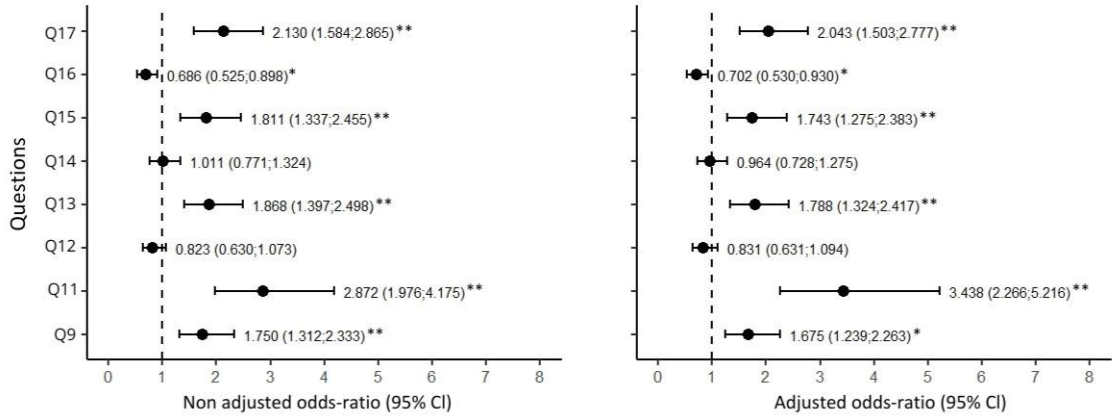


FIGURE 2. NON-ADJUSTED (BIVARIATE) AND ADJUSTED (MULTIPLE) ODDS RATIOS FOR A MORE POSITIVE RESPONSE AMONG RESPONDENTS FROM SÃO PAULO COMPARED TO THOSE FROM SALVADOR (P<0.05*, P<0.001**).

For conventional meat, the main ideas in response to question 8 cited by the 809 respondents were: i) production (21.6%), with words like farm, production, reproduction; ii) suffering (11.7%), with citations such as cruelty, torture, suffering; iii) logistics (11.6%), which includes words such as distribution, transport, logistics. For cultivated meat, the main answers given involved i) innovation (12.1%), with words like technology, advance, innovative; ii) neophobia (10.8%), with words such as strange, fear, distrust; iii) artificial (8.2%), containing words such as false, unnatural, artificial (Figure 3).

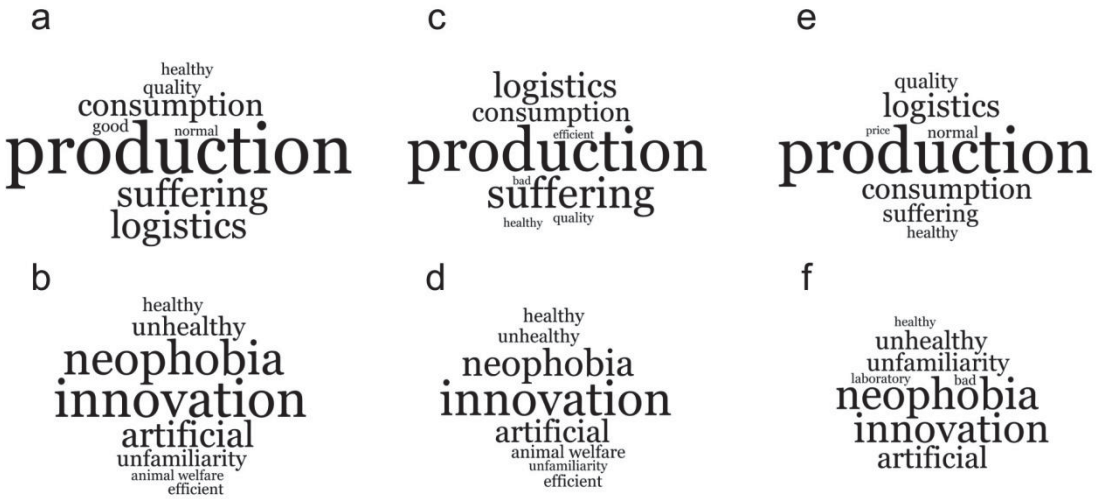


FIGURE 3. WORDS REPRESENTING THE IDEAS EXPRESSED BY 809 RESPONDENTS FROM SÃO PAULO AND SALVADOR ABOUT CONVENTIONAL MEAT (A) AND ABOUT CULTIVATED MEAT (B); WORDS REPRESENTING THE IDEAS EXPRESSED BY 419 RESPONDENTS FROM SÃO PAULO ABOUT CONVENTIONAL MEAT (C) AND ABOUT CULTIVATED MEAT (D);WORDS REPRESENTING THE IDEAS EXPRESSED BY 309 RESPONDENTS FROM SALVADOR ABOUT CONVENTIONAL MEAT (E) AND ABOUT CULTIVATED MEAT (F).

3.4 DISCUSSION

Our results show that cultivated meat was not well known in Brazil in 2019, with respondents from Salvador demonstrating greater unfamiliarity compared to those from São Paulo. Concomitantly, conventional meat was more appealing to people from Salvador, those with lower income and with lower education. Salvador is the State capital city with the most fragile economic and employment rates in Brazil (where 16.0% of the population was unemployed in 2019), considering the comparison of 40 social indicators and the performance of municipal government in areas such as income and education, according to Sustainable City Institute (ICE, 2023). Additionally, according to the general ranking of the Entrepreneurial Cities Index (ICE, 2023), which considers each of seven determinants - regulatory environment, infrastructure, market, access to capital, innovation, human capital, and culture - and their indicators, São Paulo leads as the most developed city in Brazil (with a score of 8.67) e an human development index (HDI) scoring 0,868 while Salvador appears in the 47th position (with a score of 6.05) with an HDI scoring 0,759 (UNDP, 2025). Lack of familiarity with cultivated meat was cited as a barrier by participants (Pandurangan & Kim, 2015). Prior knowledge was also described as a

driving factor for cultivated meat acceptance (Weinrich et al., 2020; Verbeke et al., 2015). A study conducted in Germany with 713 participants showed that 38.0% of them already had prior knowledge of cultivated meat and demonstrated greater acceptance (Weinrich et al., 2020). A study with 1,296 participants in the Netherlands indicated that 79.0% had never heard of cultivated meat. However, after explaining the technique and its possible advantages and disadvantages, 52.0% claimed to be willing to try it (Flycatcher, 2013). Additionally, a study conducted with 739 participants in the southern region of Brazil showed that 39.3% of them responded positively to the questions after watching an explanatory video about cellular agriculture (Valente et al., 2019). Overall, the level of knowledge is embedded in a dynamic set of information and, as such, it is likely to improve rapidly as news about cultivated meat becomes increasingly frequent (Valente et al., 2019). It seems relevant to scrutinize the social inequalities in the regions studied to avoid biased interpretations that may suggest that people who reject cultivated meat do not like it, when in fact they may not have received adequate or any information about it.

The overall results in terms of intention to consume cultivated meat were relatively low, with respondents from São Paulo showing greater interest. Studies conducted in Italy have shown cultivated meat consumption intentions of 54.0%, among 525 participants (Mancini & Antonioli, 2019), while in Germany the rate was 57.0%, among 713 participants (Weinrich et al., 2020). In the United States, the consumption intention was even higher, with 65.3%, among 673 participants (Wilks & Phillips, 2017). Interestingly, in Brazil, intentions to consume cultivated meat were also higher in previous studies. Among residents of the Southern region of the country, consumption intentions of 63.6% (Valente et al., 2019) and 59.3% (Fernandes et al., 2021) were reported. In the Southeast region of Brazil, the consumption intention was even higher, reaching 80.9% among residents (de Oliveira et al., 2021). Therefore, the difference in acceptance among all studied regions of Brazil seems significant. This is confirmed by our study, the first one to use the same methodology and simultaneous surveys to allow for a valid comparison between geographic regions.

Apparently, people are interested in eating cultivated meat out of curiosity regarding the organoleptic properties of the product. An important factor when considering whether the people would consume cultivated meat or not is whether it tastes the same as conventional meat (Ruzgys & Pickering, 2020). Indeed, sensory

quality is an important characteristic to increase consumer acceptability (Liu et al., 2023; Siddiqui et al., 2022a). Nonetheless, flavor and texture can be adjusted to increase the acceptance of cultivated meat in the near and distant future (Bryant & Barnett, 2020).The perception of the flavor of cultivated meat diverges from that of conventional meat. A study conducted with 214 participants in Canada, where 38% believed that cultivated meat would not have the same flavor as conventional meat, while 30% stated that it would have the same taste (Ruzgys & Pickering, 2020). Although the flavor and texture of cultivated meat are unknown in Brazil and most people in the world, this does not prevent many people from wanting to eat it, with curiosity been a driving force according to our results.

Animal welfare issues are important motivations for the interest in consuming cultivated meat, with people from São Paulo showing a more positive outlook on this relationship. The problems related to animal suffering in intensive production systems were exposed for the first time in 1964, with the publication of the book Animal Machines (Harrison, 1964). The welfare of animals raised in industrialized intensive farming and the naturalization of their slaughter are the main problems cited by Brazilians (Biscarra-Bellio et al., 2023; Valente et al., 2019; Heidemann et al., 2020; Marques & Mauad et al., 2022). Thus, cultivated meat emerges as an alternative for meat production without animal suffering and slaughter.

Human health was frequently mentioned as a justification for the desire to eat cultivated meat. Nonetheless, many respondents believed that conventional meat had a more positive relationship with human health than cultivated meat, mainly those who had never heard about cultivated meat. As an important source of protein and other nutrients, meat is understood as a driver for global human health (Geiker et al., 2021; Leroy et al., 2023). On the other hand, meat consumption is related to human health issues such as colon cancer (Domingo & Nadal, 2017), as well as cardiovascular diseases and type 2 diabetes (Qian et al., 2020). Thus, the conflicting opinions registered by respondents seem to parallel scientific literature (Verbeke et al., 2015; Onwezen et al., 2021). In terms of nutritional value, cultivated meat has the potential to be superior to conventional meat, as its production allows for modifying the nutrient content, for instance, controlling the fat content and optimizing it with omega-3 fatty acids (Chriki & Hocquette, 2020), in addition to having advantages such as the possibility of increasing its biological value by adding various vitamins, trace elements, amino acids, unsaturated fatty acids, and the fact that it cannot be a

source of helminthes (Nobre, 2022; Bhat et al., 2022) or many of the pathogens which may be present in conventional meat settings. It is important to highlight that cultivated and conventional meat are essentially the same product, differing principally in their methods of production. Therefore, some nutritional characteristics that impact human health, whether positive or negative, will be common to both types of meat.

The environment was less frequently observed in our data as a reason for consuming cultivated meat. However, people believed that the relationship between cultivated meat and the environment is more positive than that of conventional meat, a perception that is especially evident among the inhabitants of São Paulo. Despite the importance of protecting the environment, studies have shown that a minority of consumers are aware of the environmental impact of conventional meat (Hartmann & Siegrist, 2017). Since animal production contributes to global environmental degradation, one approach is to decrease meat consumption (Sanchez-Sabate et al., 2019), substituting it for meat analogues (Michell et al., 2021). Cultivated meat is frequently presented as environmentally sounder. Compared to conventional meat production, cultivated meat is associated with approximately 7–45% less energy, 78–96% lower greenhouse gas emissions, 99% lower land use, and 82–96% lower water use, depending on the product compared (Tuomisto & de Mattos, 2011; Tuomisto et al., 2014; Begho & Zhu, 2023). Therefore, relatively high industrial energy demand has been estimated for cultivated meat (Tuomisto et al., 2024). Providing information about environmental benefits may increase the number of consumers in the market for cultivated meat (Tsavkirai et al., 2023). A barrier to this logic is that; however, for consumers to understand the environmental benefits of cultivated meat, more transparency on the environmental problems of conventional meat is required; however, such transparency is lacking and difficult to achieve (Hannan, 2020). However, all these data are estimates, as there is currently no large-scale global production of cultivated meat.

Respondents who consume meat more frequently, younger individuals, men, those with higher educational levels, and those with higher incomes have shown a more positive opinion towards cultivated meat. However, it seems difficult to predict which food protein items will be in higher demand in the next decades (Biscarra-Bellio et al., 2023). Cultivated meat is more attractive to young people in Brazil (Chriki et al., 2021), which may be related to the fact that consumers who are younger, with

higher level of education, wealthier, and politically progressive leaning are generally found to hold more positive views towards adopting novel food technologies (Cattaneo et al., 2019; Onwezen et al., 2021). At the same time, people who follow an omnivorous diet showed a strong intention to adopt alternative proteins, considering them as complementary to their regular diet (Abebe et al., 2024). Such positive opinions may be considered a starting point for the new food industry to design novel strategies of products in the perspective of the circular economy. These markers can contribute to the creation of an ecosystem that encompasses the social groups where people sympathetic to cultivated meat are found. Thus, marketing strategies can be targeted at this audience, as well as developing tactics to reach those who initially do not appear as enthusiasts of the new food systems.

Neophobia, the perception of artificiality, and lack of familiarity with the product were reasons commonly mentioned for rejecting the consumption of cultivated meat. The level of food neophobia, a predictor of acceptance, is related to social conservatism towards the disruptive food products (Tomiyama et al., 2020; Siegrist et al., 2020). Furthermore, when consumers perceive food technology as unnatural, they are more likely to believe the technology is risky and are less prone to accept any potential benefits the technology may have (Weinrich et al., 2020; Ruzgys & Pickering, 2020; Begho & Zhu, 2023). Indeed, awareness of alternative protein sources is a psychological capability critical to shifting preferences away from meat. Having little or no awareness of alternative proteins is a significant barrier to consumption (Nguyen et al., 2021). Democratizing access to information for unilingual populations requires efforts regarding the continuous offering of cultivated food terminology in local languages (Garbin et al., 2024), especially given that the use of English terms may heighten perceptions of unfamiliarity among non-English speakers regarding cellular agriculture. The importance of increasing the use of local language is recognized, with translated terminology making access to new products and production systems more available to residents who do not speak foreign languages (Onwezen et al., 2021). Decreasing conventional meat attachment and food neophobia, as well as increasing familiarity with and knowledge of the new food products, are important challenges to be overcome (van Dijk et al., 2023). As cultivated meat has been perceived as having high degree of unnaturalness, communications and marketing of cultivated products should strive to portray cultivated meat in a more natural and favorable light (Siddiqui et al., 2022b).

Educating society has always proved to be effective in overcoming psychological hindrance; therefore, communication channels need to be better exploited (Siegrist & Hartmann, 2020). Consumers should be encouraged to become more familiar with the product, so they can reflect upon it with knowledge. One method of doing this is to use terminology and product labeling of a less technical nature (Siddiqui et al., 2022c). As cultivated meat becomes more prevalent in the daily lives of consumers, the perception of fear and artificiality regarding the product may decrease.

Conventional meat production is well established, while cultivated meat represents a disruptive innovation not yet in the market. As new technologies for alternative proteins, like cultivated meat, are expected to emerge soon (Morais-da-Silva et al., 2022), replacing conventional meat may become easier, less taboo and even a social differentiation marker (Hocquette, 2023). The individual transition may be in the form of a partial replacement of conventional meat, as seen in flexitarian diets (Teixeira et al., 2024). However, the dominant conventional meat-centered culture tends to remain (Dagevos & Verbeke, 2022). Our findings highlight the need for strategies to improve knowledge about cultivated meat, requiring tailored planning based on regional characteristics, even within the same country.

Some potential biases and limitations may have influenced the results of this work. The sampling, while extensive in two large Brazilian cities, may not fully represent the general population. The online questionnaire may have attracted more participants with internet access and familiarity with or at least curiosity about cultivated meat. In addition, the reliance on limited respondent stratification may relate to subgroups of the population not being represented in our survey, which requires caution in making inferences for the specific cities studied and even more so for the country in general. The limited number of questions in the survey, especially open-ended questions, is also a limitation, which combined with the need for extracting key words may result in an oversimplification of respondent views. The self-reported data may exhibit social desirability bias, where respondents provide answers that they consider socially acceptable, susceptible to personal interpretations and selective memory (Regmi et al., 2016; Ball, 2019). Additionally, the lack of prior knowledge about cultivated meat intrinsically limited the strength of rationales supporting the responses regarding the perceptions of its potential impacts regarding the environment, human health, and animal welfare. An additional intrinsic issue relates to the dynamic character of the acceptance of cultivated meat, even

more marked as our results show the significance of knowledge and familiarity, both of which tend to increase with time. This means that the picture our data set shows is best understood as historical than as descriptive of today's scenario. These limitations underscore the complexities of gathering data and interpreting public opinion on cultivated meat, also exposing the need for continued research.

3.5 CONCLUSION

The acceptance of cultivated meat varies significantly across Brazil, likely due to the country's continental size, economic disparity, and rich cultural diversity. This variation suggests that the dissemination of knowledge about cultivated meat may encounter barriers related to regional public understanding, accessibility, and preferences. Our results have direct implications, as they make such challenges evident, and expose the need to considerate regional identities when promoting cultivated meat, as resistance may stem from unfamiliarity or concerns about changes to food traditions. It remains to be studied whether variations emerge in countries with different geographical, demographic and cultural profiles.

Our findings highlight the importance of regional considerations not only for academic research but also for practical applications in public policy, industry practices, and consumer education initiatives. The efficiency of public policies will benefit from targeted educational initiatives that address the specific concerns of different regions, while industry practitioners might adjust their outreach strategies to be more culturally sensitive. In addition, collaborating with local institutions is likely to foster a more productive approach to introducing cultivated meat.

Future studies are warranted to explore the influence of different demographic factors on acceptance, assess the efficacy of targeted educational strategies in enlightening perceptions, and track opinion shifts over time as knowledge and availability of cultivated meat increase. Such research will be invaluable in fostering public understanding, addressing misconceptions, supporting public policies and facilitating informed decision-making regarding cultivated meat and other alternative proteins.

REFERENCES

ABEBE GK, ISMAIL MR, KEVANY K, HAILESLASSIE HA, PAULEY T. Canadians' experiences of alternative protein foods and their intentions to alter current dietary patterns. **J Agric Food Res**. 2024;18:101354. doi:10.1016/j.jafr.2024.101354.

BALL HL. Conducting Online Surveys. **Journal of Human Lactation**. 2019;35(3):413-417. doi:10.1177/0890334419848734.

BEGHO T, ZHU Y. Determinants of consumer acceptance of meat analogues: Exploring measures of risk preferences in predicting consumption. **J Agric Food Res**. 2023;11:100509. doi:10.1016/j.jafr.2023.100509.

BHAT ZF, MORTON JD, BEKHIT AED, KUMAR S, BHAT HF. Cultured meat: challenges in the path of production and 3D food printing as an option to develop cultured meat-based products. **Altern Proteins**. 2022;1:271–95. doi:10.1201/9780429299834-9.

BISCARRA-BELLIO JC, DE OLIVEIRA GB, MARQUES MCP, MOLENTO CFM. Demand changes meat as changing meat reshapes demand: The great meat revolution. **Meat Science**. 2023;196:109040. doi:10.1016/j.meatsci.2022.109040.

BOSCARDIN M, DORR AC. Percepções dos Consumidores em Relação à Carne Cultivada. **Fronteiras: Journal of Social, Technological and Environmental Science**. 2023;12(2):89-97. doi:10.21664/2238-8869.2023v12i2.p89-97.

BRYANT C, BARNETT J. Consumer acceptance of cultured meat: A systematic review. **Meat Sci**. 2018;143:8-17. doi:10.1016/j.meatsci.2018.04.008.

BRYANT CJ, BARNETT JC. What's in a name? consumer perceptions of in vitro meat under different names. **Appetite**. 2019;137;104–113. doi:10.1016/j.appet.2019.02.021.

BRYANT C, BARNETT J. Consumer acceptance of cultured meat: An updated review (2018–2020). **AppISci**. 2020;10(15):5201. doi:10.3390/app10155201.

CATTANEO C, LAVELLI V, PROSERPIO C, LAUREATI M, PAGLIARINI E. Consumers' attitude towards food by-products: the influence of food technology neophobia, education and information. **Int J Food Sci Technol**. 2019;54:679-87. doi:10.1111/ijfs.13978.

CHRIKI S, HOCQUETTE JF. The myth of cultured meat: a review. **Front Nutr**. 2020;7:7. doi:10.3389/fnut.2020.00007.

CHRIKI S, PAYET V, PFLANZER SB, ELLIES-OURY MP, LIU J, HOCQUETTE E, REZENDE-DE-SOUZA JH, et al. Brazilian consumers' attitudes towards so-called "cell-based meat". **Foods**. 2021;10(11):2588. doi:10.3390/foods10112588.

DAGEVOS H, VERBEKE W. Meat consumption and flexitarianism in the Low Countries. **Meat Sci**. 2022;192:108894. doi:10.1016/j.meatsci.2022.108894.

DE OLIVEIRA GA, DOMINGUES CHDF, BORGES JAR. Analyzing the importance of attributes for Brazilian consumers to replace conventional beef with cultured meat. **PLoS One**. 2021;16(5). doi:10.1371/journal.pone.0251432.

DOMINGO JL, NADAL M. Carcinogenicity of consumption of red meat and processed meat: a review of scientific news since the IARC decision. **Food Chem Toxicol**. 2017;105:256–61. doi:10.1016/j.fct.2017.04.028.

DUARTE SJH, MAMEDE MV, ANDRADE SMO. Opções teórico-metodológicas em pesquisas qualitativas: representações sociais e discurso do sujeito coletivo. **Saúde Soc**. 2009;18(4):620-6. doi:10.1590/S0104-12902009000400006.

EGOLF A, HARTMANN C, SIEGRIST M. When evolution works against the future: disgust's contributions to the acceptance of new food technologies. **Risk Anal**. 2019;39(7):1546-59. doi:10.1111/risa.13279.

FERNANDES A, COSTA L, TEIXEIRA O, SANTOS F, REVILLION JP, SOUZA A. Consumption behavior and purchase intention of cultured meat in the capital of the “state of barbecue,” Brazil. **Br Food J**. 2021;123(9):3032–55. doi:10.1108/BFJ-08-2020-0698.

FLYCATCHER. Kweekvlees [Cultivated meat]. 2013. [cited 2024 Nov 04]. Available from: http://www.flycatcherpanel.nl/news/item/nwsA1697/media/images/Resultaten_onderzoek_Kweekvlees.pdf.

GARBIN VP, PINTO PT, LUZ-FREITAS MS, MOLENTO CFM. Ética animal e proteínas alternativas: questões atuais em terminologia da língua portuguesa. **Arch VetSci**. 2024;29(1). doi:10.5380/avs.v29i1.

GEIKER NRW, BERTRAM HC, MEJBORN H, DRAGSTED LO, KRISTENSEN L, CARRASCAL JR, et al. Meat and human health—current knowledge and research gaps. **Foods**. 2021;10(7):1556. doi:10.3390/foods10071556.

GFI. Construindo um sistema alimentar justo, seguro e sustentável. 2022. [cited 2024 Nov 11]. Available from: https://gfi.org.br/

GIACALONE D, JAEGER SR. Consumer acceptance of novel sustainable food technologies: A multi-country survey. **J Clean Prod**. 2023;408:137119. doi:10.1016/j.jclepro.2023.137119.

GODFRAY H, AVEYARD P, GARNETT T, HALL JW, KEY TJ, LORIMER J, et al. Meat consumption, health, and the environment. **Science**. 2018;361. doi:10.1126/science.aam5324.

HANNAN J. Meatsplaining: the animal agriculture industry and the rhetoric of denial. Sydney: Sydney University Press; 2020.

HANSEN A, JAKOBSEN J, WETHAL U. New geographies of global meatification: The BRICS in the industrial meat complex. In: HANSEN A, SYSE KL, editors.

Changing meat cultures: Food practices, global capitalism, and the consumption of animals. New York: Routledge; 2021. p. 35-59.

HARRISON R. Animal machines. London: Vincent Stuart Ltd; 1964.

HARTMANN C, SIEGRIST M. Consumer perception and behavior regarding sustainable protein consumption: A systematic review. **Trends Food Sci Technol**. 2017;61:11–25. doi:10.1016/j.tifs.2016.12.006.

HEIDEMANN MS, MOLENTO CFM, REIS GG, PHILLIPS CJC. Uncoupling meat from animal slaughter and its impacts on human-animal relationships. **Front Psychol**. 2020;11:1824. doi:10.3389/fpsyg.2020.01824.

HOCQUETTE JF. Consumer perception of livestock production and meat consumption; an overview of the special issue "Perspectives on consumer attitudes to meat consumption". **Meat Sci**. 2023;200:109163. doi:10.1016/j.meatsci.2023.109163.

IBGE. Instituto Brasileiro de Geografia e Estatística. 2022 [cited 2024 Jul 23]. In: Cidades e Estados [Internet]. [about 1 screen]. Available from: https://www.ibge.gov.br/cidades-e-estados.html?view=municipio.

ICE. Índice de Cidades Empreendedoras. Ranking 2023. 2023 [cited 2024 Nov 11]. [about 1 screen]. Available from: https://ice.enap.gov.br/ranking.

LEROY F, SMITH NW, ADESOGAN AT, BEAL T, IANNOTTI L, MOUGHAN PJ, MANN N. The role of meat in the human diet: evolutionary aspects and nutritional value. **Anim Front**. 2023;13(2):11–18. doi:10.1093/af/vfac093.

LIU J, CHRIKI S, KOMBOLO M, SANTINELLO M, PFLANZER SB, HOCQUETTE E, et al. Consumer perception of the challenges facing livestock production and meat consumption. **Meat Science**. 2023;200:109144. doi:10.1016/j.meatsci.2023.109144.

NEZLEK JB, FORESTELL CA. Food neophobia and the Five Factor Model of personality. **Food Qual Prefer**. 2019;73:210-4. doi:10.1016/j.foodqual.2018.11.007.

NGUYEN J, FERRARO C, SANDS S, LUXTON S. Alternative protein consumption: A systematic review and future research directions. **Int J Consum Stud**. 2021;46:1691-717. doi:10.1111/ijcs.12797.

NOBRE, FS. Cultured meat and the sustainable development goals. **Trends Food Sci Technol**. 2022;124:140–53. doi:10.1016/j.tifs.2022.04.011.

MANCINI MC, ANTONIOLI F. Exploring consumers' attitude towards cultured meat in Italy. **Meat Science**. 2019;150:101-10. doi:10.1016/j.meatsci.2018.12.014.

MARQUES SCC, MAUAD JRC, DOMINGUES CHF, BORGES JAR, SILVA JR. The importance of local food products attributes in Brazil consumer’s preferences. **Future Foods**. 2022;5:100125. doi:10.1016/j.fufo.2022.100125.

MICHAELIS Moderno Dicionário. [cited 2024 Nov 11]. [Internet]. Available from: https://michaelis.uol.com.br.

MICHEL F, HARTMANN C, SIEGRIST M. Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. **Food Qual Prefer**. 2021;87:104063. doi:10.1016/j.foodqual.2020.104063.

MORAIS-DA-SILVA RL, REIS GG, SANCTORUM H, MOLENTO CFM. The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States and Europe. **Front Sustain Food Syst**. 2022;6:1056615. doi:10.3389/fsufs.2022.1056615.

ONWEZEN MC, BOUWMAN EP, REINDERS MJ, DAGEVOS H. A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. **Appetite**. 2021;159:105058. doi:10.1016/j.appet.2020.105058.

PAKSERESHT A, KALIJI SA, CANAVARI M. Review of factors affecting consumer acceptance of cultured meat. **Appetite**. 2022;170:105829. doi:10.1016/j.appet.2021.105829.

PANDURANGAN M, KIM DH. A novel approach for in vitro meat production. **ApplMicrobiolBiotechnol**. 2015;99:5391-5. doi:10.1007/s00253-015-6671-5.

PASITKA L, WISSOTSKY G, AYYASH M, YARZA N, ROSOFF G, KAMINKER R, et al. Empirical economic analysis shows cost-effective continuous manufacturing of cultivated chicken using animal-free medium. **Nature Food**. 2024;5:693–702. doi:10.1038/s43016-024-01022-w.

PHILLIPS C, MOLENTO C, BOGUEVA D, MARINOVA D. Planetary health and animal and plant dietary proteins. In: PREEDY VR, editor. Plant and animal proteins in health and disease prevention. Milton Park, UK: Taylor and Francis; 2024. Forthcoming.

POORE J, NEMECEK T. Reducing food's environmental impacts through producers and consumers. **Science**. 2018;360(6392):987–92. doi:10.1126/science.aaq0216.

QIAN F, RIDDLE MC, WYLIE-ROSETT J, HU FB. Red and processed meats and health risks: how strong is the evidence? **Diabetes Care**. 2020;43(2):265-71. doi:10.2337/dci19-0063.

R CORE TEAM. R: A language and environment for statistical computing. 2023 [cited 2024]. Vienna: R Foundation for Statistical Computing. [about 1 screen]. Available from: https://www.R-project.org/.

REGMI PR, WAITHAKA E, PAUDYAL A, SIMKHADA P, VAN TEIJLINGEN E. Guide to the design and application of online questionnaire surveys. **Nepal J Epidemiol**. 2016;6(4):640-644. doi:10.3126/nje.v6i4.17258.

RUZGYS S, PICKERING GJ. Perceptions of cultured meat among youth and messaging strategies. **Frontiers in Sustainable Food Systems**. 2020;4:122. doi:10.3389/fsufs.2020.00122.

SANCHEZ-SABATE R, BADILLA-BRIONES Y, SABATÉ J. Understanding attitudes towards reducing meat consumption for environmental reasons: A qualitative synthesis review. **Sustainability**. 2019;11(22):1–38. doi:10.3390/su11226295.

SEPTIANO F, SUNG B, DUONG C, CONROY D. Are two reasons better than one? How natural and ethical appeals influence consumer preferences for clean meat. **J Retail Consum Serv**. 2023;71:103225. doi:10.1016/j.jretconser.2022.103225.

SIDDIQUI SA, BAHMID NA, KARIM I, MEHANY T, GVOZDENKO AA, BLINOV AV, NAGDALIAN AA, ARSYAD M, LORENZO JM. Cultured meat: Processing, packaging, shelf life, and consumer acceptance. **LWT – Food Science and Technology**. 2022a;172:114192. doi:10.1016/j.lwt.2022.114192.

SIDDIQUI SA, KHAN S, FAROOQI MQU, SINGH P, FERNANDO I, NAGDALIAN A. Consumer behavior towards cultured meat: A review since 2014. **Appetite**. 2022b;179:106314. doi:10.1016/j.appet.2022.106314.

SIDDIQUI SA, KHAN S, MURID M, ASIF Z, OBOTUROVA NP, NAGDALIAN AA, et al. Marketing Strategies for Cultured Meat: A Review. **Applied Sciences**. 2022c;12;8795. doi:10.3390/app12178795.

SIEGRIST M, SÜTTERLIN B, HARTMANN C. Perceived naturalness and evoked disgust influence acceptance of cultured meat. **Meat Sci**. 2018;139:213-9. doi:10.1016/j.meatsci.2018.02.007.

SIEGRIST M, HARTMANN C. Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. **Appetite**. 2020;155:104814. doi:10.1016/j.appet.2020.104814.

SOCCOL CR, MOLENTO CFM, REIS GG, KARP SG. Cultivated Meat: Technologies, Commercialization and Challenges. Springer Nature; Cham. 2024. doi:10.1007/978-3-031-55968-6.

TEIXEIRA CD, MARCHIONI DM, MOTTA VWL, CHAVES V, GOMES S, JACOB MCC. Flexitarians in Brazil: who are they, what do they eat, and why? **Appetite**. 2024;192:107093. doi:10.1016/j.appet.2023.107093.

TOMIYAMA AJ, KAWECKI NS, ROSENFELD DL, JAY JA, RAJAGOPAL D, ROWAT AC. Bridging the gap between the science of cultured meat and public perceptions. **Trends Food Sci Technol**. 2020;104:144–52. doi:10.1016/j.tifs.2020.07.019.

TUOMISTO HL, DE MATTOS MJ. Environmental impacts of cultured meat production. **Environ Sci Technol**. 2011 Jul 15;45(14):6117-23. doi: 10.1021/es200130u.

TUOMISTO HL, ELLIS MJ, HAASTRUP P. Environmental impacts of cultured meat: alternative production scenarios; 2014. In: Proceedings of the 9th international conference on life cycle assessment in the agri-food sector [Internet]. Available from: https://core.ac.uk/download/pdf/38629617.pdf.

TUOMISTO HL, RYYNÄNEN T. Environmental impacts of cultivated meat. In: SOCCOL CR, MOLENTO CFM, REIS GG, KARP SG, editors. Cultivated meat. Springer Nature; Cham: 2024. doi:10.1007/978-3-031-55968-6_14.

TSVAKIRAI C, NALLEY L, RIDER S, VAN LOO E, TSHEHLA M. The alternative livestock revolution: prospects for consumer acceptance of plant-based and cultured meat in South Africa. **J Agric Appl Econ**. 2023;55:710–29. doi:10.1017/aae.2023.36.

UNDP. Atlas do Desenvolvimento Humano no Brasil | United Nations Development Programme. 2025. Available from: https://www.undp.org/pt/brazil/desenvolvimento-humano/atlas-do-desenvolvimento-humano-no-brasil.

UNITED NATIONS, Department of Economic and Social Affairs, Population Division. World population prospects 2022 [Internet]. New York: United Nations; 2022 [cited 2024 Jun 13]. Available from: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

USDA. Brazil once again becomes the world's largest beef exporter. 2021 [cited 2024 Jun 13]. In: Economic Research Service [Internet]. [about 1 screen]. Available from: https://www.ers.usda.gov/amber-waves/2019/july/brazil-once-again-becomes-the-world-s-largest-beef-exporter/.

VALENTE JDPS, FIEDLER RA, HEIDEMANN MS, MOLENTO CFM. First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil. **PLoS One**. 2019;14(8). doi:10.1371/journal.pone.0221129.

VAN DER WEELE CN, DRIESSEN C. How normal meat becomes stranger as cultured meat becomes more normal: ambivalence and ambiguity below the surface of behavior. **Front Sustain Food Syst**. 2019;3:69. doi:10.3389/fsufs.2019.00069.

VAN DIJK B, JOUPPILA K, SANDELL M, KNAAPILA A. No meat, lab meat, or half meat? Dutch and Finnish consumers' attitudes toward meat substitutes, cultured meat, and hybrid meat products. **Food Quality and Preference**. 2023;108:104886. doi:10.1016/j.foodqual.2023.104886.

VERBEKE W, MARCU A, RUTSAERT P, GASPAR R, SEIBT B, FLETCHER D, et al. Would you eat cultured meat? Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. **Meat Science**. 2015;102;49–58. doi:10.1016/j.meatsci.2014.11.013.

WEINRICH R, STRACK M, NEUGEBAUER F. Consumer acceptance of cultured meat in Germany. **Meat Science**. 2020;1:107924. doi:10.1016/j.meatsci.2019.107924.

WILKS M, PHILLIPS CJC. Attitudes to in vitro meat: A survey of potential consumers in the United States. **PLoS One**. 2017;12(2). doi:10.1371/journal.pone.0171904.

WILKS M, PHILLIPS CJC, FIELDING K, HORNSEY MJ. Testing potential psychological predictors of attitudes towards cultured meat. **Appetite**. 2019;136:137-45. doi:10.1016/j.appet.2019.01.027.

4 SHOULD CELLULAR AGRICULTURE BE TAUGHT IN UNDERGRADUATE PROGRAMS IN BRAZIL?

ABSTRACT

The development of alternative protein production requires careful planning, with education playing a crucial role in creating new job opportunities and accomplishing the potential of cellular agriculture to meet various socioeconomic, environmental and ethical goals. This field encompasses biological disciplines, including cell cultivation, fermentation and molecular biology, as well as knowledge in broader social and environmental sciences. To prepare future professionals in this area, education and training programs must integrate expertise from such diverse fields. This study sought to understand the intention to learn about cellular agriculture among Brazilian professionals and undergraduate students. An online questionnaire was distributed from February 2022 to February 2023, receiving responses from 382 participants, including those from agrarian sciences and other fields. Of the respondents, 281 (73.6%) expressed a desire to learn about cellular agriculture, motivated by the benefits of cultivated meat and the opportunity to access state-of-the-art knowledge related to the innovative nature of the field. Interest was particularly notable among those in the agrarian sciences, who viewed this area as a promising entry into an emerging job market. Among the participants, 305 (79.8%) had heard of cultivated meat, 290 (75.9%) were interested in trying it, and 141 (36.9%) felt that consuming this type of food would impact their personal life. Notably, 43 (18.9%) indicated a willingness to switch to an exclusive consumption of cultivated meat. The study highlights interest in cellular agriculture, reflecting its perceived innovation and benefits, and signaling a demand for deeper understanding and job opportunities in the field.

Keywords: Cellular animal science. Education. Opinion. Learning.

4.1 INTRODUCTION

Concerns about the ethics and environmental consequences of conventional meat consumption have led to a rapid expansion in the development of alternatives (Godfray et al., 2018). Protein diversification appears promising for sustainability since there is a potential to significantly benefit the environment (Poore and Nemecek, 2018). Although cultivated meat production has a relatively high industrial energy demand, it requires considerably less land than conventional meat production. The climate impacts of cultivated meat vary depending on the energy source used, and it also demonstrates lower water consumption. However, achieving the sustainable development goals by 2030 may still be challenging (Tuomisto and Ryynänen, 2024). Furthermore, alternative proteins seem to address public health,

food safety, and animal welfare issues; however, they still need to navigate several pathways to become a reality (van der Weele et al., 2019; Nobre, 2022).

The term alternative protein encompasses food products developed as analogues or actual cell-based animal products which do not involve conventional systems of raising and killing animals to produce meat, eggs, milk, and all their processed forms. As such, alternative proteins are produced with a variety of methods, which can be summarized into three main categories: plant-based meat, milk, and egg analogues; fermentation products including animal proteins produced via precision fermentation; and cultivated products, which are real animal products resulting from original animal cells multiplied ex vivo, i.e., out of animal bodies (Soccol et al., 2024). There are reasons to believe such production means may become mainstream, e.g. according to Tubb and Seba (2020), we are going through the second domestication, the domestication of microorganisms and animal cells for the production of food, with exponentially higher possibilities for productivity.

Brazil is the largest exporter of beef meat and the second largest producer of meat in the world (Economic Research Service, 2021), comparably relevant also for poultry and pork markets. According to Morais-da-Silva et al. (2022a), the introduction of alternative protein products in Brazil requires planning to maximize the benefits and mitigate the disadvantages for the country's development. Within such planning, investment in training and development of people seems essential to create new employment opportunities (Heidemann et al., 2020b; Morais-da-Silva et al.,2022b).In this sense, fifteen actions have been classified within three main domains: societal dialogue, changes in policies and regulations, and the design of market initiatives (Biscarra-Bellio et al., 2023). Among these actions, supporting education and dialogue among universities seems necessary for people to find new job opportunities within alternative protein production chains, since cellular agriculture has vast potential to promote various socioeconomic goals (Marques et al., 2024; Mugabe et al., 2024).

Cellular agriculture not only enables the production and access to proteins in diverse locations and environments but also stimulates economic development and job creation (Stephens et al., 2018). Thus, this innovative approach to food production may become a key piece in building a more sustainable and inclusive food system. As with any field, providing training through diverse educational initiatives enhances skills development. Such achievement benefits from actively

involving students in learning programs focused on agricultural technology and innovation (Newell and Glaros, 2024). Although the science of producing cultivated meat on a large scale is under development, it seems already relevant to consider how education can enhance job opportunities, given that positions in the cultivated meat sector require a higher level of education and skills for production (Spiros et al., 2023).

According to Stout et al. (2024), dedicated education and training programs for building the future cellular agriculture workforce will need to draw on expertise from various fields. The topic of alternative proteins has been advancing significantly in the industry and the media, but it remains an emerging topic in academia and the field may greatly benefit from an impulse in academic research and in specific professional training (GFI, 2022). For this to materialize, initiatives within Universities are required, hence universities are central players and important actors for economic development, and their contributions towards sustainability efforts at the local level may be substantial. However, there is a need for a better understanding of the potential role that universities can play in addressing global challenges (Leal Filho et al., 2019). One aspect that collaborates with the efficiency of academic achievements is a match between initiatives by universities and students interests.

Although students in higher education tend to value innovation (Stout et al., 2024), their stance regarding the new food protein production chains is yet to be understood, especially when considering relevant differences which may exist when comparing the various related fields of knowledge and initial reaction to alternative proteins. This study aimed to understand the intention to learn about cellular agriculture by Brazilian professionals and students.

4.2 MATERIAL AND METHODS

An online questionnaire with 10 questions (Table 1) was made available from February 2022 to February 2023. The sociodemographic data (questions 1 to 4) collected information on age, city, professional activity, and, if applicable, the respondents' undergraduate program. Questions 5 to 9 were multiple-choice, with questions 6 to 9 also requiring justifications. Question 10 was open-ended and non-compulsory.

TABLE 1. QUESTIONNAIRE AVAILABLE ONLINE FROM FEBRUARY 2022 TO FEBRUARY 2023.

Number	Question	Answers
1.	How old are you?	open-ended compulsory
2.	Where do you reside? (City/state)	open-ended compulsory
3.	What is your occupation?	open-ended compulsory
4.	If you are currently pursuing an undergraduate degree, what is your major?	open-ended compulsory
5.	Have you ever heard about cultivated meat?	yes/no compulsory
6.	Would you be interested in learning about this technology? Please justify your response.	yes/no compulsory
7.	Do you believe this new technology could impact your professional success in your current field? Please justify your response.	yes/no/maybe compulsory
8.	Would you be open to trying cultivated meat if you knew its origin and quality of preparation? Please justify your response.	yes/no/maybe compulsory
9.	Do you think consuming this type of food would affect any aspect of your personal life? Please justify your response.	yes/no/maybe compulsory
10.	What are your opinions on cultivated meat?	open-ended non-compulsory

The justifications for questions 6 to 9 and the responses to the open-ended question 10 were analyzed by two researchers, who individually synthesized the responses into preliminary central ideas using the Collective Subject Discourse (CSD) method (Duarte et al., 2009). The results of the individual analyses conducted by the two researchers were then combined to define the final central ideas. The results were presented in the form of an info graphic for question 7 and as a word cloud for questions 9 and 10. The results for questions 5 to 10, presented as absolute numbers and percentages tables.

4.3 RESULTS

Our results come from 382 participants from various regions of Brazil, with 204 (53.4%) aged between 18 and 29, 124 (32.5%) between 30 and 49, and 54 (14.1%) over 50 years-old. Of the respondents, 263 (68.8%) were from the State of Parana, with 241 (63.1%) from the city of Curitiba, capital of the State, and its metropolitan

region, and with 40 (10.4%) from Minas Gerais and 19 (4.97%) from São Paulo. The remaining 39 (10.2%) were grouped due to the low representation of each region. Concerning their occupation, 76 (19.9%) respondents were working in agrarian sciences, including 63 veterinarians, nine animal scientists, and four agronomists. Around a third of total respondents (125, 32.7%) were involved in other fields; they were grouped due to the low representation of each one of 30 other cited fields. In addition, there were 186 (48.7%) undergraduate students, with 138 (74.2%) within the agrarian sciences (130 in veterinary medicine and eight in animal science programs) and 48 (25.8%) within other areas. Thus, respondents were grouped into four categories: professionals in agrarian sciences, other professionals, undergraduate students in agrarian sciences, and other undergraduate students. There were five respondents who were simultaneously professionals and undergraduate students.

When asked if they had heard about cultivated meat, 305 (79.8%) of the total respondents answered yes, and 77 (20.2%) answered no. Considering the different categories, among professionals in agrarian sciences, 68 (89.5%) answered yes; among those from other fields, 85 (68.0%) answered yes; among undergraduate students in agrarian sciences, 123 (89.1%) answered yes; finally, among undergraduate students in other areas, 32 (66.7%) answered yes (Table 2).

From all respondents, 281 (73.6%) answered that they would like to learn about cellular agricultureand200 (71.2%) provided justifications for their answers. The main ideas in the justifications were grouped into four themes: i) benefits, with phrases such as “it is a technology that may reduce the number of animals raised for meat production”, “this technology produces meat without the slaughter of animals” and “it will bring benefits to society”; ii) knowledge, with phrases such as “acquire knowledge about this new area”, “knowledge is never in excess”, “to form an opinion about cultivated meat”, and “it is important to be informed”; iii) innovation, with phrases such as “curricular bases should follow innovations”, “innovation drives the world”, and “it is important to understand innovations thoroughly to apply them safely”; iv) opportunity, with phrases such as “it is important to have a competitive edge in the job market to work where there are few professionals”, and “it has significant potential for professional activity, because it is a field with vast growth potential (Figure 1). All responses are presented in Table 2.

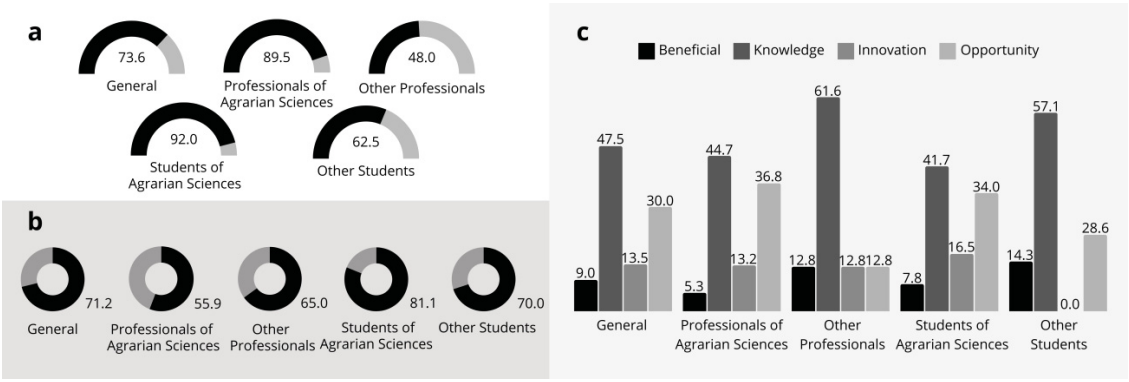


FIGURE 1. GENERAL AND GROUP PERCENTAGE RESPONSES BY 382 PARTICIPANTS REGARDING INTEREST IN LEARNING ABOUT CELLULAR AGRICULTURE (A); PARTICIPANTS WHO PROVIDED A JUSTIFICATION TO THEIR ANSWERS (B); REASONS TO LEARN ABOUT CELLULAR AGRICULTURE (C), FROM FEBRUARY 2022 TO FEBRUARY 2023.

When asked if this new technology would interfere with their professional success, 51 (13.4%) of the total respondents answered yes, 254 (66.5%) answered no, and77 (20.1%) answered maybe. Of the total, 180 (47.1%) respondents provided justifications. The main ideas in the justifications for responses were grouped into i) ignorance, with phrases such as “I do not know how to comment on it”, “I cannot be certain about the answer”, and “I am unfamiliar with it”; ii) disinterest, with phrases such as “it is outside my field of expertise”, “I do not need it to perform my professional activities”, and “I do not work in that area”; iii) neophobia, with phrases such as “the production sector is at risk, many people could lose their income”, and “it is going to limit the activities of various professionals”; iv) opportunities, with phrases such as “it could create job opportunities”, and “I believe it is a great opportunity for my professional success, potentially opening new avenues for success”. The percentages for the responses are shown in Table 2.

When asked if they would be open to try cultivated meat, provided the origin and quality of its preparation were known, 290 (75.9%) respondents answered yes, 33 (8.6%) no and 59 (15.5%) maybe; in addition, 295 (77.2%) provided justifications for their answers. The main ideas in the justifications for responses were grouped into i) alternative, with phrases such as “I believe it will be an alternative to traditional meat consumption”; ii) animal welfare, with phrases such as “I would love to be able to consume meat without it involving the death of animals”; iii) knowledge, with phrases such as “to know in order to form an opinion”;iv) disinterest, with phrases such as “I would not go back to eating meat”; v) doubts, with phrases as “I do not

know”; vi) innovation, with phrases such as “I am in favor of new technologies”; v) environmental, with phrases such as “to continue consuming animal protein in a sustainable way”; vi) neophobia, with phrases such as “I am somewhat apprehensive, everything new brings some hesitation”; vii) health, with phrases such as “I believe it would not harm my health”; viii) food security, with phrases such as “it could potentially be a solution to food scarcity”. The percentages of the responses are shown in Table 2.

From all respondents, 141 (36.9%) answered that consuming this type of food would affect some aspect of their personal lives, 135 (35.3%) answered that it would not and 106 (27.8%) answered maybe; 227 (59.4%) provided justifications. Among the justifications there were i) cultivatism, with phrases such as “I would prefer to eat cultivated meat rather than meat from slaughtered animals”; ii) disinterest, with phrases such as “I am vegetarian” and “I am vegan”; iii) alternative, with phrases such as “my family members still consume meat from slaughter and it would be an alternative to them”; iv) animal welfare, with phrases such as “it would reduce animal exploitation”; v) cost, with phrases such as “high cost”; vi) doubt, with phrases such as “I am in doubt”; and vii) health, with phrases such as “better nutritional qualities” (Figure 2). The percentages of the responses are shown in Table 2.

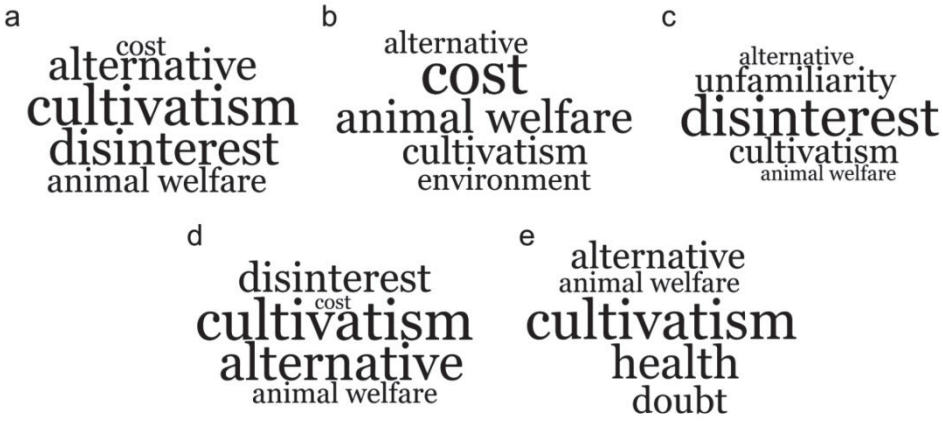


FIGURE 2. WORDS REPRESENTING THE IDEAS EXPRESSED BY 227 RESPONDENTS OF AN ONLINE QUESTIONNAIRE CONDUCTED BETWEEN FEBRUARY 2022 AND FEBRUARY 2023, WHO JUSTIFIED THEIR RESPONSES ABOUT HOW CELLULAR AGRICULTURE WOULD AFFECT THEIR PERSONAL LIVES (A); WORDS REPRESENTING THE IDEAS EXPRESSED BY 38 PROFESSIONALS IN AGRARIAN SCIENCES (B), 71 PROFESSIONALS IN OTHER FIELDS (C), 90 UNDERGRADUATE STUDENTS IN AGRARIAN SCIENCES (D), AND 28 STUDENTS IN OTHER FIELDS (E).

When asked about the personal opinions on cultivated meat, 317 (82.9%) respondents expressed their views, and the main ideas in the responses were: i) animal welfare, with phrases such as “it would be interesting to reduce animal suffering”; ii) nice, with phrases such as “It is cool”, and “I am optimistic”; iii) one welfare, with phrases such as “a new opportunity to protect the planet, animals, and humans” and “reduction of environmental impacts in the world”; iv) unfamiliarity, with phrases such as “I do not know”; v) doubt, with phrases such as “maybe, I am not sure yet”; vi) innovation, with phrases such as “I believe it is an innovative technology that will bring significant advancements in various fields”; vii) unnecessary, with phrases such as “I think it is unnecessary”; viii) neophobia, with phrases such as “I find it strange”, and “I find it repulsive”; ix) food security, with phrases such as “it is an option since the demand for food is increasing” and x)environment, with phrases such as “important step for the environment” (Figure 3). The percentages of the responses are shown in Table 2.

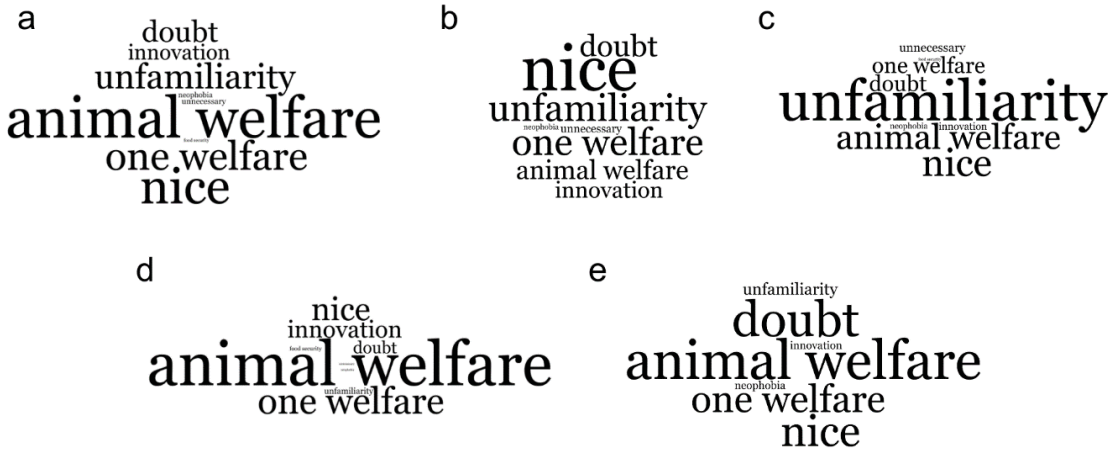


FIGURE 3. WORDS REPRESENTING THE IDEAS EXPRESSED BY 317 RESPONDENTS OF AN ONLINE QUESTIONNAIRE CONDUCTED BETWEEN FEBRUARY 2022 AND FEBRUARY 2023, WHO ISSUED THEIR OPINIONS ABOUT CULTIVATED MEAT (A); 62 PROFESSIONALS IN AGRARIAN SCIENCES (B), 100 PROFESSIONALS IN OTHER FIELDS (C), 117 UNDERGRADUATE STUDENTS IN AGRARIAN SCIENCES (D), AND 39 STUDENTS IN OTHER FIELDS (E).

TABLE 2. FULL DATASET WITH THE PARTICIPATION OF RESPONDENTS FROM AN ONLINE QUESTIONNAIRE AVAILABLE FROM FEBRUARY 2022 TO FEBRUARY 2023, IN BRAZIL.

Question	Answers	Groups of respondents				
		General	Professionals Agrarian Sciences	Other professionals	Undergraduate students Agrarian Sciences	Undergraduate students other areas
5	Yes	305 (79.8%)	68 (89.5%)	85 (68.0%)	123 (89.1%)	32 (66.7%)
	No	77 (20.2%)	8 (10.5%)	40 (32.0%)	15 (10.9%)	16 (33.3%)
6	Yes	290 (75.9%)	60 (78.9%)	80 (64%)	115 (83.3%)	38 (79.2%)
	No	33 (8.6%)	6 (7.9%)	16 (12.8%)	7 (5.1%)	4 (8.3%)
	Maybe	59 (15.5%)	10 (13.2%)	29 (23.2%)	16 (11.6%)	6 (12.5%)
	Justified	295 (77.2%)	59 (77.6%)	93 (74.4%)	113 (81.9%)	32 (66.7%)
				Justifications		
	Alternative	37 (12.5%)	5 (8.5%)	12 (12.9%)	16 (14.2%)	4 (12.5%)
	Animal welfare	27 (9.2%)	5 (8.5%)	5 (5.4%)	12 (10.6%)	5 (15.6%)
	To know	116 (39.3%)	27 (45.7%)	32 (34.4%)	4 (42.5%)	10 (31.3%)
	Disinterest	30 (10.2%)	5 (8.5%)	11 (11.8%)	10 (8.8%)	4 (12.5%)
	Doubts	26 (8.8%)	4 (6.8%)	14 (15.1%)	5 (4.4%)	3 (9.4%)
	Innovation	29 (9.8%)	4 (6.8%)	10 (10.8%)	11 (9.7%)	4 (12.5%)
	Environmental	6 (2.0%)	2 (3.4%)	2 (2.1%)	2 (1.8%)	1 (3.6%)
	Neophobia	12 (4.1%)	4 (6.8%)	4 (4.3%)	-	2 (6.2%)
	Health	9 (3.1%)	3 (5.0%)	2 (2.1%)	3 (2.7%)	-
	Food security	-	-	1 (1.1%)	2 (1.8%)	-
7	Yes	281 (73.6%)	68 (89.5%)	60 (48.0%)	127 (92.0%)	30 (62.5%)
	No	101 (26.4%)	8 (10.5%)	65 (52.0%)	11 (8.0%)	18 (37.5%)
	Justified	200 (71.2%)	38 (55.9%)	39 (65%)	103 (81.1%)	21 (70.0%)
				Justifications		
	Benefits	18 (9.0%)	2 (5.3%)	24 (61.6%)	8 (7.8%)	3 (14.3%)
	Knowledge	95 (47.5%)	17 (44.7%)	24 (61.6%)	43 (41.7%)	12 (57.1%)
	Innovation	27 (13.5%)	5 (13.2%)	5 (12.8%)	17 (16.5%)	-
	Opportunities	60 (30.0%)	14 (36.8%)	5 (12.8%)	35 (34%)	6 (28.6%)
8	Yes	51 (13.4%)	24 (31.6%)	31 (24.8%)	66 (47.8%)	20 (41.7%)
	No	254 (66.5%)	28 (36.8%)	51 (40.8%)	49 (35.5%)	9 (18.7%)
	Maybe	77 (20.1%)	24 (31.6%)	43 (34.4%)	23 (16.7%)	19 (39.6%)
	Justified	180 (47.1%)	37 (48.7%)	66 (52.8%)	52 (37.7%)	25 (52.1%)
				Justifications		
	Ignorance	12 (6.7%)	1 (2.7%)	5 (7.6%)	5 (9.6%)	1 (4.0%)
	Disinterest	105 (58.3%)	18 (48.7%)	47 (71.2%)	24 (46.2%)	16 (64.0%)
	Neophobia	8 (4.4%)	4 (10.8%)	-	4 (7.7%)	-
	Opportunities	55 (30.6%)	14 (37.8%)	14 (21.2%)	19 (36.5%)	18 (32.0%)
9	Yes	141 (36.9%)	24 (31.6%)	31 (24.8%)	66 (47.8%)	20 (41.7%)

	No	135 (35.3%)	28 (36.8%)	51 (40.8%)	49 (35.5%)	9 (18.8%)
	Maybe	106 (27.8%)	24 (31.6%)	43 (34.4%)	23 (16.7%)	19 (39.5%)
	Justified	227 (59.4%)	38 (50.0%)	71 (56.8%)	90 (65.2%)	28 (58.3%)
				Justifications		
	Cultivatism	43 (18.9%)	5 (13.2%)	10 (14.1%)	22 (24.4%)	6 (21.4%)
	Disinterest	38 (16.7%)	3 (7.9%)	16 (22.5%)	14 (17.8%)	3 (10.7%)
	Alternative	34 (15%)	3 (7.9%)	7 (9.7%)	20 (22.2%)	4 (14.3%)
	Animal welfare	26 (11.5%)	6 (15.8%)	6 (8.5%)	11 (12.2%)	3 (10.7%)
	Costs	22 (9.7%)	8 (21.1%)	6 (8.5%)	8 (8.9%)	-
	Doubts	18 (7.9%)	4 (10.5%)	6 (8.5%)	4 (4.4%)	4 (14.3%)
	Unfamiliarity	15 (6.6%)	3 (7.9%)	10 (14.1%)	-	2 (7.1%)
	Health	13 (5.7%)	1 (2.6%)	6 (8.5%)	1 (1.1%)	5 (17.9%)
	Culture	7 (3.1%)	1 (2.6%)	-	6 (6.7%)	-
	Environment	7 (3.1%)	4 (10.5%)	2 (2.8%)	-	1 (3.6%)
	Personal values	4 (1.8%)	-	2 (2.8%)	2 (2.2%)	-
10	**Answered**	317 (83.0%)	62 (81.6%)	100 80.0 (%)	117 84.8 (%)	39 (79.6%)
				Opinions		
	Animal welfare	78 (24.6%)	7 (11.3%)	17 (17.0%)	44 (37.6%)	10 (25.6%)
	One welfare	54 (17.0%)	10 (16.1%)	11 (11.0%)	26 (22.2%)	7 (17.9%)
	Nice	67 (21.1%)	17 (27.4%)	19 (19.0%)	23 (19.7%)	8 (20.5%)
	Unfamiliarity	47 (14.8%)	10 (16.1%)	28 (28.0%)	6 (5.1%)	3 (7.7%)
	Doubt	40 (12.6%)	8 (12.9%)	11 (11.0%)	12 (10.3%)	9 (23.1%)
	Innovation	29 (9.1%)	6 (9.7%)	5 (5.0%)	17 (14.5%)	2 (5.1%)
	Neophobia	10 (3.2%)	2 (3.2%)	4 (4.0%)	2 (1.7%)	2 (5.1%)
	Food security	6 (1.9%)	0 (0.0%)	2 (2.0%)	4 (3.4%)	0 (0.0%)
	Unnecessary	11 (3.5%)	3 (4.8%)	6 (6.0%)	2 (1.7%)	0 (0.0%)

4.4 DISCUSSION

Our results indicate that a relevant percentage of students and professionals are familiar with cultivated meat, particularly those in agrarian sciences. Knowledge about cultivated meat in Brazil has been studied before, with variable results. Valente et al. (2019) described a knowledge rate of 81.9% among 626 respondents from Southern region of Brazil and Biscarra-Bellio and Mendes (submitted) described a knowledge rate of 38.3% among809 respondents from Southeast and Northeast regions of Brazil. Beyond the cultural diversity among these Brazilian regions, there was also a factor of participants educational levels, who\ich were higher for Valente

et al. (2019). Heidemann et al. (2020b), observed resistance to cultivated meat from veterinarians (76.8%; 209/272) and animal scientists (23.2%; 63/272), primarily due to a lack of knowledge. Lack of familiarity is known to be a significant factor correlated with resistance, including the idea that as contact with cultivated meat increases the more normal it becomes (van der Weele and Driessen, 2019).

The importance of promoting the dissemination of the new technologies as well as opportunities for professional knowledge and increasing engagement with it was restated by the views of the majority of our participants. The task is then establishing initiatives to move in the direction of such goals. According to Biscarra-Bellio and Mendes et al. (in preparation), some academic initiatives, such as extension projects, are reaching external audiences to present alternative proteins in Brazil. The "Bife Sem Bicho" (Animal-free Steak) extension project at the Federal University of Parana, running from December 2023 to August 2024, has reached 2.800 people through social media posts about cellular agriculture on Instagram, and the podcast videos on Youtube have received 585 views. Additionally, in Brazil, there are five groups of undergraduate and postgraduate students from Federal University of Parana (UFPR), State University of Campinas (UNICAMP), Federal University of Minas Gerais (UFMG), Federal University of Santa Catarina (UFSC), and São Paulo State University (UNESP) participating in The Good Food Institute Alternative Protein Project, a global student movement dedicated to turning universities into engines for alternative protein education, research, and innovation, which aims to provide information about alternative proteins to diverse audiences (GFI 2024). Although some initiatives involving academia may reach the general public, more communication channels are required to provide not only scientific news but also general updates on the topic. Independent initiatives do not seem to be sufficient to attain the educational goals in a robust manner, and the relevance of public policies has been highlighted (Herrero et al., 2020; Marques et al., 2024).

Participants expressed an interest in learning about cellular agriculture, driven by the benefits of cultivated meat and its production for the animals, the environment, and human health, as well as the opportunity to acquire knowledge in this innovative field. Notably, students showed more interest than professionals, with many individuals within agrarian sciences viewing this area as a chance to engage in the emerging job market. Conversely, individuals from various fields expressed a lack of

interest in pursuing a career in this domain, citing concerns about job loss and feeling inadequately informed about the topic. In the first analysis of the perceptions of veterinarians and animal scientists regarding cultivated meat in Brazil, Heidemann et al. (2020b) observed resistance due to the perceived artificiality and sensory characteristics of cultivated meat. The perceived artificiality maybe mitigated with more awareness through discussions on this subject (Bryant and Barnett, 2018), which sums to the importance of educational efforts.

Cellular agriculture lies at the intersection of bioengineering, food science, nutrition science, agricultural science, food policy, and consumer psychology, and thus the variation of views across participants from different fields is relevant. Our results bring a hint that such variation may be significant, within a context which is building up in the literature. Brazilian experts identified the field of veterinary and animal sciences as a promising profession in the initial stage of cultivated meat development, and that there is potential for cultivated meat production to create new and higher-skilled jobs for these professionals, since they have knowledge in animal health, genetics, nutrition, meat inspection and meat quality (Heidemann et al., 2020b; Biscarra-Bellio e Paolini et al., submitted); however, experts from other countries did not mention these fields (Morais-da-Silva et al., 2022b).This issue seems to require further attention, considering that resistance against the development of cellular agriculture may build up commonly stemming from those in the first part of the food production chain, due to a perception of potential loss. According to Morais-da-Silva et al. (2022a), professionals who already work in the food production chain may be relocated to other positions and areas within the new production systems (Morais-da-Silva et al., 2022a). According to Bogueva and Marques et al. (2023), knowledge about new products and their distribution chains is essential for the actors to engage in diversification that may allow for participation in the new systems. Moreover, since the technology is currently under development, completely new roles may emerge as the new chain matures (Heidemann et al., 2020b). The complex relationship between perceptions and level of familiarity and knowledge on one side, and stances that those involved may assume can be determinant of the future of alternative protein chains and warrants research and policy initiatives.

The understanding of a demand for learning about cellular agriculture provided by our results leads to questions about the offering of educational opportunities. The availability of courses in cellular agriculture remains scarce, with some countries showing first initiatives. For instance, in the United States there is The Cellular Agriculture & Bio Fabricated Foods, organized by Tufts University and The University of North Carolina (UNC), developed in partnership with students from the Chapel Hill Alt Protein Project, a student organization developed with support from the Good Food Institute (GFI); in Singapore, the Nanyang Technological University (NTU) offers the undergraduate course Future Foods: Introduction to Advanced Meat Alternatives; in the Netherlands, a proposal led by Wageningen University & Research, in collaboration with Maastricht University and Delft University of Technology, has been put forward to develop three courses about precision fermentation, cultured meat, and the societal and sustainability aspects of cellular agriculture; in Israel, Technion (Israel Institute of Technology) announced the establishment of the Sustainable Protein Research Center; in Canada, The Cellular Agriculture Institute in the University of Alberta and the University of the Fraser Valley have recent initiatives around training.

In Brazil, some educational initiatives have also been taken. The Federal University of Parana offered five editions of the Introduction to Cellular Animal Sciences course, in both graduate and postgraduate programs since 2020. The Federal University of Minas Gerais, where a prototype of cultivated meat has been presented in 2023, offers the course Cellular Agriculture with a Focus on Cultivated Meat for students of the Biological Sciences program. The State University of Campinas offers the course Alternative Proteins: Made from Plants, Fermentation, and Cultivated Meat within the graduate program of the Food Engineering Faculty. Additional initiatives around training have been led in Brazil by the GFI. For instance, the GFI offers an open-access online course. The Science of Alternative Proteins, and provides the syllabi for courses on Alternative Proteins available in the resources section of their website (GFI, 2022). Thus, there are increasing opportunities to learn about cellular agriculture in Brazil, including formal initiatives that can evolve to contribute to fulfilling the demand for new professionals in the nascent alternative protein industry; however, it is likely that a more concerted effort involving educational policies will be required considering the type of production ecosystem

which needs to be developed if cellular agriculture production chains are to be satisfactorily established. In this sense, a more integrated training approach can be suggested, and an initial structure may already be underway. According to Biscarra-Bellio and Paolini (submitted), there are mandatory courses in veterinary medicine, animal science, bioengineering and food engineering programs that, despite their current focus on conventional animal protein topics, can be adapted to relate to different stages of the cultivated meat chain. Additionally, there are courses in some programs that have more specific content directly related to the new technology of cultivated meat production, which can serve as an inspiration for creating new courses to be implemented in the curricula of all interested programs.

Our results show that the recognition of the roles of some professionals may be increasing with the advancement of cellular agriculture in the country, which is in agreement with Reis et al. (2020).However, some negative attitudes may be related to the fact that cultivated meat is a novel food not yet available for consumption in Brazil (Wilks et al., 2019). As the field of alternative proteins becomes more well-known, the intention to learn and enter this new market is likely to increase even further, and those with early access to educational initiatives tend to be favored.

The low qualification of labor in the first stages of the animal production chain, i.e. on-farm animal raising activities, may pose a significant social problem if there is a profound change in the meat production chain in Brazil or a significant global sourcing movement, from conventional to cellular products marketing. Thus, there is a need to develop a national workforce to meet the demands for positions in the new chain and provide job opportunities for people, with positive side-effects of educational opportunities. While some workers may be able to transition to other agricultural activities, such as growing ingredients for new alternative meat chains, most job opportunities will require higher qualifications (Morais-da-Silva et al., 2022b; Stout et al., 2024). Approximately 15% of individuals working in Brazilian agribusiness , including activities in agriculture and livestock production, processing and other agri-services, have higher education, whether incomplete or complete (CEPEA, 2023). A classic argument of labor sociology and labor economics is that technological upgrading objectively causes workers to lose their jobs, but the actual historical experience since the industrial revolution tells us that it does not cause large-scale structural unemployment (Zhang, 2023).However, there are risks if

educational activities are not carefully fostered. The demand for high intention of learning about cellular agriculture among students and professionals in Brazil is valuable, as such current and future professionals are those who will be on-field, interacting directly with farmers and others who will benefit from learning about cellular agriculture.

The respondents of this study were inhabitants of urban areas, and this fact may explain the low resistance among the participants. Positive impacts are perhaps mostly visible in urban areas, with localizing high-skilled jobs in biotechnology and engineering (Newel and Glaros, 2024), and negative consequences may fall upon rural communities (Marques et al., 2024). According to Tubb and Seba (2020), jobs in animal feed and production activities can be most affected, represent up to 23% of the jobs in the conventional meat chain. Thus, policies are needed to protect rural communities from losing out. Training and retraining programs must both develop the next generation of scientists capable of tackling the technological hurdles and create employment in areas where animal agriculture might decline (Stout et al., 2024).

A minority of respondents believed that new technologies would not interfere with their professional success, justified by a lack of knowledge, doubts, or disinterest in the topic, either because they did not wish to work professionally in the field or as consumers, found them unnecessary, or experienced neophobia. According to Finistrella et al., 2024, neophobia is the fear of the new and unknown. Thus, disinterest or resistances, that are justified by neophobia, are likely to be attenuated by education. Furthermore, neophobia tends to decrease as cultivated meat becomes more familiar to society at large: as put by van der Weele and Driessen (2019), normal meat may become stranger as cultivated meat becomes more normal.

Some respondents expressed confidence that the arrival of this new technology would not negatively impact their professional success, as they understand that this area enables the production of complementary protein alternatives, thus adding to conventional production systems instead of replacing them. They referred to a logical phenomenon, which may be led by interplay of various factors, such as the increasing demand for meat, comparative characteristics between traditional and cell-based products, and degree of environmental and animal ethics awareness by consumers, with cost arguably leading the way. The costs of cellular products are recognized as an important challenge to be overcome. Current

production technologies result in low yields, leading to economic projections that hinder the scalability of cultivated meat (Hubalek et al., 2022). More recently, Pasitka et al. (2024) conducted a techno-economic analysis for a theoretical production facility of 50,000 L, showing that the cost of cultivated chicken can drop to the range of organic meat at US$6.20 per pound by utilizing perfusion technology. However, such theoretical predictions remain to be proved in practice. Overall, as common with disruptive innovations, initial cellular agriculture costs seem prohibitive but they tend to drop dramatically, on a historical series time frame of first fifteen years (Tubb and Seba, 2020).

Most respondents were ready to try cultivated meat, provided they knew its origin and preparation method. They were also concerned about the welfare of animals raised and slaughtered for conventional meat production, seeing these types of foods as an alternative to consume products of animal origin.

The cultural context determines the place that different foods occupy within people (Giacolone et al., 2023). Valente et al. (2019) observedthat63.6% of the 626 participants declared they would eat cultivated meat. Gomez-Luciano et al. (2019) in their survey with 216 respondents reported that the willingness to purchase cultivated meat alternatives in Brazil may increase if the perception of its healthiness, safety and nutritiousness increases. According to a survey carried out by Chriki et al. (2021) with 4471 respondents, 46.6% of Brazilians consider cultivated meat as a promising and acceptable option and 66% were willing to try it. A later survey with 225 respondents confirms that Southeastern Brazilians are willing to consume cultivated meat: 80.9% of the respondents were willing to try it (de Oliveira et al., 2021). In Porto Alegre (Rio Grande do Sul, Southern Brazil), a survey with 538 respondents demonstrated that six out of ten people were willing to try cultivated meat alternatives (Fernandes et al., 2021). Among 809 respondents from Southeast and Northeast regions of Brazil, 265 (32.7%) expressed interest in trying cultivated meat, and 211 (26.1%) stated that they would not consume it, while 333 (41.2%) were unsure (Biscarra-Bellio and Mendes et al., in preparation). The studies seem to indicate a positive outlook for the arrival of cultivated meat in Brazil, which is confirmed by our results. However, an important variance in results is evident, as expected in a country as big and diverse as Brazil. Thus, more research is required to better understand whether it will become a daily part of consumers' plates in the country.

Most respondents believed that their personal lives could be changed if they started consuming cultivated meat, opting for eating cultivated meat exclusively. The frequency of such answers suggests a role for new terminology, such as “cultivatism”, to indicate a preference for consuming animal products originating from cellular agriculture. This positioning may indicate that cultivated meat is seen by many as a solution for mitigating pre-existing cognitive dissonance, where people enjoy eating meat but are troubled by the harm caused to animals in its production (Hopwood and Bleidorn, 2019). According to Loughnan et al., 2014, it is necessary to provide a novel perspective for everyday naturalized actions like eating meat, which are not commonly conceptualized as moral choices, to deal with the meat paradox, and it is necessary to offer a new perspective on normalized actions like eating meat, which are not commonly viewed as moral choices, to address the meat paradox. With the advent of alternative proteins, the meat paradox may feel easier to confront, and desensitization toward animals may decrease, as people would no longer have to tolerate animal suffering for the sake of meat consumption (Heidemann et al., 2020a).

In addition to animal welfare, some participants cited that alternative proteins could help reduce access difficulties to food worldwide. Cultivated meat represents innovations that promise to enhance food security (Nobre, 2022), as reducing the consumption of conventional animal products may contribute to achieving this goal (Alexandre et al., 2017). Given the wide variety of formulations and blends, alternative proteins can meet the nutritional demands of many. Furthermore, some waste from the food industry can be up cycled to create novel ingredients. Such practices not only support food security but also contribute to the goal of establishing a sustainable global food supply system (Malila et al., 2024).

In summary, the flourishing of cellular agriculture depends on the training of its workers in all levels and related areas. Although our study relies on a small non-stratified sample of the total population of those involved in food production in the country, it indicates that structuring education in cellular agriculture is well-received by some, as there appears to be an awareness of job opportunities in this emerging field in the studied region. Even though it is not of high interest to all, innovations are commonly picked up by a few who tend to become leaders, and our results show that these few are currently available.

As limitations of this work, Brazil's diversity highlighted the need for more research with greater stratification of respondents, allowing for a more accurate characterization of Brazilians' views across different areas. The "other" category reflected this variety and may have limited the interpretation of the data. Additionally, the research instrument used proved insufficient for exploring the reasons and logic behind the responses. To gain a deeper understanding of participants' opinions, it would be ideal to conduct more research using semi-structured interviews, which can reveal important nuances that were not captured in the current format. When interpreting the comments left by our respondents, it is important to consider the fact that people with a more positive outlook on the topic may feel more motivated to leave additional comments, as this request for opinion about cultivated meat was not mandatory. Therefore, a bias toward a higher proportion of positive comments is likely in our study. Another issue is the limited interaction with respondents who showed disinterest in the topic. If predictions are fulfilled, it is plausible that their lives will be changed by the development of cellular agriculture. This issue deserves further attention so that transitions do not leave anyone behind.

Our results showed that Brazilian undergraduate students and professionals seem interested in learning about cellular agriculture to acquire the skills and competencies that will enable them to take advantage of the opportunities which this emerging field can offer. Thus, it is possible to suggest a demand for the development of educational programs and infrastructure to prepare professionals who already have some knowledge of the subject but wish to deepen their understanding. Despite the limitations, our study highlights the importance of investigating the views and opinions of students and professionals identified as the current or future workforce in food production regarding alternative proteins. More studies with professionals and students from diverse fields of knowledge in different regions of Brazil are needed to better understand both the demand and how new knowledge can be most effectively presented and utilized by those interested.

4.5 CONCLUSION

Our results showed that Brazilian undergraduate students and professionals seem interested in learning about cellular agriculture to acquire the skills and

competencies that will enable them to take advantage of the opportunities which this emerging field can offer. Thus, it is possible to suggest a demand for the development of educational programs and infrastructure to prepare professionals who already have some knowledge of the subject but wish to deepen their understanding. Despite the limitations, our study highlights the importance of investigating the views and opinions of students and professionals identified as the current or future workforce in food production regarding alternative proteins. More studies with professionals and students from diverse fields of knowledge in different regions of Brazil are needed to better understand both the demand and how new knowledge can be most effectively presented and utilized by those interested.

REFERENCES

ALEXANDER, Peter; BROWN, Calum; ARNETH, Almut; DIAS, Clare; FINNIGAN, John; MORAN, Dominic; ROUNSEVEL, Mark D. A. Could Consumption Of Insects, Cultured Meat Or Imitation Meat Reduce Global Agricultural Land Use? **Global Food Security**, V. 15, P. 22-32, 2017. https://doi.org/10.1016/j.gfs.2017.04.001.

BARBER, Bernard. Resistance By Scientists To Scientific Discovery: This Source Of Resistance Has Yet To Be Given The Scrutiny Accorded Religious And Ideological Sources. **Science**, v. 134, p. 596–602, 1961. https://doi.org/10.1126/science.134.3479.596.

BISCARRA-BELLIO, Jennifer Cristina; MENDES, Gabriel; OLEGÁRIO, Juliana Do Canto; MOLENTO, Carla Forte Maiolino. Teaching, Research And Extension In Cellular Animal Science In A Brazilian University. (In preparation).

BISCARRA-BELLIO, Jennifer Cristina; OLIVEIRA, Gabriela Bussi; MARQUES, Maria Cecilia Pinto; MOLENTO, Carla Forte Maiolino. Demand Changes As Meat Reshapes Demand: The Great Meat Revolution. **Meat Science**, v. 196, article 109040, 2023. https://doi.org/10.1016/j.meatsci.2022.109040.

BISCARRA-BELLIO, Jennifer Cristina. C.; PAOLINI, Georgia; MOLENTO, Carla Forte Maiolino. Cellular Agriculture Education In Brazilian Undergraduate Programs: Not As Far As It Seems. (Submitted).

BOGUEVA, Diana; MARQUES, Maria; MOLENTO, Carla Forte Maiolino; MARINOVA, Dora; PHILLIPS, Clive J. C. Will The Cows And Chickens Come Home? Perspectives Of Australian And Brazilian Beef And Poultry Farmers Towards Diversification. **Sustainability**, v. 15, article 12380, 2023. https://doi.org/10.3390/su151612380.

BRYANT, Christopher; BARNETT, Julie. Consumer Acceptance Of Cultured Meat: A Systematic Review. **Meat Science**, v. 143, p. 8–17, 2018. https://doi.org/10.1016/j.meatsci.2018.04.008.

CEPEA. Boletim Mercado De Trabalho Do Agronegócio Brasileiro: 4º Trimestre De 2023. Retrieved from: **Boletim Mt Agro (Usp.Br)**. Accessed: set. 2024.

CHRKI, Sghaier; PAYET, Vincent; PFLANZER, Sérgio Bertelli; ELLIES-OURY, Marie-Pierre; LIU, Jingjing; HOCQUETTE, Élise; REZENDE-DE-SOUZA, Jonatã Henrique; HOCQUETTE, Jean-François. Brazilian Consumers' Attitudes Towards So-Called "Cell-Based Meat". **Foods**, v. 10, n. 11, article 2588, 2021. https://doi.org/10.3390/foods10112588.

DE OLIVEIRA ANDRADE, Gabriela; DOMINGUES, Carla Heloisa De Faria; BORGES, João Augusto Rossi. Analyzing The Importance Of Attributes For Brazilian Consumers To Replace Conventional Beef With Cultured Meat. **PLoS One**, v. 16, n. 5, article e0251432, 2021. https://doi.org/10.1371/journal.pone.0251432.

DUARTE, Sebastião Junior Henrique; MAMEDE, Marli Villela; ANDRADE, Sônia Maria Oliveira. Opções Teórico-Metodológicas Em Pesquisas Qualitativas: Representações Sociais E Discurso Do Sujeito Coletivo. **Saúde E Sociedade São Paulo**, v. 18, n. 4, p. 620–626, 2009. https://doi.org/10.1590/s0104-12902009000400006.

ECONOMIC RESEARCH SERVICE - USDA. Brazil Once Again Becomes The World's Largest Beef Exporter. **Amber Waves**, 21 jul. 2019. Retrieved from: https://www.ers.usda.gov/amber-waves/2019/july/brazil-once-again-becomes-the-world-s-largest-beef-exporter/. Accessed: 15 ago. 2024.

FERNANDES, Alice Munz; COSTA, Lucas Teixeira; TEIXEIRA, Odilene De Souza; SANTOS, Francisca Viviane Dos; REVILLION, Jean Philippe Palma; DE SOUZA, Ângela Rozane Leal. Consumption Behavior And Purchase Intention Of Cultured Meat In The Capital Of The "State Of Barbecue," Brazil. **British Food Journal**, v. 123, n. 9, p. 3032–3055, 2021. https://doi.org/10.1108/bfj-08-2020-0698.

FINISTRELLA, Viviana; GIANNI, Nicoletta; FINTINI, Danilo; MENGHINI, Deny; AMENDOLA, Silvia; DONINI, Lorenzo Maria; MANCO, Melania. Neophobia, Sensory Experience, And Child's Schemata Contribute To Food Choices. **Eating And Weight Disorders**, v. 29, p. 25, 2024. https://doi.org/10.1007/s40519-024-01657-5.

GFI. Plano de Ensino Para Disciplinas em Proteínas Alternativas. **The Good Food Institute**, Brasil, 2022. Retrieved from: *GFI Brasil Lança Plano de Ensino para Disciplinas em Proteínas Alternativas - GFI Brasil*. Accessed: 15 ago. 2024.

GFI. The Alternative Protein Project. **The Good Food Institute**, 2024. Retrieved from: *The Alt Protein Project | GFI Brasil*. Accessed: 20 set. 2024.

GIACALONE, Davide; JAEGER, Sara. R. Consumer Acceptance of Novel Sustainable Food Technologies: A Multi-Country Survey. **Journal of Cleaner**

Production, v. 408, article 137119, 2023. https://doi.org/10.1016/j.jclepro.2023.137119.

GODFRAY, Charles J.; AVEYARD, Paul; GARNETT, Tara; HALL, Jim W.; KEY, Timothy J.; LORIMER, Jamie; PIERREHUMBERT, Ray T.; SCARBOROUGH, Peter; SPRINGMANN, Marco; JEBB, Susan A. Meat Consumption, Health, and the Environment. **Science**, v. 361, article eaam5324, 2018. https://doi.org/10.1126/science.aam5324.

GÓMEZ-LUCIANO, Cristiano Alberto; DE AGUIAR, Luis Kluve; VRIESEKOOP, Frank; URBANO, Beatriz. Consumers' Willingness to Purchase Three Alternatives to Meat Proteins in the United Kingdom, Spain, Brazil, and the Dominican Republic. **Food Quality and Preference**, v. 78, article 103732, 2019. https://doi.org/10.1016/j.foodqual.2019.103732.

HEIDEMANN, Marina Sucha; MOLENTO, Carla Forte Maiolino; REIS, Germano Glufke; PHILLIPS, Clive. J. C. Uncoupling Meat from Animal Slaughter and Its Impacts on Human-Animal Relationships. **Frontiers in Psychology**, v. 11, 2020a. https://doi.org/10.3389/fpsyg.2020.01824.

HEIDEMANN, Marina Sucha; TACONELI, Cesar. A.; REIS, Germano Glufke; PARISI, Giulia; MOLENTO, Carla Forte Maiolino. Critical Perspective of Animal Production Specialists on Cell-Based Meat in Brazil: From Bottleneck to Best Scenarios. **Animals**, v. 10, n. 9, p. 1678, 2020b. https://doi.org/10.3390/ani10091678.

HERRERO, Ario; THORNTON, Philip K.; MASON-D'CROZ, Daniel, et al. Innovation Can Accelerate the Transition Towards a Sustainable Food System. **Nature Food**, v. 1, n. 4, p. 266–272, 2020. https://doi.org/10.1038/s43016-020-0074-1.

HOPWOOD, Christopher J.; BLEIDORN, Wiebke. Psychological Profiles of People Who Justify Eating Meat as Natural, Necessary, Normal, or Nice. **Food Quality and Preference**, v. 75, p. 10–14, 2019. https://doi.org/10.1016/j.foodqual.2019.02.004.

HUBALEK, Sophie; POST, Mark J.; MOUTSATSOU, Panagiota. Towards Resource-Efficient and Cost-Efficient Cultured Meat. **Current Opinion in Food Science**, v. 47, article 100885, 2022. https://doi.org/10.1016/j.cofs.2022.100885.

LEAL FILHO, Walter; VARGAS, Valeria Ruiz; SALVIA, Amanda Lange, et al. The Role of Higher Education Institutions in Sustainability Initiatives at the Local Level. **Journal of Cleaner Production**, v. 233, p. 1004-1015, 2019. https://doi.org/10.1016/j.jclepro.2019.06.059.

LOUGHNAN, Steve; BASTIAN, Brock; HASLAM, Nick. The Psychology of Eating Animals. **Current Directions in Psychological Science**, v. 23, n. 2, p. 104-108, 2014. https://doi.org/10.1177/0963721414525781.

MALILA, Yuwares; OWOLABI, Iyiola O.; CHOTANAPHUTI, Tanai; SAKDIBHORNSSUP, Napat; ELLIOTT, Christopher T.; VISESSANGUAN, Wonnop;

KAROONUTHAISIRI, Nitsara; PETCHKONGKAEW, Awanwee. Current Challenges of Alternative Proteins as Future Foods. **Science of Food**, v. 8, p. 53, 2024. https://doi.org/10.1038/s41538-024-00291-w.

MARQUES, Maria Cecilia; MORAIS-DA-SILVA, Rodrigo Luis; BISCARRA-BELLIO, Jennifer Cristina; UETA, Mariana Hase; MOLENTO, Carla Forte Maiolino. Global and Regional Policies for Cultivated Meat. In: Soccol, Carlos Ricardo; Molento, Carla Forte Maiolino; Reis, Germano Glufke; Karp, Susan Grace (Eds.). **Cultivated Meat: Technologies, Commercialization and Challenge**. Springer, 2024. https://doi.org/10.1007/978-3-031-55968-6_18.

MENDES, Gabriel; BISCARRA-BELLIO, Jennifer Cristina; MOLENTO, Carla Forte Maiolino. Do Attitudes to Cultivated Meat Vary Within the Same Country? The Case of Brazil. (Submitted).

MORAIS-DA-SILVA, Rodrigo Luis; REIS, Germano Glufke; SANCTORUM, Hermes; MOLENTO, Carla Forte Maiolino. The Social Impact of the Transition from Conventional to Cultivated and Plant-Based Meats: Evidence from Brazil. **Food Policy**, v. 111, article 102337, 2022a. https://doi.org/10.1016/j.foodpol.2022.102337.

MORAIS-DA-SILVA, Rodrigo Luis; VILLAR, Eduardo G.; REIS, Germano Glufke; SANCTORUM, Hermes; MOLENTO, Carla Forte Maiolino. The Expected Impact of Cultivated and Plant-Based Meats on Jobs: The Views of Experts from Brazil, the United States, and Europe. **Humanities and Social Sciences Communications**, v. 9, article 297, 2022b. https://doi.org/10.1057/s41599-022-01316-z.

MUGABE, Deus; HANLEY, Laura; NEWMAN, Lenore; NEWMAN, Kate; FRASER, Evan D. G. The Potential for Cellular Agriculture to Advance Sustainable Development Goals. In: **Cellular Agriculture: Technology, Society, Sustainability and Science**, p. 361-377, 2024. https://doi.org/10.1016/b978-0-443-18767-4.00020-2.

NEWELL, Robert; GLAROS, Alesandros. Chapter 3 - Sustainable Food Systems, Development Paths, and Scenarios for Cellular Agriculture. In: FRASER, E. D. G.; KAPLAN, D. L.; NEWMAN, L.; YADA, R. Y. (Eds.). **Cellular Agriculture**, p. 29-45. Academic Press, 2024. https://doi.org/10.1016/b978-0-443-18767-4.00022-6.

NOBRE, Farley Simon. Cultured Meat and the Sustainable Development Goals. **Trends in Food Science & Technology**, v. 124, p. 140-153, 2022. https://doi.org/10.1016/j.tifs.2022.04.011.

PASITKA, Laura; WISSOTSKY, Guy; AYYASH, Muneef; YARZA, Nir; ROSOFF, Gal; KAMIINKER, Revital; NAHMIAS, Yaakov. Empirical Economic Analysis Shows Cost-Effective Continuous Manufacturing of Cultivated Chicken Using Animal-Free Medium. **Nature Food**, v. 5, p. 693-702, 2024. https://doi.org/10.1038/s43016-024-01022-w.

POORE, Joseph; NEMECEK, Thomas. Reducing Food's Environmental Impacts Through Producers and Consumers. **Science**, v. 360, n. 6392, p. 987-992, 2018. https://doi.org/10.1126/science.aaq0216.

REIS, Germano Glufke; HEIDEMANN, Marina Sucha; BORINI, Felipe Mendes; MOLENTO, Carla Forte Maiolino. Livestock Value Chain in Transition: Cultivated (Cell-Based) Meat and the Need for Breakthrough Capabilities. **Technology in Society**, v. 62, article 101286, 2020. https://doi.org/10.1016/j.techsoc.2020.101286.

SOCCOL, Carlos Ricardo; MOLENTO, Carla Forte Maiolino; REIS, Germano Glufke; KARP, Susan Grace. **Cultivated Meat: Technologies, Commercialization and Challenge**. Springer, 2024. https://doi.org/10.1007/978-3-031-55968-6_18.

SPIROS, Kris; HALL, Sawyer; DARLING, Jane; BENAMI, Maya (Eds.). **Modern Meat: The Next Generation of Meat from Cells**. 1. ed. Cellular Agriculture Society, 2023.

STEPHENS, Neil; SILVIO, Lucy Di; DUNSFORD, Illtud; ELLIS, Marianne; GLENCROSS, Abigail; SEXTON, Alexandra. Bringing Cultured Meat to Market: Technical, Socio-Political, and Regulatory Challenges in Cellular Agriculture. **Trends in Food Science & Technology**, v. 78, p. 155-166, 2018. https://doi.org/10.1016/j.tifs.2018.04.010.

STOUT, Andrew J.; YUEN Jr., John S. K.; SALDANA, Yadira Tejeda; FRASER, Evan D. G.; KAPLAN, David. Education and Training. In: **Cellular Agriculture: Technology, Society, Sustainability and Science**, p. 487-513, 2024. https://doi.org/10.1016/b978-0-443-18767-4.00004-4.

TUBB, Catherine; SEBA, Tony. Rethinking Food and Agriculture 2020–2030: The Second Domestication of the Cow, and the Collapse of Industrial Livestock Farming. **RethinkX**, 2020. Retrieved from: https://www.rethinkx.com/food-and-agriculture. Accessed: [15 Aug. 2024].

TUOMISTO, Hanna L.; RYYNÄNEN, Tony. Environmental Impacts of Cultivated Meat. In: SOCCOL, Carlos Ricardo; MOLENTO, Carla Forte Maiolino; REIS, Germano Glufke; KARP, Susan Grace (Eds.). **Cultivated Meat: Technologies, Commercialization and Challenge**. Springer, Cham, 2024. https://doi.org/10.1007/978-3-031-55968-6_14.

VALENTE, Júlia de Paula Soares; FIEDLER, Rodrigo Alonso; HEIDEMANN, Marina Sucha; MOLENTO, Carla Forte Maiolino. First Glimpse on Attitudes of Highly Educated Consumers Towards Cell-Based Meat and Related Issues in Brazil. **PLOS ONE**, v. 14, n. 8, article e0221129, 2019. https://doi.org/10.1371/journal.pone.0221129.

VAN DER WEELE, Core; DRIESSEN, Clemens. How Normal Meat Becomes Stranger as Cultured Meat Becomes More Normal: Ambivalence and Ambiguity Below the Surface of Behavior. **Frontiers in Sustainable Food Systems**, v. 3, p. 69, 2019. https://doi.org/10.3389/fsufs.2019.00069.

WILKS, Matti; PHILLIPS, Clive J. C.; FIELDING, Kelly; HORNSAY, Matthew J. Testing Potential Psychological Predictors of Attitudes Towards Cultured Meat. **Appetite**, v. 136, p. 137-145, 2019. https://doi.org/10.1016/j.appet.2019.01.027.

ZHANG, Zhuo. The Impact of the Artificial Intelligence Industry on the Number and Structure of Employments in the Digital Economy Environment. **Technological Forecasting and Social Change**, v. 197, article 122881, 2023a. https://doi.org/10.1016/j.techfore.2023.122881

5 TEACHING, RESEARCH AND EXTENSION IN CELLULAR ANIMAL SCIENCE AT THE FEDERAL UNIVERSITY OF PARANA

ABSTRACT

The rise of the global population in the next decades coupled with the meatification of diets in Asia and Africa will drive a substantial increase in global demand for meat. This raises significant concerns regarding animal welfare, public health, food security and the sustainability of conventional animal production. Cellular animal science offers promising response to such challenges. Training skilled professionals in cellular agriculture is essential to support its development and integration. This study outlines the implementation process of Cellular Animal Science at the Federal University of Parana (UFPR), including the development of the first courses in Introduction to Cellular Animal Science at both graduate and undergraduate levels and the establishment of the Cellular Animal Science Laboratory (Zoocel). Additionally, the extension project Bife Sem Bicho was conceptualized to propagate knowledge about cultivated animal products and other alternative proteins, engaging both university audiences and the public. Our findings indicate that UFPR has made significant advancement in the cellular animal science field by establishing foundational courses, a dedicated laboratory, and outreach initiatives. The study reveals strong student demand for hands-on training in alternative protein production systems, underscoring the importance of further laboratory developments for teaching. Additionally, the integration of research, teaching, and outreach activities has promoted scientific knowledge and increased student interest in cellular agriculture, highlighting the potential of this model to train qualified professionals and expand awareness of and skills in sustainable food production systems alternatives to intensive animal production.

Keywords: Cellular agriculture; education; laboratory.

5.1 INTRODUCTION

The global population is expected to reach approximately 8.5 billion by 2030, 9.7 billion by 2050, and 10.4 billion by 2100 (United Nations, 2022). In addition, the continuous increase in global meat demand also derives from a process known as meatification, a concept describing that meat is moving from the periphery to the center of human diets, as daily meat consumption expands from western countries to become a global phenomenon (Hansen, Jakobsen, & Wethal, 2021). The ever-growing world meat demand raises critical concerns regarding the intensification of animal production and related animal welfare, public health, food security and sustainability issues (Bryant & Barnett, 2020; Biscarra-Bellio et al., 2023; Phillips et al., 2024; Philips et al., 2024).

Cellular animal science, also known as cellular agriculture, has emerged as a promising alternative to conventional animal production systems, offering a

production perspective that does not involve animal slaughter (Post, 2014a; Slade, 2018; Biscarra-Bellio et al., 2023). Such field has attracted increasing attention from the public, popular media, animal welfare organizations, the scientific community, and investors (Goodwin & Shoulders, 2013; Schneider, 2013; Verbeke et al., 2015; Stephens et al., 2018,Biscarra-Bellio et al., 2023), especially following the production of the first prototype of a cultivated burger in 2013 (Post, 2014b). Thus, it seems relevant that this innovative food technology be introduced and promoted in the academic environment through teaching, research, and outreach initiatives (Newell & Glaros, 2024).

Addressing the educational needs of a new scientific domain requires a significant expansion of university initiatives, since few institutions have specialized curricula and this gap of knowledge can limit the exploration of career opportunities within the sector (Stout et al., 2024).This is likely especially relevant when highly specialized professionals are needed to accelerate progress in the field. The implementation of introductory and specialized courses may help; however, very few courses that focus specifically on cellular agriculture are currently available (The Good Food Institute, 2022). Cellular animal science not only can open doors to a wide range of careers but may also offer the chance to be part of a transformative movement towards a more sustainable future (Morais-da-Silva et al., 2022). Thus, with such robust reasons, documenting and analyzing the implementation of alternative protein initiatives at specific universities is warranted to understand best strategies for effectively addressing the educational gaps and supporting the growth of the emerging food production chains.

Therefore, this study aims to document and analyze the implementation of Cellular Animal Science at Federal University of Parana (UFPR), in Southern Brazil, focusing on three main aspects: the offering of the first courses in Introduction to Cellular Animal Science (ICAS) at both undergraduate and graduate levels, including the perceptions of course attendees; the reporting of the process of conceptualizing, installing, and operating a research and educational cellular agriculture laboratory (the Cellular Animal Science Laboratory –Zoocel of the Federal University of Parana - UFPR); and the scientific dissemination of cellular agriculture through an outreach initiative(the extension project Bife Sem Bicho). This article is expected to contribute to a broader understanding of how universities can address educational gaps and

support the growth of alternative protein sectors, for the benefit of humans, animals and the environment.

5.2 METHODOLOGY

Our documentation encompassed comprehensive details on the implementation process of Cellular Animal Science at UFPR, through a period spanning from 2019 to 2024. In the teaching context, comprehensive surveys were conducted to outline the procedures necessary to design and implement the Introduction to Cellular Animal Science course at UFPR, at both undergraduate and graduate levels. These surveys included interviews and collaborative efforts with international Universities and a thorough review of online information, all of which with the essential support from the Good Food Institute – GFI Brazil. Subsequently, an analysis of the records in the Microsoft Teams groups from the editions offered was used to develop a renewed course syllabus, as well as to assess the number of enrolled students in the first course editions and their level of participation.

To better understand the impact the courses had on student learning, an online questionnaire consisting of 16 questions was administered from February 2022 to July 2024. Students from the five editions of ICAS, from 2020 to 2024, were invited to participate in this research. Additionally, individuals who attended isolated lectures, classes, or webinars on cellular animal science conducted by members of the Cellular Animal Science Laboratory (Zoocel) team were invited to participate and share their opinions. This research was approved by the Federal University of Parana's Ethics Committee for Research Involving Humans under protocol number 5.669.675. The questions that make up the questionnaire are presented in Table 1. To analyze the justifications provided for the responses to open-ended questions, key-words provided by respondents were used as central ideas using the Discourse of the Collective Subject (DCS) method (Duarte, Mamede, & Andrade, 2009).

TABLE 1. QUESTIONNAIRE ADMINISTERED FROM FEBRUARY 2022 TO JULY 2024, COMPOSED OF A TOTAL OF 9 QUESTIONS.

Number	Question
1	How old are you?
2	Which city do you live in? (City/state)
3	If you are an undergraduate student, what program are you enrolled in?
4	If you have a postgraduate degree, what type is it? (Specialization, Master's, PhD, postdoctoral research)

5	Have you ever attended a class, course, discipline, or lecture on Cellular Animal Science (alternative proteins, plant-based meat, cultivated meat, precision fermentation)?
6	What is the impact of learning cellular animal science on your career?
7	Do you feel prepared to enter this new production chain?
8	If you have had access to the content, on a scale of 1 to 10, how would you rate it?
9	If you would like to learn about something that was not mentioned, please tell us what you felt was missing.

Regarding the laboratorial context, equipment and facility testing activities, which included the evaluation of the Zoocel implementation, were analyzed. This involved introducing activities in the laboratory, testing the functionality of the equipment and the suitability of the facilities for the specific purposes of cellular animal science. The data obtained during these activities were recorded, including descriptive information about the procedures performed, results achieved, challenges encountered, and solutions implemented. This report is intended to provide an initial frame work for the process of implementing routine practices in the laboratory.

Regarding the extension initiatives, the Bife Sem Bicho project aims to disseminate scientific knowledge about cellular animal science through posts on Instagram and LinkedIn and interviews published on the YouTube channel. The Bife Sem Bicho publications were analyzed through engagement metrics on social media, in the Insights tab on Instagram and the Analytics tab provided by YouTube Creator Studio.

5.3 RESULTS

The Federal University of Parana (UFPR) was the first Brazilian University to implement cellular animal science content in both postgraduate and undergraduate programs, with courses entitled Introduction to Cellular Animal Science (ICAS), and first offered in 2020. Under this context, concomitant initiatives related to the insertion of the area within the University and regional scenario have arisen; however, the process of fundraising for the implementation of a cellular animal science laboratory at UFPR was marked by challenges. Since 2019, there have been several attempts to secure funding, such as submitting a proposal to Funding Authority for Studies and Projects (FINEP), which was then not successful. Additionally, attempts with the third sector did not prosper either. However, continuous efforts bore important fruits, such as the first Scientific Initiation mentorship on cultivated meat, funded by UFPR, and

the mentoring of postgraduate students with CAPES scholarships from the Veterinary Science Post-graduation Program, whose work resulted in relevant scientific publications. An important achievement came in 2020, with the approval of a proposal submitted to GAIA, a Belgian animal protection NGO, which made it possible to hire a postdoctoral researcher to study the social impacts of cellular animal science. The impact of this funding was decisive, as it allowed for the continuation of strategic studies and the formation of a solid knowledge base.

One significant milestone to date was the approval of the New Research and Innovation Arrangement (NAPI) in Alternative Proteins in 2023, with funding from the State Government of Parana through its research supporting agency, Fundação Araucária. With 36 goals, NAPI Alternative Proteins aims to strengthen Parana and Brazil's food producers through innovations in biotechnology, engineering, veterinary medicine, animal science, administration, agronomy, and related areas producers by utilizing innovative production systems to develop the essential stages to produce alternative proteins, while consolidating teaching, research and outreach in the field and establishing a new food industry in the State. With a consolidated multidisciplinary team that includes six research groups in three universities across the State (UFPR, State University of Maringa, and Pontifical Catholic University of Parana), the NAPI Alternative Proteins project represents a force in research and innovation in Brazil, as the team expertise covers a complex range of knowledge for the advancement in the production of alternative proteins. This financial support made it possible to establish a network of researchers and broaden the research and educational laboratorial infrastructure. With such developments, the acquisition of further resources through new partnerships and successful grant applications was significantly facilitated. For example, a second major funding was secured through the project Aflorabem, recently approved in a FINEP call. This scenario opens doors for collaborations with other institutions and funding agencies, solidifying cellular animal science as an area of growing innovation and relevance in the State of Parana. It also clearly demonstrates the value of investments in cellular agriculture, which can rapidly attract more funding and thus start a virtuous cycle of investment and scientific as well as agrarian and industrial development, with evident social and economic benefits.

The Cellular Animal Science Laboratory (Zoocel) is a teaching, research, and extension unit dedicated to cellular agriculture, with its implementation being one of

the objectives of the NAPI Alternative Proteins project. Established in September 2023, Zoocel offers conditions for the development of scientific projects involving food production through cell cultivation on a bench scale. It aims to support activities across various industry spheres, including education, consumer acceptance, biosecurity, and the inclusion of conventional producers in the alternative protein value chain. As a newly established laboratory, it is currently possible to glimpse short-term impacts following its creation. The laboratory is part of the Agricultural Sciences Sector at the University, on a campus that hosts the Veterinary Medicine, Animal Science, and Agronomy programs, where research, teaching, and extension activities initiated by the laboratory and its research group have been conducted. In the following sections, we analyzed teaching, research, and extension dimensions of Cellular Animal Science implementation at UFPR.

5.3.1 Teaching

The Federal University of Parana has offered five courses related to cellular animal science, both at the undergraduate and graduate levels. In July 2020, the UFPR Veterinary Sciences Post-graduate Program (PPGCV) launched its first course in this area, entitled Introduction to Cellular Animal Science, offered online and in English. This inaugural course was offered for15 students. Later, in October 2020, the same program offered the second edition of this course, again in English and online, with an increased enrollment opportunity to 20 students. Subsequently, in November 2021, the program offered the third edition of the course, this time in Portuguese, entitled Introdução à Zootecnia Celular, also online, now for30 students. All editions reached full student enrollment, with additional students on a waiting list.

The postgraduate course covered a wide range of essential topics for the study of cellular animal science. The course program encompassed basic concepts from cellular agriculture and plant-based, fermentation and cell-cultivation production processes to issues such as the power of disruption for problems related to conventional animal production chains. Topics explored included Sustainable Development Goals (SDGs), animal welfare, consumer market trends, value chain in meat transition, social impacts, one welfare and global health, and industry development. Additionally, the courses provided a comprehensive understanding of biotechnology fundamentals, food safety, technology of products of animal origin, food security, and teaching and research practices. This interdisciplinary approach

offered students a global perspective of the field, enabling them to understand the various factors driving the transformation of the food and biotechnology industries. The main weakness of the Introduction to Cellular Animal Science courses was their completely theoretical approach, with no hands-on activities due to the absence of laboratorial infrastructure.

In 2022, a request for approval of an optional ICAS course was submitted to both the academic Programs in Veterinary Medicine and in Animal Science at UFPR and, after approval was granted; in March 2023 the Programs received their first ICAS course edition, in Portuguese and entitled Introdução à Zootecnia Celular (Figure 1).

FIGURE 1. FIRST COURSE OF INTRODUCTION TO CELLULAR AGRICULTURE OFFERED TO THE VETERINARY MEDICINE AND ANIMAL SCIENCE UNDERGRADUATE PROGRAM AT FEDERAL UNIVERSITY OF PARANA (UFPR) IN MARCH 2023.

This optional course, coded AZ145, attracted 37 enrolled students. With a workload of 18 hours, the course was offered in-person. Subsequently, in February 2024, the same course was offered again for undergraduate students, with 16 enrolled students. Thus, in total, the ICAS course has attracted 118 students with its five editions offered at both graduation and post-graduation levels.

The study plan for the undergraduate course covered a variety of fundamental topics for a comprehensive understanding of the field, representing an update on the previous editions for postgraduation students. These topics included concepts related

to alternative proteins, exploring different sources and production methodologies, and analyzing new food production systems, highlighting innovative technologies transforming the food industry and positively impacting animal ethics, sustainability, food safety and security, and public health. Public policies were also discussed, reflecting on how legislation and regulations may shape the development and expansion of cellular animal science, and the social impacts related to this new food production method. The plan also included topics like education and research, emphasizing the importance of advancing knowledge in this field, and animal welfare, highlighting the ethics associated with reducing animal suffering through biotechnology. Global health was an important point, reflecting on how cellular animal science can contribute to more sustainable food systems, which are also safer for public health, especially considering the reduction of the risk of antimicrobial resistance and new pandemics (United Nations Environment Program and International Livestock Research Institute (2020). Finally, economic aspects such as investments and startups both in Brazil and worldwide were covered, opening reflections on how the market is responding to cellular agriculture and how emerging companies are driving the transition to new food production methods.

5.3.1.1 Students' opinions about their learning experiences

All students were invited to fill a post-course evaluation form. Of the 41 respondents, 30 (73.2%) were between 18 and 30 years old, 3 (7.3%) were between 31 and 40, and 8 (19.5%) were over 41 years old. Of the total, 34 (82.9%) were from Curitiba, Parana, while the other 7 (17.1%) were from other five Brazilian states. Among the respondents, 30 (73.2%) were undergraduate students, with 27 (90%) studying veterinary medicine, 2 (6.7%) in animal science, and 1 (3.3%) in bioprocess engineering and biotechnology. The remaining 11 (26.8%) were postgraduates, including 1 (9.1%) with a specialization, 4 (36.3%) with a master's degree, 5 (45.5%) with a doctorate, and 1 (9.1%) who had already completed a postdoctoral fellowship. Among the participants, 17 (41.4%) completed undergraduation, 10 (24.4%) completed postgraduation, while 12 (29.3%) accessed the content through lectures, and 2 (4.9%) did not access the content. Overall, 38 respondents (92.7%) expressed interest in pursuing a career in the field, while 3 (7.3%) felt less inclined to do so. As for the perceived readiness to enter workforce in the field, 15 (36.6%) felt ready, 7

(17.1%) felt unprepared, and 19 (46.3%) were uncertain. Respondents suggested additional educational initiatives, with 17 (32.7%) supporting the establishment of a full postgraduate program dedicated to cellular agriculture, 3 (5.7%) supporting a graduate program, 27 (52.0%) the inclusion of courses in existing programs, and 5 (9.6%) the integration of cellular agriculture content into current courses within existing programs. A majority (73.2%) rated the course as excellent, with some overlapping with the 21 (51.2%) respondents who in addition expected more in-depth and practical activities (Figure 2).

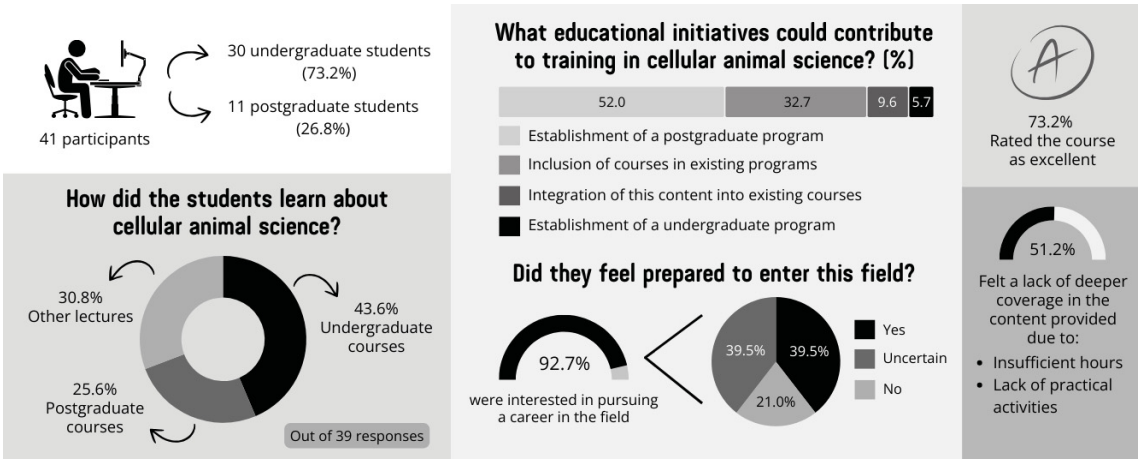


FIGURE 2. OPINIONS OF RESPONDENTS WHO PARTICIPATED IN THE INTRODUCTION TO CELLULAR ANIMAL SCIENCE COURSES OR RELATED ACTIVITIES AT UFPR FROM 2020 TO 2024.

The results suggest that the cellular agriculture courses had a significant impact on students' career considerations, indicating that such courses are effective in raising awareness and interest in this field. Additionally, there is a clear demand for practical activities and a need to enhance students' confidence in their preparedness for careers in alternative proteins. While the courses played an important role, there are opportunities to further refine the course structure, especially given the current availability of laboratory facilities at the University.

The structuring and implementation of an introductory course proved to be relatively straightforward and cost-effective, with a significant impact on student education, resulting in a positive cost-benefit ratio and demonstrating a viable alternative for integrating cellular agriculture and alternative proteins into the university curriculum. Additionally, participants' feedback highlighted the demand for the inclusion of related topics within existing courses, which could be an equally effective and less resourceful strategy for initially promoting the field. Expanding the

availability of a dedicated course across various programs in agricultural sciences, biological sciences, and bioprocess engineering may further attract interested students. Overall, the offering of an introductory cellular agriculture course is both viable and worthwhile, as a strategic approach to bring students close to this new field in the absence of resources to the offering of a full course with laboratory activities. In addition, such an educational initiative facilitates attaining the support for the full development of the area within the University, as it attracts student attention and puts cellular agriculture as a live topic on campus. Finally, the more institutions engage with cellular agriculture, the easier it becomes for the field to flourish, as external support is vital in the first steps. In our case, the fundamental support came through the essential work of the GFI Brazil, whose efforts we can now join to further support cellular agriculture in our country.

5.3.2 Research

The inauguration of Zoocel at UFPR was one of the objectives of the project NAPI Alternative Proteins. The founding goals of the laboratory were teaching and research in the field of alternative proteins, more specifically establishing primary cellular culture for cultivated meat production, developing alternative culture media free of animal-derived ingredients, producing proves of concept of cultured meat in small-scale conditions, and training and education resulting from scientific initiation, master's, doctoral, and postdoctoral opportunities. Although this report focuses on the establishment of the Zoocel laboratory at the Agrarian Sector of the UFPR, it is important to consider that the NAPI Alternative Proteins is a broader project in which other five research groups have as fruitful and relevant activities as those within the Zoocel umbrella, each group with their own identities and goals.

For the purpose of creating a fully operational laboratory dedicated to cellular agriculture teaching and research, we combined our previous experiences with those of other groups within the NAPI Alternative Proteins, and conducted literature research to compile essential information about the basic materials and equipment needed for such a laboratory. Equipment listed included biosafety cabinet, peristaltic compressor pump, laboratory water bath, centrifuge, CO_2 incubator, CO_2 cylinders, distiller, liquid N_2 container, vertical refrigerator, horizontal freezer, AID pipette, inverted light microscope, autoclave, sterilization and drying oven, magnetic stirrer,

pH meter, adjustable volume micropipette, precision scales, simple microscope, thermocycler, bioreactor for animal cell culture, and computers, in addition to consumable chemical, biological and laboratory materials (for a more detailed list, please contact authors directly). Based on this preliminary list, an analysis of the infrastructure for setting up the laboratory was conducted, using the two rooms located in the Center for Innovations in Agricultural Sciences (CIAG) in the UFPR Agricultural Sciences Sector which were designated for setting the Zoocel up.

The biosafety level considered most suitable for working with animal cells from both established lineages and primary culture was level 2 (BSL-2). One of the rooms (Room 1) was designated for washing, sterilization, preparation, and storage of materials, also serving as a gowning anteroom, while the other (Room 2) was reserved for laboratory activities where users must wear personal protective equipment, such as lab coats, caps, and masks. In addition, internal connections between the two rooms were established through the opening of a door and a window, and the outside door in Room 2 was permanently closed. According to these definitions, the placement of the listed equipment was considered, including creating floor plans and 3D models for adequate layout visualization. During this process, some difficulties were identified, such as delays in advancing activities and specific structural issues, and some adaptations were made accordingly.

To establish the workflow at the Zoocel laboratory, the facilities were first cleaned, including the biosafety cabinet, incubator, benches, and floor. The stock of reagents and consumable materials was checked and recorded. The cabinet was tested for proper operation by placing nutrient agar plates inside the work area with the airflow on for one hour, then placing them in the incubator to check for bacterial growth. The incubator was also equipped with a CO2 cylinder, which was tested for leaks and monitored constantly. The acquisition of our first the bioreactor was an important event, providing new possibilities as well as a landmark for the Zoocel activities. It consists of a control tower and two 2-liter autoclavable glass vessels. It arrived in the laboratory in June 2024, and procedures for its operation are currently under way. The proper gases are being acquired, and the final details of its installation as well as the training sessions are planned for the first semester of 2025. In addition, the acquisition of a fermenter to be used for either yeast or bacterial growth is planned for 2025, expanding the Zoocel initiatives to include research and

teaching activities with both animal cell culture and precision fermentation techniques (Figure 3).

FIGURE 3. WASHING ROOM (A) AND CELL CULTURE ROOM (B) AT THE CELLULAR ANIMAL SCIENCE LABORATORY (ZOOCEL), FEDERAL UNIVERSITY OF PARANA AT THE AGRICULTURAL SCIENCES SECTOR, CURITIBA, PARANA, BRAZIL IN SEPTEMBER 2024.

The laboratory's functionality was assessed through a test culture with a commonly used immortalized cell line, the Vero cells which derive from kidney epithelial cells of the African green monkey (Figure 4).

FIGURE 4. TESTING EQUIPMENTS AND PROCEDURE WORKFLOW FOR CELL CULTURE AT THE CELLULAR ANIMAL SCIENCE LABORATORY (ZOOCEL), FEDERAL UNIVERSITY OF PARANA (UFPR) WITH AN IMMORTALIZED CELL LINE.

In summary, significant progress has been achieved so far, transforming the Agrarian Sector of UFPR into an agricultural campus fully prepared to perform research and teaching within the domains of cellular agriculture. In terms of research, such achievements have yet another layer of benefits, as they have created a

positive feedback loop through which a sensible increase in our success regarding research grant applications has recently become evident.

This is an important message for public and private institutions considering support for cellular agriculture, as seed investments seem to open a potential flow of further financial support from multiple sources.

5.3.2.1 Scientific Publications

Research on cellular animal science coordinated by professor Carla Forte Maiolino Molento began before the establishment of Zoocel, by members from the Animal Welfare Laboratory (LABEA) at UFPR, and was likely key for garnering the needed support for the foundation of the Cellular Animal Science Laboratory. Again, the strategic approach was to create low-cost research activities, due to the then low availability of funding. The group of researchers was composed of professors, postgraduation students (masters, doctoral, and postdoctoral fellowship), and undergraduation students engaged in scientific initiation and term papers holding a wide range of topics in their research. The published papers from members of research groups in cellular agriculture, Federal University of Parana, from 2019 to 2024 are presented in Table 2.

TABLE 2. PUBLISHED PAPERS FROM MEMBERS OF RESEARCH GROUPS IN CELLULAR AGRICULTURE, FEDERAL UNIVERSITY OF PARANA, FROM 2019 TO 2024.

Authorship	Title	Journal	DOI
Valente *et al.* (2019)	First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil	PLoS One	https://doi.org/10.1371/journal.pone.0221129
Reis *et al.* (2019)	Emerging Market Multinationals and International Corporate Social Responsibility Standards: Bringing Animals to the Fore.	Journal of Business Ethics	https://doi.org/10.1007/s10551-019-04144-5
Heidemann *et al.* (2020a)	Critical Perspective of Animal Production Specialists on Cell-Based Meat in Brazil: From Bottleneck to Best Scenarios	Animals	https://doi.org/10.3390/ani10091678
Heidemann *et al.* (2020b)	Uncoupling meat from animal slaughter and its impacts on human-animal relationships	Frontiers in Psychology	https://doi.org/10.3389/fpsyg.2020.01824
Reis *et al.* (2020)	Livestock value chain in transition: Cultivated (cell-based)	Technology in Society	https://doi.org/10.1016/j.techsoc.2020.

	meat and the need for breakthrough capabilities		101286
Reis *et al.* (2020)	Cell-based meat and firms' environmental strategies: new rationales as per available literature	Sustainability	https://doi.org/10.3390/su12229418
Letti *et al.* (2021)	Cultivated meat: recent technological developments, current market and future challenges	Biotechnology Research and Innovation	http://dx.doi.org/10.4322/biori.202101
Reis *et al.* (2021)	Can radical innovation mitigate environmental and animal welfare misconduct in global value chains? The case of cell-based tuna	Technological Forecasting and Social Change	https://doi.org/10.1016/j.techfore.2021.120845
Reis *et al.* (2021)	Governance and Standardization in Fish Value Chains: Do They Take Care of Key Animal Welfare Issues?	Journal of Agricultural & Environmental Ethics	https://doi.org/10.1007/s10806-021-09870-3
Goes *et al.* (2021)	When stakeholder theory meets justification theory: An intersection proposal	Cadernos Ebape.Br (FGV)	https://doi.org/10.1590/1679-395120200179
Moreira *et al.* (2021)	Social Media Analysis to Understand the Expected Benefits by Plant-Based Meat Alternatives Consumers	Foods	https://doi.org/10.3390/foods10123144
Letti *et al.* (2021)	Cultivated meat: recent technological developments, current market and future challenges	Biotechnology Research and Innovation	http://dx.doi.org/10.4322/biori.202101
Morais-da-Silva *et al.* (2022a)	The expected impact of cultivated and plant-based meats on jobs: the views of experts from Brazil, the United States and Europe	Humanities & Social Sciences Communications	https://doi.org/10.1057/s41599-022-01316-z
Morais-da-Silva *et al.* (2022b)	The social impacts of a transition from conventional to cultivated and plant-based meats: Evidence from Brazil	Food Policy	https://doi.org/10.1016/j.foodpol.2022.102337
Morais-da-Silva *et al.* (2022c)	The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States and Europe	Frontiers in Sustainable Food Systems	http://dx.doi.org/10.3389/fsufs.2022.1056615
Goes *et al.* (2022)	When Justification Theory Meets Responsible Innovation: A Study of Cell-Based Meat.	Technology And Society	https://doi.org/10.1177/09717218221075158

Moreira *et al.* (2022)	Reducing meat consumption: insights from a bibliometric analysis and future scopes	Future Foods	https://doi.org/10.1016/j.fufo.2022.100120
Silva *et al.* (2022)	What about an alternative meat? The effect of neophobia and negative affection on willingness to buy meat substitutes.	Remark. Revista Brasileira de Marketing	https://periodicos.uninove.br/remark/index
Reis *et al.* (2022)	The interplay of entrepreneurial ecosystems and global value chains: Insights from the cultivated meat entrepreneurial ecosystem of Singapore.	Technology in Society	https://doi.org/10.1016/j.techsoc.2022.102116
Biscarra-Bellio *et al.* (2023)	Demand changes meat as changing meat reshapes demand: The great meat revolution	Meat Science	https://doi.org/10.1016/j.meatsci.2022.109040
Bogueva *et al.* (2023)	Will the Cows and Chickens Come Home? Perspectives of Australian and Brazilian Beef and Poultry Farmers towards Diversification	Sustainability	https://doi.org/10.3390/su151612380
Reis *et al.* (2023)	David vs Goliath: The challenges for plant-based meat companies competing with animal-based meat producers.	Journal Of Cleaner Production	https://doi.org/10.1016/j.jclepro.2023.138705
Abrahao *et al.* (2023)	Cultured Manatee Meat Aiding Amazon Biodiversity Conservation: Discussing a Proposed Model	Conservation	https://doi.org/10.3390/conservation3020021
Garbin *et al.* (2024)	Ética animal e proteínas alternativas: questões atuais em terminologia da língua portuguesa	Archives of Veterinary Science	http://dx.doi.org/10.5380/avs.v29i1
Soccol *et al.* (2024)	Cultivated Meat: Technologies, Commercialization and Challenges	Springer Nature	https://doi.org/10.1007/978-3-031-55968-6_18
Newton *et al.* (2024)	Price above all else: An analysis of expert opinion on the priority actions to scale up production and consumption of plant-based meat in Brazil.	Frontiers In Sustainable Food Systems	https://doi.org/10.3389/fsufs.2024.1303448
Mendes & Biscarra-Bellio *et al.* (submitted)	How much do opinions regarding cultivated meat vary within the same country. The cases of Salvador and São Paulo, Brazil.	PLoS One	To be announced.
Goes *et al.* (2024)	Stakeholders' justifications in innovation: the case of cell-based meat.	Innovation: The European Journal of Social Science Research	https://doi.org/10.1080/13511610.2024.2352744

5.3.2.2 Works presented at events

Some members of the LABEA and Zoocel research groups presented works regarding cellular animal science at events from 2021 to 2024 such as seminars, congresses, and conferences in different locals (Table 3).

TABLE 3. ABSTRACTS ACCEPTED AT EVENTS FROM MEMBERS OF THE ANIMAL WELFARE LABORATORY (LABEA) AND THE CELLULAR ANIMAL SCIENCE (ZOOCEL) RESEARCH GROUPS, FEDERAL UNIVERSITY OF PARANA, FROM 2021 TO 2024.

Authorship	Title	Event	Place
Biscarra-Bellio *et al.* (2021)	Intenção de Consumo de Carne Celular no Brasil	VI Animal Defense Seminar. National Forum for Animal Protection and Defense	Curitiba, PR. Brazil
Paolini *et al.* (2021)	Proposal for Brazilian Higher Education in Alternative Proteins.	VI Animal Defense Seminar. National Forum for Animal Protection and Defense	Curitiba, PR. Brazil
Biscarra-Bellio *et al.* (2021)	Introduction to Cellular Animal Sciences	SEE-U Conference International Relations Office at University Federal do Parana.	Curitiba, PR. Brazil
Morais-da-Silva *et al.* (2021)	The animal stance in the socio-technical transition to sustainability: the case of cultivated meat.	Proceedings of the 37th European Group for Organizational Studies. EGOS Colloquium.	Amsterdam, Netherlands.
Paolini *et al.* (2022)	Possibilities for higher education in alternative proteins in Brazil	29ª EVINCI Evento de Iniciação Científica 13ª SIEPE Semana Integrada de Ensino Pesquisa e Extensão UFPR	Curitiba, PR. Brazil
Grenzi *et al.* (2022)	Nutrição de animais de companhia baseada em proteína de carne celular	29ª EVINCI Evento de Iniciação Científica 13ª SIEPE Semana Integrada de Ensino Pesquisa e Extensão UFPR	Curitiba, PR. Brazil
Biscarra-Bellio *et al.* (2022)	Avoiding the Risk of Deepening Inequalities In The Food Production Chain: An Initial Framework for Higher Education Regarding Alternative Protein	RGS-IBG Annual International Conference: *Geographies beyond recovery*	London, United Kingdom.
Mendes *et al.* (2023)	Zootecnia Celular: Bife Sem Bicho? Conhecendo Carne, Ovos, Leite e Derivados sem Sofrimento e Abate de Animais	21º ENEC Encontro de Extensão e Cultura 14ª SIEPE Semana Integrada de Ensino Pesquisa e Extensão UFPR	Curitiba, PR. Brazil
Mendes *et al.* (2023)	Consumer Acceptance of Cultivated Meat in Brazil	30ª EVINCI Evento de Iniciação Científica 14ª SIEPE Semana Integrada de Ensino Pesquisa e	Curitiba, PR. Brazil

		Extensão UFPR	
Mendes *et al.* (2023)	Consumer Acceptance of Cultivated Meat in Brazil	1º International Conference of the Portuguese Association for Cellular Agriculture	Braga, Portugal
Morais-da-Silva *et al.* (2023)	The Potential Relevance of Associations for the Progress of Cellular Agriculture: The Case of Cell Agri Brazil	1º International Conference of the Portuguese Association for Celular Agriculture.	Braga, Portugal
Valim *et al.* (2023)	Zootecnia Celular: Bife Sem Bicho? Conhecendo Carne, Ovos, Leite e Derivados sem Sofrimento e Abate de Animais	41º SEURS Seminário de Extensão Universitária da Região Sul	Ponta Grossa, PR. Brazil
Coelho *et al.* (2024)	Crescimento De Células Vero e MDBK em Meio Livre de Soro Fetal Bovino	29º CBCTA 2024 - Brazilian Congress of Food Science and Technology	Florianopolis , SC. Brazil
Biscarra-Bellio *et al.* (2024)	A glimpse on students' perceptions of education in Cellular Animal Sciences in a Brazilian University	2nd International Conference of the Portuguese Association for Cellular Agriculture	Portugal
Mendes *et al.* (2024)	Cellular Agriculture at UFPR: Research, Teaching, and Extension Initiatives	I COAP 1st Conference on Alternative Proteins	Campinas, SP. Brazil
Biscarra-Bellio *et al.* (2024)	Cell Ag Brazil: Accelerating the Alternative Proteins Sector In Brazil	I COAP 1st Conference on Alternative Proteins	Campinas, SP. Brazil
Garbin *et al.* (2024)	Preliminary analysis of animal-derived inputs in cultivated meat patents: the importance of technical descriptions	I COAP 1st Conference on Alternative Proteins	Campinas, SP. Brazil
Garbin *et al.* (2024)	The role of food bioprinting in sensory food aversion of individuals with Autism Spectrum Disorder (ASD)	I COAP 1st Conference on Alternative Proteins	Campinas, SP Brazil
Gularte *et al.* (2024)	Perception of vegetarians and vegans regarding the inclusion of cultivated meat in their dogs' diet	I COAP 1st Conference on Alternative Proteins	Campinas, SP. Brazil
Biscarra-Bellio *et al.* (2024)	Cellular Agriculture: Who Wants To Learn About This New Technology?	I International Conference Cell Ag Brazil and I NAPI Alternative Proteins Meeting.	Curitiba, PR. Brazil
Mendes *et al.*	Intenção de Consumo da Carne	VII Animal Defense Seminar.	Brasília, DF.

(2024)	Celular nas Cidades de Salvador e São Paulo, no Brasil	National Forum for Animal Protection and Defense	Brazil
Mendes *et al.* (2024)	Bife Sem Bicho: Conhecendo a Carne, Ovos, Leite e Derivados sem sofrimento e morte de animais	VII Animal Defense Seminar. National Forum for Animal Protection and Defense	Brasília, DF. Brazil
Mendes *et al.* (2024)	Zootecnia celular na UFPR: iniciativas de pesquisa, ensino e extensão	31ª EVINCI 15ª SIEPE Semana Integrada de Ensino Pesquisa e Extensão UFPR	Curitiba, PR. Brazil
Gularte *et al.* (2024)	Percepção de vegetarianos e veganos sobre a inclusão de carne celular na dieta de seus animais de estimação	31ª EVINCI 15ª SIEPE Semana Integrada de Ensino Pesquisa e Extensão UFPR	Curitiba, PR. Brazil
Chaudhary *et al.* (2024)	Toward a global protein transition: urgency, potential, and international cooperation	G20 Brasil 2024	Brazil

5.3.3 Extension

The UFPR's first extension project in cellular agriculture, entitled Bife Sem Bicho (a Portuguese pun for steak without an animal): understanding meat, eggs and dairy without the suffering and death of animals, was created in February 2023. The project aims to offer a meaningful contact with cellular animal science, in an accessible and inviting manner, to the university community as well as the general public. The project goals are to disseminate and to promote knowledge about scientific advancements related to environmental, social, economic, public health, food safety and security, and animal ethics aspects associated with alternative proteins.

In this context, the project includes two subprojects organized according to the type of content produced and its presentation format. Subproject 1, entitled Zoocel na Rede, focuses on developing and managing a website for the Zoocel laboratory, as well as creating social media profiles to disseminate and expand access to information on cellular animal science and Zoocel's daily activities. Activities in this subproject range from website planning to producing content for social media posts to generate engagement and interaction with the public, broadening knowledge and the debate on the topic. The second subproject, Pod Bife Sem Bicho offers a podcast

featuring interviews with professionals who work or are involved with cellular animal science, both within and outside UFPR. The podcast target audience is composed of undergraduation students interested in deepening their knowledge on the subject, as well as society in general, with the goal of informing about innovations in the field. Its development involves planning episodes, selecting interviewees, preparing questions, and recording, posting episodes on digital platforms, and promoting them.

The LinkedIn (Zoocel Laboratório de Zootecnia Celular | LinkedIn) and Instagram (@zoocel.ufpr) accounts were created to provide information about cellular animal science, including highlights from researchers and their projects at Zoocel. So far, LinkedIn has 244 followers and 114 connections, and it features 33 posts. The Instagram account has shared 59 images and 17 videos, mainly aiming to clarify common doubts about the topic. From August 2024 to October 2024, the profile @zoocel.ufpr reached approximately 3,5 thousand accounts, with a current number of 767 followers. The most popular post to date is the video Cultivated meat is agro! which alludes to a catchphrase referring to the powerful agricultural activities in Brazil, with a total of 5,007 views. Additionally, a LinkedIn profile was created to replicate the content posted on Instagram. The website (https://zoocel.ufpr.br/) includes information on research projects, team, scientific productions, and news related to the laboratory.

FIGURE 6. LOGO OF BIFE SEM BICHO EXTENSION PROJECT FROM THE CELLULAR ANIMAL SCIENCE LABORATORY (ZOOCEL), FEDERAL UNIVERSITY OF PARANA, AND THE QR CODE FOR THE ACCESS TO THE SOCIAL MEDIA MANAGED BY MEMBERS OF ZOOCEL ON THE INTERNET.

The Zoocel YouTube channel (https://www.youtube.com/@zoocelufpr) has seven published videos (Figure 7).

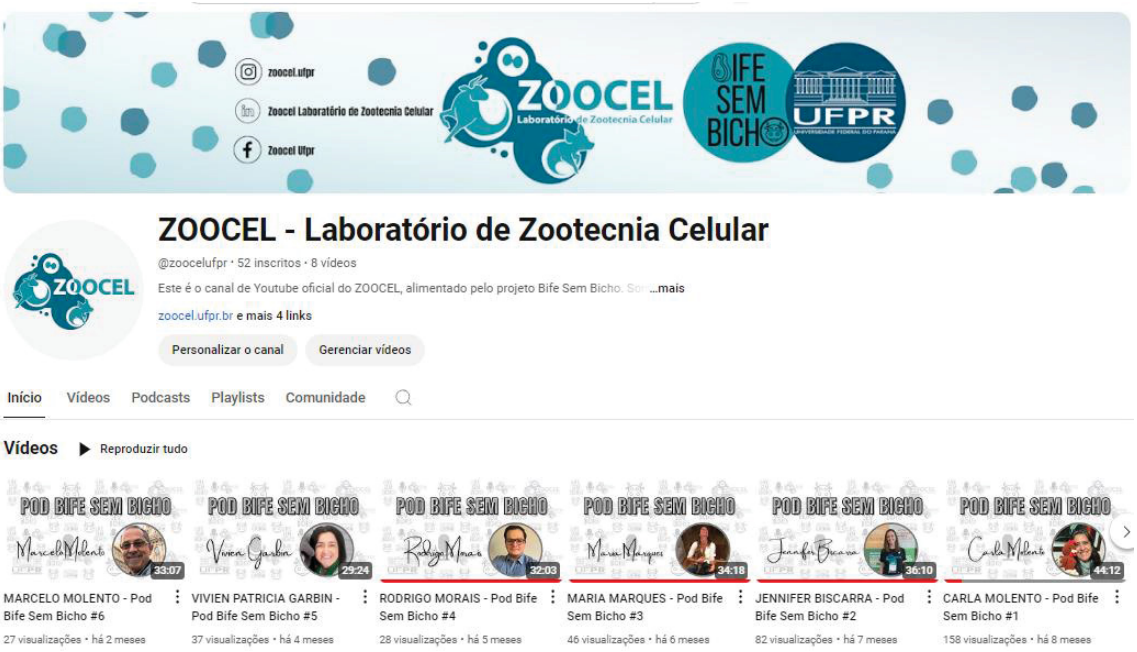


FIGURE 7. YOUTUBE CHANNEL WHERE THE PODCASTS OF POD BIFE SEM BICHO, PART OF THE EXTENSION PROJECT BIFE SEM BICHO FROM THE CELLULAR ANIMAL SCIENCE LABORATORY (ZOOCEL), FEDERAL UNIVERSITY OF PARANA, FROM FEBRUARY 2023 ARE POSTED SINCE FEBRUARY 2023.

The first video was a glossary covering essential terminology in cellular animal science. The following six videos are videocasts where extension project member's interview researchers involved in cellular agriculture. The interviews explored topics such as animal welfare, professional training for the field, the integration of rural producers into the alternative protein production chain, potential social impacts, and appropriate terminology to use for alternative proteins in Brazilian Portuguese, and global health. The Zoocel YouTube channel has 52 subscribers and a total of 600 views. Additionally, the channel achieved 4,3 thousand impressions, representing the frequency with which video were shown to viewers.

5.3.4 Miscellaneous

For planning and execution of many of the works already completed and those in progress, certain partnerships have been fundamental for the Cellular Animal Science Laboratory. The Good Food Institute (GFI) was instrumental in initial educational initiatives carried out by our group, providing important collaboration involving the Technion University of Israel, which made a significant contribution of educational materials. More recently, Zoocel group was able to contribute to the development of a teaching plan currently made available by GFI Brazil (GFI, 2022).

The partnership with Global Action in the Interest of Animals (GAIA, a Belgian NGO based in Brussels) focused on the social impacts of alternative meats and resulted in three scientific publications, which can be considered the inauguration of the scientific approach to the social impacts of alternative proteins in Brazil: The expected impact of cultivated and plant-based meats on jobs: The views of experts from Brazil, the United States and Europe (Morais-da-Silva et al., 2022a) in the journal Humanities and Social Sciences Communications; The social impacts of a transition from conventional to cultivated and plant-based meats: Evidence from Brazil (Morais-da-Silva et al., 2022b) in the journal Food Policy; and The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States and Europe (Morais-da-Silva et al., 2022c) in the journal Frontiers in Sustainable Food Systems.

The partnership with Curtin University in Australia facilitated joint activities related to understanding the needs of farmers in the context of new food production systems, leading to the publication of the article Will the cows and chickens come home? Perspectives of Australian and Brazilian beef and poultry farmers towards diversification (Bogueva et al., 2023) in the journal Sustainability. Negotiations with the University of Alberta in Canada resulted in the signing of a memorandum of understanding between the institution and the State of Parana's funding agency, Fundação Araucária, for the mobility of up to 10 students per year between research institutions in Parana and the Canadian university. Similarly, there is also a partnership with Wageningen University in the Netherlands in synergy with Zoocel, hence the coordinator of this proposal was invited to participate as a visiting researcher within the scope of a project funded by the Dutch government to develop the production of milk and derivatives through precision fermentation. Thus, the international universities with which the Zoocel group maintains partnerships are establishing permanent institutional research and teaching structures in the field of alternative proteins, creating high-potential scenarios for joint work in the coming years.

The Pollination Project Foundation (TPPF) focuses on global transformation and social change; although it emphasizes small grants, the partnership between our team and TPPF was crucial as it provided the necessary resources for the founding of Brazilian Association of Cellular Agriculture (Cell Ag Brazil). Currently, Cell Ag Brazil is part of the Network of Cellular Agriculture (NCA), in which the Cell Ags

Greece, Portugal, the Netherlands, Italy, Germany, the UK, and Canada, among others, also participate. The Cell Ag Brazil is expected to contribute by promoting and accelerating cellular agriculture and by acting as a facilitator of national and international dialogue on emerging technologies for food production. In a second round of support, TPPF significantly contributed to the organization of the I International Cell Ag Brazil Conference and the I NAPI Alternative Proteins Meeting. During the event, the recently published book Cultivated Meat: Technologies, Commercialization and Challenges (Soccol et al., 2024) published by Springer Nature was launched. This book was edited by four UFPR professors involved with the NAPI Alternative Proteins, and features contributions from members of the group as well as the work of additional Brazilian researchers in an array of institutions and States, providing a solid platform for the dissemination of Brazilian excellence in research regarding alternative proteins.

Additionally, undergraduate students from the Veterinary Medicine and Animal Science programs at UFPR, along with graduate students in Veterinary Sciences from the Animal Welfare and Cellular Animal Science laboratories, have recently created the Alternative Protein Project (APP) UFPR. The Alt Protein Project is a global student movement dedicated to transforming universities into engines for alternative protein education, research, and innovation. Students at all levels of training, from first-year undergraduates to graduate students about to defend their theses, are the driving force behind the Alt Protein Project, which is gaining momentum at universities worldwide. There are currently 79 universities involved globally, with six in Brazil. In addition to UFPR, the Federal University of Minas Gerais (UFMG), Federal University of Santa Catarina (UFSC), São Paulo State University (UNESP), São Paulo University (USP), and UNICAMP (University of Campinas) have also established their own APPs.

5.4 CONCLUSION

Our results indicate that UFPR is successfully entering the field of cellular animal science, with advancements in teaching, research, and outreach. The progression highlights the need for ongoing efforts and a broader expansion of these three pillars, to encompass an increasing number of students and professionals interested in the field as well as to support advancements in other institutions. Further

research and teaching efforts seem warranted to solidify this field at both undergraduate and postgraduate levels in Brazil.

In terms of teaching, the creation of new courses or the adaptation of existing ones across different academic programs are the logical next steps. Moreover, students have expressed a predictable demand for hands-on experience in alternative protein production techniques. In this context, universities may consider upgrading their laboratories or establishing new facilities to meet the practical training demands. The results may then add up to the broad and complex range of developments required for Brazil to participate in the new food production systems that are being set up across the world. This may, in turn, strengthen the regional and national landscape of alternative proteins, contributing to increased sustainability and ethics in food production. A last word of caution: the time for investments in research and education is now. If Brazilian institutions are caught with resistance from incumbents or bureaucratic entanglements, we may repeat the consequences of previous disruptive innovations to which we did not react in a timely fashion, such as digital technologies for instance. However, due to the magnitude of agricultural activities in our country, this can be a completely different story. Will Brazil play a leadership role in cellular agriculture? The answer depends largely on what we do now.

REFERENCES

BISCARRA-BELLIO, Jennifer Cristina et al. Demand changes meat as changing meat reshapes demand: The great meat revolution. **Meat Science**, v. 196, article 109040, 2022.

BOGUEVA, Diana et al. Will the cows and chickens come home? Perspectives of Australian and Brazilian beef and poultry farmers towards diversification. **Sustainability**, v. 15, n. 16, article 12380, 2023.

BRYANT, Christopher; BARNETT, Julie. Consumer acceptance of cultured meat: An updated review (2018–2020). **Applied Sciences**, v. 10, n. 15, article 5201, 2020.

CHAUDHARY, Ankur et al. Rumo a uma transição global de proteínas: Abordagens para atingir metas climáticas e promover a segurança alimentar. **T20 Brasil**. (n.d.). Think 20: Task Force for the G20. Recuperado de: https://t20brasil.org/en

DUARTE, Sebastião Junior Henrique; MAMEDE, Marli Villela; ANDRADE, Sônia Maria Oliveira. Opções Teórico-Metodológicas em Pesquisas Qualitativas: Representações Sociais e Discurso do Sujeito Coletivo. **Saúde e Sociedade**, v. 18, n. 4, p. 620-626, 2009.

GARBIN, Vivien Patricia et al. Ética animal e proteínas alternativas: questões atuais em terminologia da língua portuguesa. **Archives of Veterinary Science**, v. 29, n. 1, 2024.

GFI. Plano de Ensino para Disciplinas em Proteínas Alternativas. **The Good Food Institute**, Brasil. Recuperado de: GFI Brasil lança Plano de Ensino para Disciplinas em Proteínas Alternativas - GFI Brasil, 2022. Acessado em: 15 ago. 2024.

GOODWIN, Joy; SHOULDERS, Catherine. The future of meat: a qualitative analysis of cultured meat media coverage. **Meat Science**, v. 95, p. 445–450, 2013.

HANSEN, A.; SYSE, K.L. (Eds.). Changing meat cultures: Food practices, global capitalism, and the consumption of animals, p. 35-59, 2021.

HEIDEMANN, Marina Sucha et al. Critical Perspective of Animal Production Specialists on Cell-Based Meat in Brazil: From Bottleneck to Best Scenarios. **Animals**, v. 10, n. 9, article 1678, 2020a.

HEIDEMANN, Marina Sucha et al. Uncoupling meat from animal slaughter and its impacts on human-animal relationships. **Frontiers in Psychology**, v. 11, article 1824, 2020b.

LETTI, Luiz Alberto Junior et al. Cultivated meat: recent technological developments, current market and future challenges. **Biotechnology Research and Innovation**, v. 5, n. 1, article e2021001, 2021.

MORAIS-DA-SILVA, Rodrigo Luiz et al. The expected impact of cultivated and plant-based meats on jobs: The views of experts from Brazil, the United States and Europe. **Humanities and Social Sciences Communications**, v. 9, n. 1, article 297, 2022a.

MORAIS-DA-SILVA, Rodrigo Luiz et al. The social impacts of a transition from conventional to cultivated and plant-based meats: Evidence from Brazil. **Food Policy**, v. 111, article 102337, 2022b.

MORAIS-DA-SILVA, Rodrigo Luiz et al. The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States and Europe. **Frontiers in Sustainable Food Systems**, v. 6, article 1056615, 2022c.

NEWELL, Robert; GLAROS, Alesandros. Sustainable food systems, development paths, and scenarios for cellular agriculture. In: FRASER, Evan D.G.; KAPLAN, David L.; NEWMAN, Lenore; YADA, Rickey Y. (Eds.). **Cellular Agriculture**, p. 29-45, 2024. Academic Press.

PHILLIPS, C.; MOLENTO, C.; BOGUEVA, D.; MARINOVA, D. Planetary health and animal and plant dietary proteins. In: PREEDY, V.R. (Ed.). **Plant and Animal Proteins in Health and Disease Prevention**, Milton Park, UK: Taylor and Francis, 2024. (Forthcoming).

POST, Mark Johannes. Cultured beef: medical technology to produce food. **Science of Food and Agriculture**, v. 94, p. 1039–1041, 2014a.

POST, Mark Johannes. An alternative animal protein source: cultured beef. **Annals of the New York Academy of Sciences**, article 1328, p. 29-33, 2014b.

REIS, Germano Glufke et al. Livestock value chain in transition: Cultivated (cell-based) meat and the need for breakthrough capabilities. **Technology in Society**, v. 62, article 101286, 2020a.

SCHNEIDER, Kevin. Concentrating on healthy feeding operations: the national school lunch program, cultured meat, and the path to a sustainable food future. **Journal of Land Use & Environmental Law**, v. 29, article 145, 2013.

SLADE, Peter. If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. **Appetite**, v. 125, p. 428–437, 2018.

SOCCOL, Carlos Ricardo (Ed.) et al. **Cultivated Meat: Technologies, Commercialization and Challenges**. Cham: Springer Nature, 2024.

STEPHENS, Neil; KING, Emma; LYALL, Catherine. Blood, meat, and upscaling tissue engineering: anticipated markets, and performativity in the biomedical and agri-food sectors. **Bio Societies**, v. 13, n. 2, p. 368–388, 2018.

STOUT, AJ et al. Education and training. In: FRASER, Evan D.G.; KAPLAN, David L.; NEWMAN, Lenore; YADA, Rickey Y. (Eds.). **Cellular Agriculture: Technology, Society, Sustainability and Science**, p. 487-513, 2024.

THE GOOD FOOD INSTITUTE BRASIL. Plano de Ensino para Disciplinas em Proteínas Alternativas. Brasil: The Good Food Institute, 2022. Disponível em: https://gfi.org.br/wp-content/uploads/2023/04/Plano-de-Ensino-para-Discipinas-em-Proteinas-Alternativas-Modelo-Conceitual.pdf

UNITED NATIONS. World population prospects 2022: Summary of results. Nova York: Department of Economic and Social Affairs Population Division, 2022. Disponível em: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

UNITED NATIONS ENVIRONMENT PROGRAMME and International Livestock Research Institute. **Preventing the Next Pandemic: Zoonotic diseases and how to break the chain of transmission**. Nairobi, Quênia, 2020.

VALENTE, Júlia de Paula Soares et al. First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil. **PLOS One**, v. 14, n. 8, 2019.

VERBEKE, Wim et al. 'Would you eat cultured meat?' Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. **Meat Science**, v. 102, p. 49–58, 2015.

6 CELLULAR AGRICULTURE EDUCATION IN BRAZILIAN UNDERGRADUATE PROGRAMS: NOT AS FAR AS IT SEEMS

ABSTRACT

Cellular agriculture has the potential to transform global food production through alternative proteins, necessitating a skilled workforce. This study aimed to analyze the syllabi of Brazilian graduate programs related to food production to identify those addressing cellular agriculture topics. We reviewed nineteen undergraduate curricula from Veterinary Medicine, Animal Science, Bioprocess and Biotechnology Engineering, and Food Engineering across twelve institutions. These were compared with the syllabus of the Introduction to Cellular Animal Science course at UFPR and the undergraduate minor in Cellular Agriculture at Tufts University, as well as knowledge required for cultivated meat production. Our comparative analysis found that courses such as Microbiology and Biochemistry exhibited 100% similarity, while Statistics and Economics (94.7%) and Cellular Biology and Genetics (68.4%) also showed consistent content. In contrast, courses in Sustainability (94.7%), Administration and Entrepreneurship (89.5%), and others revealed significant variability. The study concludes that existing programs provide foundational knowledge for professionals entering this emerging field, but further specialization is necessary. Additionally, our findings could inform the development of new curricula specifically designed to prepare professionals for careers in cellular agriculture.

Keywords: Cellular animal science. Courses. Curriculum. Professionals.

6.1 INTRODUCTION

Conventional meat production systems present challenges such as environmental impacts, animal welfare and public health issues, lack of food security, and sustainability problems (Post et al., 2020). Future technologies and systemic innovation are critical for the transformation that the global food system needs (Herrero et al., 2020). The global animal products industry has come under increasing scrutiny in recent years due to the magnitude of its environmental, ethical, and human health impacts (Scollan et al., 2010). These concerns, coupled with projections that the demand for protein products will continue to rise over the coming decades mean that there is an urgent need for new methods of food protein production that are more sustainable and ethical. In such scenario, cultivated meat production presents a potential alternative for producing animal protein, as it is potentially more sustainable (Zhao et al., 2020) and uncoupled with animal suffering and killing (Heidemann et al., 2020).

Cultivated meat is produced by culturing muscle tissue from a collection of cells from a live animal, and the tissue samples are submitted for cell isolation,

multiplication, and differentiation to produce meat (Ong et al., 2020). For the development of cultivated meat, some techniques used are the same ones that pioneered other cell culture applications in the field of biotechnology (Specht et al., 2018). It is a technology that works as part of the broader field of cellular agriculture and in collaboration with innovation in the field of plant-based proteins (Stephens et al., 2018).

Studies have shown that cultivated meat production emits substantially less greenhouse gases and requires only a fraction of land compared to conventional meat production. While water use in cultivated meat production is lower when compared to the production of conventional meat, it is higher compared to conventional poultry production. However, the high energy requirement may remain a challenge for the cultivated meat production (Tuomisto, 2014). In addition, cultivated meat can improve animal welfare, reduce zoonotic and food-borne diseases, and reduce the use of environmental resources, promoting reforestation and the protection of wildlife; furthermore, by controlling the process, it is possible to create a product with greater benefits to human health (Bhat et al., 2015).

As investments increase at an accelerated pace, it is expected that cultivated meat products will gradually reach the markets in the coming years (Godfray, 2019), and since it does not rely on animal farming, significant transformations in the conventional meat chain are likely (Reis et al., 2020). This implies opportunities for professionals who have fundamental roles in the conventional meat chain, such as veterinarians and animal scientists, as well as professionals involved in the food industry such as food engineers, bioprocess engineers, and biotechnologists, among others that has knowledge in genetics, nutrition, human health, cell development, management, as well as processing, packaging, marketing, control, and inspection of meat (Heidemann et al., 2020). In addition to this knowledge, professionals who play key roles in reducing resistance, aiding farmers in transitioning to alternative meats, preventing animal disease and suffering, and managing skills such as supply chain management will be crucial (Morais-da-Silva, et al., 2022b). Once the necessary knowledge for professionals aiming to work in the alternative protein field is recognized, it becomes possible to identify which courses already offers subjects that meet these needs and to suggest adaptations to existing programs that train professionals for the food production sector. In Brazilian higher education, curriculum structures are based on National Curricular Guidelines to

ensure quality standards. For Veterinary Medicine, these guidelines mandate that programs equip veterinarians with knowledge across agricultural and health sciences, including animal production, food production, and public health, while adapting to changes in technology and law. In Animal Science, the guidelines emphasize providing a solid foundation in scientific and technological knowledge, ethical awareness, and the ability to manage animal production systems within various market contexts (MEC, 2024). For the Bioprocess and Biotechnology Engineering program, regulated by CONFEA resolution 1108, graduates are trained to work with biological systems in health, agriculture, food, energy, environment, and more. The Food Engineering program, regulated by resolution 2 of April 24, 2019, focuses on equipping professionals to research, develop, and apply new technologies with innovative and entrepreneurial skills to address various challenges (CONFEA, 2018).

The relevance of the scope of the four undergraduate programs concerning new forms of animal-origin products or similar foods presents a positive scenario, as there is a need for education to expand the pool of scientists and engineers entering the field of alternative proteins (GFI, 2022). With greater numbers of programs and courses in the area of alternative proteins, there will likely be an increase in the number of highly qualified graduates seeking careers in this field.

It will also lead to the establishment of new businesses and institutes, facilitating market competition and scientific collaboration with a greater likelihood of generating products and ideas for the advancement of new industries (GFI, 2022). Meanwhile, the greater the engagement of different careers, the smaller tends to be the resistance against new food systems, as both neophobia and the fear of job loss are reduced. In reality, increased engagement with cellular agriculture positively impacts job opportunities (Morais-da-Silva et al., 2021).

Currently, some universities offering courses in the field of cellular agriculture include Tufts University in Massachusetts and the University of North Carolina (UNC) in the United States; Nanyang Technological University (NTU) in Singapore; and Wageningen University & Research in the Netherlands. In Brazil, the State University of Campinas (UNICAMP) offers a postgraduate course titled Alternative Proteins: Made from Plants, Fermentation, and Cultivated Meat within its Faculty of Food Engineering. The Federal University of Minas Gerais (UFMG) was the first Brazilian University to offer a theoretical-practical course titled Cellular Agriculture in the

Context of Alternative Protein, where students explored the scientific history of cultivated meat, discussed the environmental impact of extensive cattle production, and learned about the industrial bioprocess involved in producing cultivated meat. The Federal University of Parana (UFPR) has offered five courses on cellular agriculture since July 2020, both at the undergraduate and postgraduate levels, and both titled Introduction to Cellular Animal Science.

As teaching initiatives advance, there is a growing need to discuss education in cellular agriculture in line with the National Curricular Guidelines of the Ministry of Education in Brazil. This study aims to analyze the syllabi and courses of some Brazilian undergraduate programs related to food production to identify those that already cover topics in cellular agriculture.

6.2 MATERIAL AND METHODS

The programs in Veterinary Medicine, Animal Science, and Bioprocess and Biotechnology Engineering were selected for this study because they are actively engaged in research on alternative proteins at the Federal University of Parana (UFPR), where the study was conducted. Additionally, the Food Engineering program was included due to its critical role in food production and its significant contribution to the advancement of cellular agriculture. While this study focuses on these four programs, it is important to note that this selection is not exhaustive, and other programs may also play a key role in the development of alternative proteins.

For data gathering and the analysis of the curricula and syllabi, we first accessed the website of the Brazilian Ministry of Education, where a list of all higher education institutions in the country was available. The following three inclusion criteria were used: (1) programs offered by federal universities that make (2) their curricula and syllabi available on the institution's websites, with (3) one institution per geographical region of the country. No federal university offering the Bioprocess and Biotechnology Engineering program was found in the Brazilian Midwest region. Thus, five institutions for each undergraduate program were selected, except for the Bioprocess and biotechnology Engineering program, for which only four institutions were chosen. Finally, the sample was composed of 19 programs (Table 1).

TABLE 1. UNDERGRADUATE PROGRAMS AND FEDERAL UNIVERSITIES PER REGIONS OF BRAZIL SELECTED FOR THE STUDY CONDUCTED FROM SEPTEMBER 2021 TO FEBRUARY 2022.

Regions of Brazil	Undergraduate programs			
	Veterinary Medicine	Animal Science	Bioprocess and Biotechnology Engineering	Food Engineering
North	UFAC Acre	UFAM Amazonas	UFT Tocantins	UFAM Amazonas
Northeast	UFBA Bahia	UFBA Bahia	UFCG Campina Grande	UFC Ceará
Midwest	UFG Goiás	UFG Goiás	NON EXISTENT	UFG Goiás
Southeast	UFMG Minas Gerais	UFMG Minas Gerais	UFRJ Rio de Janeiro	UFU Uberlândia
South	UFPR Paraná	UFPR Paraná	UFPR Paraná	UFFS Fronteira Sul

After the selection of universities, a survey and listing of all the mandatory courses that make up the curriculum of each of the 19 analyzed courses were conducted. In total, 1.065 mandatory courses were listed, including 299 courses in the Veterinary Medicine programs, 284 in Animal Sciences, 210 in Bioprocess and Biotechnology Engineering, and 272 in Food Engineering. The courses were separated by undergraduate program and grouped into categories according to their similarity. For example, all disciplines involving anatomy were grouped into one category, those involving physiology into another, and so forth. Next, courses and syllabi that seemed relevant for the teaching of cellular agriculture were selected in a first general analysis.

A thorough reading of each course syllabus was carried out to identify courses that presented relevant content. Such courses were divided into two groups: the first group was composed of courses that presented syllabi with similar contents among different institutions and programs, here called consolidated courses. The second group was composed of courses that presented different syllabi according to the specificity of each course, here called non-consolidated. Syllabi with the same name but belonging to different institutions and different undergraduate programs were compared to verify the degree of consolidation. The degree of consolidation was a measure of how consistent the contents were among programs and institutions and is not a measure of the quality of the disciplines.

In total, 220 course syllabi from the 19 undergraduate programs were analyzed, taking into account the stages of the cultivated meat production chain

(Figure 1), as well as the syllabi of the Undergraduate Minor in Cellular Agriculture program at Tufts University (Food, Nutrition, and Culture; American Meat; Ecology, Technology & Sustainability; Reactor Design; Synthetic Biology; Cell & Microbe Cultivation; Food Systems: From Farm to Table; Sustainability in Action; Practicing in Food Systems; Mechanics of Materials at the Micro & Nano Scale; Nutrition-Related Consumer Marketing; Sustainability on the Farm; Sustainability and Food Consumer; Politics, Policies and Risks in Science and Technology; Entrepreneurship & Strategy; Technical & Managerial Communication; Creativity, Innovation and Entrepreneurial Thinking; Entrepreneurial Leadership, Societal Aspects Of Design: Integration, Innovation, and Impact, Bringing Products to Market and Nutrition and Entrepreneurship) and the syllabi from the editions of the first cellular animal science course in Brazil titled Introduction to Cellular Animal Science in the postgraduate and undergraduate programs at the Federal University of Parana (Secondary Domestication, Disruptive Innovations, Issues in Conventional Meat Production, Animal Welfare, Value Chain of Conventional and Cultivated Meat, Alternative Proteins and Sustainable Development Goals (SDGs), Consumer Market for Alternative Proteins, Transition for Producers, Social Impacts of Alternative Proteins, One Health, One Welfare, Industrial Development, Biotechnology Fundamentals for Alternative Proteins, Food Safety, Technology of Products of Animal Origin and Inspection of Products of Animal Origin, Education and Research in Cellular Animal Sciences, New Food System, Investments and Startups in Brazil and Worldwide, and Cellular Agriculture Associations in Brazil and globally.

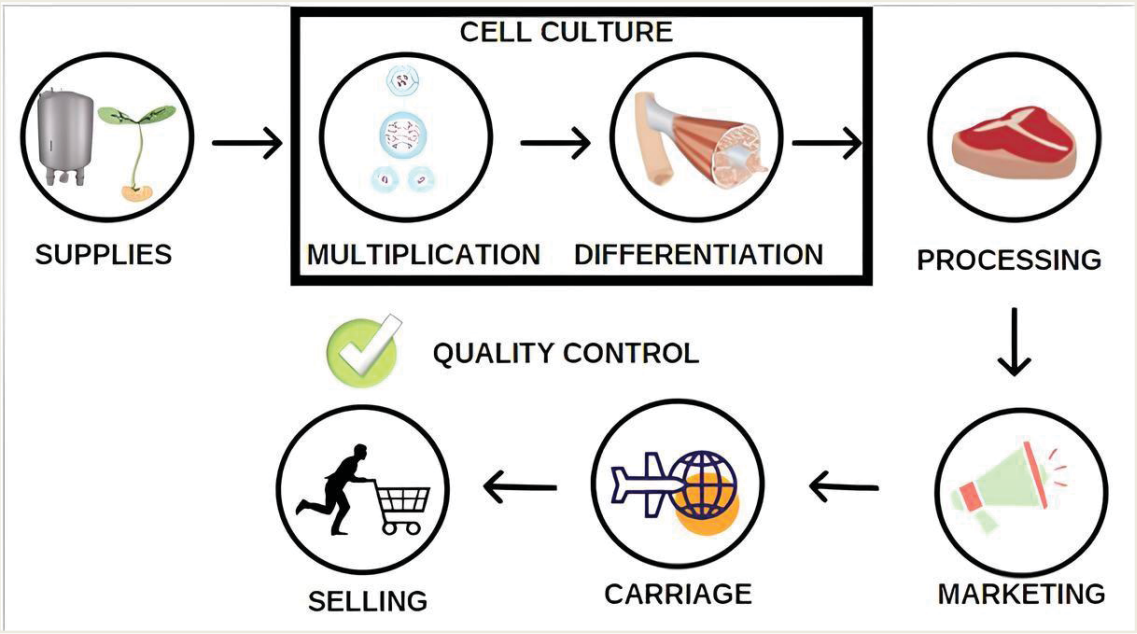


FIGURE 1. LIKELY STAGES OF THE CULTIVATED MEAT CHAIN, ADAPTED FROM MORAIS-DA-SILVA ET AL., 2022A, SANTO ET AL., 2020, AND TUOMISTO, 2014.

6.3 RESULTS

The courses and syllabi identified in the 19 undergraduate programs analyzed that have content related to cellular agriculture are listed in Table 2.

TABLE 2. CONSOLIDATED, NON-CONSOLIDATED AND RELEVANT COURSES AND SYLLABI IDENTIFIED AS RELATED TO CELLULAR AGRICULTURE IN THE 19 UNDERGRADUATE PROGRAMS IN THE STUDY CONDUCTED FROM SEPTEMBER 2021 TO FEBRUARY 2022.

	Courses	Syllabi
Consolidated	Biochemistry	Understand the chemical processes and substances that occur within living organisms. Study of the biochemical principles underlying cellular function, metabolism, and molecular biology.
	Cellular Biology	Fundamental concepts of cellular biology, including cell structure, function, and processes. Cellular mechanisms and interactions.
	Economics	Fundamental principles of economics, including the analysis of market behaviors, economic policies, and resource allocation. Economic theories.
	Statistics	Statistical methods and techniques used for data analysis. Statistical concepts.
	Genetics	Principles of inheritance, genetic variation, and the role of genetics in health and diseases.
	Microbiology	Biology of microorganisms, their ecological roles, and their importance in health, industry, and the environment. Identify and manipulate microorganisms in the laboratory.
Non-consolidated		Fundamental knowledge and skills in administration and entrepreneurship, focusing on the development, management,

Administration and Entrepreneurship	and growth of new ventures and the strategic management of organizations. Provide practical insights and theoretical foundations in business administration and entrepreneurial practices.
Biosafety	Foundational knowledge and practical skills necessary for ensuring safety in laboratories and environments where biological materials are handled. Biosafety principles, regulations, and practices to minimize the risks associated with biological hazards and protect human health, animal welfare, and the environment.
Ethics and Deontology	Ethical principles and deontological frameworks that guide professional conduct in various fields, focusing on the moral and legal obligations of professionals. Ethical dilemmas.
Inspection of Animal Products	Inspection and regulation of animal products, ensuring compliance with health, safety, and quality standards. Methodologies, regulations, and best practices for inspecting animal-derived products in various stages of production, processing, and distribution.
Public Health	Principles and practices of public health, focusing on the promotion and protection of community health. Evaluation and implementation of health interventions, understanding health systems, and addressing health disparities to improve overall public health outcomes.
Sustainability	Sustainability principles and practices, emphasizing the integration of environmental, social, and economic dimensions. Assess sustainability challenges, develop sustainable solutions, and apply sustainability concepts in various sectors.
Technology of Animal Products	Technology involved in the production, processing, and quality control of animal products. Safety, quality, and efficiency of animal-derived products within the food industry.
Animal Cell Culture	Animal cell culture techniques, including the principles, methods, and applications of culturing animal cells in vitro. Preparation, maintenance, and manipulation of animal cell cultures, as well as their use in research, biotechnology, and medical applications.
Fundamentals of Bioprocess and Biotechnology Engineering	Core principles and practices of bioprocessing and biotechnology engineering, including the design, optimization, and management of biotechnological systems and processes. Fundamental concepts of bioprocess engineering, biotechnology applications and their integration in industrial settings.
Introduction to Animal Science	Fundaments on animal science, focusing on the biology, management, and welfare of domesticated animals. Aspects of animal production, genetics, nutrition, health, and behavior, equipping students with the knowledge necessary for careers in animal science and related fields.
Fermentation Processes	Fermentation processes, including the principles, design, and optimization of fermentation systems. Biological, chemical, and engineering aspects of fermentation, as well as the practical applications in various industries such as food and beverage, pharmaceuticals, and biofuels.

From the analysis of syllabi, courses that presented relevant content for the teaching of cellular agriculture were found in all the studied programs in Brazil, such as Microbiology and Biochemistry (present in 100% of the programs), Statistics (94.7%), Economics (94.7%), Cellular Biology (68.4%), and Genetics (68.4%). These courses were considered consolidated, and the list of institutions and programs that offered these courses is described in Table 3 (a).

Among the six consolidated courses, four are present in at least one of the institutions of each of the four programs analyzed: Biochemistry, Statistics, Economics, and Microbiology. The courses on Cellular Biology and Genetics, which were present in the curriculum of at least one of the programs in veterinary medicine, animal science, and bioprocess and biotechnology engineering, were not present in any of the studied food engineering programs.

The non-consolidated courses, belonging to the second group, include Sustainability related subjects (present in 94.7% of the programs), Administration and Entrepreneurship (89.4%), Technology of Animal Products (89.4%), Ethics and Deontology (57.8%), Inspection of Animal Products (26.3%), Biosafety (21.0%), and Public Health (21.0%). The list of institutions and programs that offered these courses is described in Table 3 (b).

Among the six non-consolidated courses, four were present in at least one institution in each of the four analyzed programs: Sustainability, Administration and Entrepreneurship, Food Technology, and Ethics and Deontology. In the studied undergraduate programs of food engineering, no specific courses on Ethics were found; however, some content on ethics was present within other courses, demonstrating that the content was offered to students.

In addition, important courses for qualifying students for the cultivated meat industry and market were present in only a few programs, even though they seem relevant to all professionals seeking the abilities to work in this new field. Such courses were Introduction to Animal Science (present in 36.8% of the programs), Bioreactors (21%), Fundamentals of Bioprocess and Biotechnology Engineering (21%), Fermentation Processes (15.7%), and Animal Cell Culture (10.5%). The list of programs that offered such courses is indicated in Table 3 (c).

TABLE 3. COURSES OFFERED (O) OR NOT OFFERED (N) IN THE IDENTIFIED PROGRAMS OF THE STUDIED INSTITUTES, BASED ON THE SURVEY

CONDUCTED FROM SEPTEMBER 2021 TO FEBRUARY 2022, DIVIDED INTO CONSOLIDATED MANDATORY COURSES (A), NON-CONSOLIDATED MANDATORY COURSES (B), AND MANDATORY RELEVANT COURSES (C).

	Veterinary Medicine				Animal Science						Bioprocess engineering			Food Engineering				
	UFAC	UFBA	UFG	UGMG	UFPR	UFAM	UFBA	UFG	UFMG	UFPR	UFT	UFCG	UFRJ	UFPR	UFAM	UFC	UFG	UFU	UFFS
a. Consolidated mandatory courses																			
Biochemistry	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Cellular Biology	O	O	O	O	O	O	O	O	O	O	O	O	O	N	N	N	N	N	N
Economics	O	O	O	N	O	O	O	O	O	O	O	O	N	O	O	O	O	O	O
Statistics	O	O	O	O	O	O	O	O	O	O	N	O	O	O	O	O	O	O	O
Genetics	O	O	O	O	O	O	O	O	O	O	O	O	N	O	N	N	N	N	N
Microbiology	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
b. Non-consolidated mandatory courses																			
Administration and Entrepreneurship	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N	N
Biosafety	N	N	N	N	N	N	N	O	N	N	O	O	N	O	N	N	N	N	N
Ethics and Deontology	O	O	O	O	O	O	O	O	N	N	O	O	N	O	N	N	N	N	N
Inspection of Products of Animal Origin	O	O	O	O	O	O	O	O	N	N	N	N	N	N	N	N	N	N	N
Public Health	O	O	O	N	O	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Sustainability	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	N	O
Technology of Products of Animal Origin	O	O	O	O	O	O	O	O	O	O	O	N	O	O	O	O	O	O	O
c. Mandatory relevant courses																			
Bioreactors	N	N	N	N	N	N	N	N	N	N	O	O	O	O	N	N	N	N	N
Animal Cell Culture	N	N	N	N	N	N	N	N	N	N	O	O	N	N	N	N	N	N	N
Fundamentals of Bioprocess Engineering and Biotechnology	N	N	N	N	N	N	N	N	N	N	O	O	N	O	N	N	O	N	N
Introduction to Animal Science	O	N	O	N	O	O	O	O	N	O	N	N	N	N	N	N	N	N	N
Fermentation Processes	N	N	N	N	N	N	N	N	N	N	O	N	N	O	N	N	N	N	O

6.4 DISCUSSION

The development of cultivated meat production involves a series of biological principles on how muscle cells are organized in the animal body and aim to generate complex molecular structures that mimic meat, including muscle fibers, connective tissue, fat, and blood vessels (Tomiyama et al., 2020). However, replicating such processes on an industrial scale presents some technical challenges (Hocquette, 2016). Therefore, it may be beneficial to consider a curriculum associated with the various stages of the production process, such as sourcing inputs, cell cultivation

itself, product processing, quality control, and the final stages of transportation and sales.

During the supplies stage, Genetics and Cellular Biology courses present in the studied programs except for Food Engineering, include relevant contents. In the Genetics course, topics such as molecular genetics and biotechnology of gene expression and regulation in eukaryotes are covered. In the Cellular Biology course, there are topics related to cellular morphofunctional information, understanding of cells organized in tissues, and functional aspects of the various tissue components of the animal organism, which are important for the student to understand this phase of the production process. The initial inputs for cultivated meat are cells that can multiply and differentiate to develop specialized functionality, also known as stem cells (Warner, 2019). The cells can be removed from the animals of interest through a biopsy (Reis et al., 2020), through non-invasive techniques such as body fluids (blood, milk, urine), shed tissue (hair, feathers, teeth), and umbilical cord. In addition, when available, a cell line derived from previously extracted cells can be used (Zhang et al., 2020).

The ex vivo growth of cells requires nutrients in a similar way to the growth of the cells within the animal organism. In the absence of blood circulation for nutrient supply and waste removal, the ex vivo cells are bathed in a culture medium, an important input that provides essential nutrients and cell-signaling substances, such as carbohydrates, lipids, amino acids, vitamins, growth factors, and hormones required at different stages (Warner, 2019). The nutrients required for the culture medium are studied in the discipline of Biochemistry, and present in all programs studied, with contents related to amino acids, proteins, carbohydrates, lipids, nucleotides, nucleic acids, biological membranes, vitamins, coenzymes, hormonal control of metabolism, metabolic interrelationships in animal tissues, and biochemical studies of animal cells.

A common ingredient in the medium used for stem cell culture has been fetal bovine serum, a universal supplement containing different proteins and thousands of small-molecule metabolites at variable concentrations. However, animal origin components, including fetal bovine serum, introduce risks of contamination and undefined substances, in addition to violating the ethical principle of using fewer animals (Post et al., 2020 as ingredient sources. Therefore, current research is focusing on replacing fetal bovine serum with alternatives, such as those obtained

through fermentation processes. Thus, precision fermentation technology can have several functions in the manufacture cultivated meat products. One of them is synthesizing different components or growth factors such as a human platelet lysate or insulin-like growth factor 1, which have been identified as potential substitutes for fetal bovine serum for cell culture (Karnieli et al., 2017). For potential substitutes of fetal bovine serum, the course entitled Fermentative Processes, present in the programs of Bioprocess and Biotechnology Engineering and Food Engineering includes the different variables in growth processes of organisms used in bioprocesses, their characteristics, and examples of applications with contents such as introduction to fermentative processes, culture media for industrial fermentation, and formulation of a culture medium including water, sources of energy and sources of nitrogen. The Microbiology course, also present in all programs studied, which harmonizes with the course on Fermentative processes where the latter exists, includes relevant contents in its syllabus: morphology, cytology, biology, structure, physiology, metabolism, and genetics of microorganisms, agents, raw materials, inoculum, culture media, conduct, separation, and purification of products, obtaining products by fermentation including aerobic and anaerobic routes, industrial applications, legislation on genetic heritage access, among others.

For the production of supports, the course of Modeling and Simulation, present in the Bioprocess Engineering program, can provide a basis with contents related to generic fermentation processes, types of microorganisms, fermenters, and fermentation processes. In addition, and as is true for fundamental knowledge in other stages of the cultivated production chain, competencies from other fields not included in this study are likely relevant, such as Material Sciences and Physics. To produce structured and thick meat products, cells must be transferred to a support, also called a scaffold or structure (GFI, 2022). The support is placed inside the bioreactor and functions as a shelf, where cells are arranged during the differentiation and maturation phase to build a product more similar to meat (Specht and Lagally, 2017). The biomaterials of the supports are key components for cellular agriculture, serving as an integrated support network in which cells expand and differentiate in an anchorage-dependent manner. This porous network allows the flow of oxygen and nutrients and waste removal, as well as the removal of products to maintain cellular metabolic functions and avoid necrotic nuclei formation (Post et al., 2020). The support can be composed of a hydrogel, a macroporous biomaterial, a

sponge type, or a combination of both. Fermentation can also be an alternative method for obtaining cellulose materials to be used as support (Ben-Arye and Levenberg, 2019).

The second essential step for the production of cultivated meat is cell culture itself. During this stage, the Cell Culture course, present in Bioprocess Engineering programs, allows students to acquire knowledge related to cell culture techniques, preparation of materials and solutions necessary for cell culture, selection of high-density culture media, and obtaining animal cell products. It also involves studying the behavior and growth in different bioreactor models, which are fundamental knowledge for this stage of the process. The proliferation phase aims to produce a large number of cell duplications while keeping the cells in an undifferentiated and proliferative state (Bomkamp et al., 2022). In the differentiation phase, cells are cultivated under conditions that promote their differentiation and maturation. They may be placed on scaffolds to obtain more structured and thicker products, as previously mentioned. An ideal scaffold allows the attachment, differentiation, and maturation of cells in a specified manner, imitating the 3D cytoarchitecture of conventional meat while enabling continuous perfusion of the culture medium, analogous to tissue vascularization in living organisms (Bomkamp et al., 2022).

The Bioreactors course, present in Bioprocess Engineering programs, covers topics such as basic concepts of bioreactors, scaling up, ingredients, and medium quality. It provides students with the fundamentals for specifying reactors and how to use them, hence both phases of cell culture, multiplication, and differentiation, occur within bioreactors. Bioreactors provide the housing and control of the environmental conditions, such as temperature and oxygen levels, that allow cells to grow (GFI, 2022). In cultivated meat production, certain parameters of the bioreactors need to change according to the phase of the process. Different factors need to be removed and added during the proliferation and differentiation phases (Specht, 2018).

Throughout the research and development activities, and likely for the upstream stages of the cultivated meat chain, it is important for professionals to know the basics of biosafety regulations. This knowledge is covered in the Biosafety course, present in Animal Science and Bioprocess Engineering programs. The topics covered include basic principles of biosafety, biosafety related to facilities, laboratory organization, and chemical, physical, and biological risks. Such knowledge forms the

basis for the rationales for the establishment of standard operating procedures to be used by the large-scale cultivated meat industry.

During the processing stage, certain concepts included in the Technology of Products of Animal Origin course, present in all studied programs, are relevant to the training of professionals in the cellular agriculture field. It is important to understand traditional processes to extend the concepts to cultivated meat products. The contents of such courses cover topics such as industrialization and preservation of animal products and by-products, technological aspects of their derivatives and by-products, technological aspects involved in the preparation and processing of meat products and derivatives, and regulatory standards. Thus, the courses in this area are a logical starting point for the teaching of processing aspects of cultivated products. Meat products considered processed in the traditional meat industry are meat derivatives that have undergone processing in a way that, when cut, the cut surface no longer exhibits the characteristics of fresh meat, such as the absence of muscle fibers (FAO- Food and Agriculture Organization of the United Nations, 2005). Some cultivated meat products resemble processed meats in terms of their composition and structure. Processed cultivated meats can be produced through the proliferation of myoblasts as the raw material, followed by expansion (Ong et al., 2020). In addition, a further processing phase may be used. For example, minced cultivated meat can be produced by separately cultivating small pieces of muscle and adipose tissue on three-dimensional scaffolds and then mixing them to form a ground meat product (Ong et al., 2020).

Conventional meat production and products pose challenges to public health. For example, although concerns about food safety are not exclusively linked to animal-derived foods, many bacterial pathogens responsible for foodborne illnesses such as Salmonella, Escherichia coli, Campylobacter, and Listeria reside in the intestines of animals (Erickson and Doyle, 2012). These concerns are further amplified by the potential presence of antibiotic-resistant pathogens in meat, which is a risk associated with the misuse of antibiotics in industrial animal food production (Haskell et al., 2018). On the other hand, potential food safety risks associated with cultivated meat involve chemical safety, biosafety, and nutritional safety (Zhang et al., 2019). The components of the culture medium, additional additives for cell proliferation and differentiation, scaffold materials, and the use of antibiotics and hormones must comply with regulations (Chriki and Hocquette, 2020). In this context,

the Public Health course appears relevant as it enables students to learn about activities carried out in health surveillance and prepares them to work in various areas within public health. Additionally, courses related to the Inspection of Products of Animal Origin provide professionals with knowledge about the risks associated with inadequate processes from the production stage to the final consumer, including understanding the regulatory spheres of animal product inspection and the structure of legislation. Thus, similar processes, but related to the safety and inspection of cultivated meat products can be included in the syllabus to update these courses and incorporate alternative proteins.

Large meat processing industries and exporting companies, such as the Brazilian companies JBS and BRF, are likely to market cultivated products in addition to conventional animal-derived meat. They are also likely to be involved in distribution and logistics, with potential consumers being supermarkets, retailers, and fast-food chains, all analogous to the conventional meat supply chain (Reis et al., 2020).

Knowledge related to the discipline of Economics, present in all studied programs such as Introduction to Economics and Management of Agri-food Businesses, market potential determination, analysis for various economic and financial decision-making, market structure, conduct, and performance, enables students to understand the organization and functioning of the economy and the main market structures present in the process.

From a sales perspective, the media is an important source of information for the public and plays a crucial role in shaping public perceptions of food technologies (Bryant, 2020). While many consumers recognize the ethical potential and environmental benefits of cultivated meat, some have concerns about its perceived lack of naturalness, which can lead to concerns about food safety (Siegrist et al., 2018). The Good Food Institute (GFI) conducted a nomenclature study to determine how cultivated meat should be called; the results indicated that the term "cultivated meat" was among the well-received by consumers. Terms such as "in vitro meat" or "lab-grown meat" can be derogatory and do not contribute to a favorable public perception. The terminology used is relevant for the interpretation of much of the existing research on cultivated meat (GFI, 2016).

Despite the existence of marketing professionals responsible for product advertising, students need to have some understanding of the subject to comprehend the market for cultivated meat products. In this regard, the course of Administration

and Entrepreneurship, present in studied academic programs and with relevant content, such as culture and entrepreneurial activity, globalization and business opportunities, entrepreneurship in Brazil, the entrepreneurial process, and business planning, is important in the professional's education.

In addition to the courses directly involved in the cultivated meat production process, other disciplines are indirectly involved. Courses related to Sustainability and the environment, with content related to the contextualization of environmental changes and their consequences for individual well-being and the relationship among the environment, ecology, animal farming, and processing of animal-derived products are relevant for the formation of a critical and ethical professional. This is important because conventional meat production is one of the main contributors to environmental degradation. Currently, animal farming uses 26% of the world's land area for grazing and 29% of total agricultural water use while contributing to 14.5% of global greenhouse gas emissions (FAO, 2015). Nevertheless, there is a strong rhetoric of denial (Hannan, 2020). Thus, educating professionals for critical abilities is of paramount importance, regarding any food production system, including conventional and cellular production of animal-derived foods.

Some authors argue that cultivated meat does not eliminate animal farming because some animals need to be raised for their cells to be harvested (Chriqui and Hocquette, 2020). Additionally, some components of the culture medium are currently animal-derived, such as chicken embryo extract, fetal bovine serum, or horse serum. To fulfill the purpose of cultivated meat, which is to avoid animal farming and slaughter, all animal components must be abolished from the manufacturing process (Benny et al., 2022). In reality, these issues seem more like challenges to be overcome than perennial problems, since there is intense research activity to find alternatives to culture media, and the use of animals as a cell source depends on a small number of animals that can be kept in sanctuaries without the need for slaughter. It is likely that the production of meat dissociated from animal slaughter will positively alter the entire relationship between humans and animals (Heidemann et al., 2020). In this scenario, courses related to Ethics and Deontology, which aim to provide the foundations for ethical and legal professional behavior and are present in all studied academic programs, can be revised to include ethical issues related to the production and commercialization of cultivated meat products, as well as the comparison of the ethical issues in other production systems, such as conventional

and plant-based meat chains. In terms of animal ethics, there is an intrinsic relationship with Animal Welfare courses.

The course of Statistics, present in all studied programs is relevant for professionals to understand the highly active research in this field and be able to both work directly in the research and development of new technologies and to incorporate state-of-the-art research publications. In recent years, there has been increasing interest in cultivated meat production (National Academies of Sciences, 2017). Advances have been made by startups and research groups to establish animal cell lines, improve culture conditions, propose manufacturing platforms, and even create prototypes for taste testing (Ong et al., 2020). Non-profit organizations such as The Good Food Institute (GFI) and New Harvest have published various reports, and teaching support material, and held conferences and lectures to discuss issues such as the social impacts, feasibility, and food safety regulations of cultivated products (Waschulin and Specht, 2018). The basis for suggesting the creation of the two new courses came mostly from courses in bioprocess and biotechnology engineering programs. This is because of the technical aspects present in the production of all cultivated meats, which require knowledge and integration of cellular cultivation techniques, molecular biology, and engineering in the areas of biological tissues, chemistry, food, mechanics, materials, control, and automation, as well as biochemistry, bioinformatics, biomaterial science, and technology (GFI, 2022).

6.5 CONCLUSION

Our study has demonstrated that there is a foundational structure in the curricula of Veterinary Medicine, Animal Science, Bioprocess and Biotechnology Engineering, and Food Engineering programs of 19 different universities that can prepare professionals for the field of cellular agriculture in Brazil. We have identified thirteen mandatory courses that, despite their focus on conventional animal protein production, can be adapted and expanded to relate to the stages of the cultivated meat chain. We have also identified five courses present in some studied programs that have more specific content directly related to the new technology of cultivated meat production, which can serve as a basis for creating new courses to be implemented in the curricula of all interested programs. We hope that this initial contribution serves as a starting point for new curricular proposals in undergraduate

programs to train professionals with additional capabilities of working in the emerging field of alternative proteins.

REFERENCES

BEN-ARYE T, LEVENBERG S. Tissue engineering for clean meat production. **Front Sustain Food Syst**. 2019;3:46. doi:10.3389/fsufs.2019.00046.
BHAT ZF, Kumar S, SHARMA A. In vitro meat production: Challenges and benefits over conventional meat production. **J Integr Agric**. 2015;14(2):241-8. doi:10.1016/S2095- 3119(14)60887-X.

BOMKAMP R, ZHANG X, MILLER K. Scaffolding biomaterials for 3D cultivated meat: Prospects and challenges. **Adv Sci.** 2022;9(3):2102908. doi:10.1002/advs.202102908.

BRYANT CJ. Culture, meat, and cultured meat. **J Anim Sci**. 2020;98(8). doi:10.1093/jas/skaa172.

CHRIKI S, HOCQUETTE JF. The myth of cultured meat: A review. **Front Nutr**. 2020;7:7. doi:10.3389/fnut.2020.00007.

CONFEA. Resolução CONFEA nº 1108 de 29/11/2018. Normas Brasil; 2018. Available from: https://www.normasbrasil.com.br. Accessed August 14, 2024.

ERICKSON MC, DOYLE MP. Plant food safety issues: Linking production agriculture with One Health. In: Improving food safety through a One Health approach: Workshop summary. Washington (DC): National Academies Press; 2012. p. 13-18.

FAO. Food and Agriculture Organization of the United Nations, 2005 Food and Agriculture Organization of the United Nations. **Livestock's long shadow: Environmental issues and options.** Available from: https://www.fao.org/documents/card/en/c/4a5b6df4-0a6e-4e24-a6ff-0cda4a0b10d0. Accessed August 14, 2024.

FAO. Food and Agriculture Organization of the United Nations**. FAO statistical pocketbook.** FAO; 2015. Available from: https://www.fao.org/documents/card/en/c/4a5b6df4-0a6e-4e24-a6ff-0cda4a0b10d0. Accessed August 14, 2024.

GFI. The Good Food Institute. **The naming of tissue-engineered meat**. The Good Food Institute; 2016. Available from: https://www.gfi.org/the-naming-of-clean-meat.
GFI. The Good Food Institute Brasil. **Carne cultivada: perspectivas e oportunidades para o Brasil** / Luismar Marques Porto e Fernanda Vieira Berti. Coordenação de Katherine de Matos e Amanda Leitolis. São Paulo: The Good Food Institute Brasil; 2022.

GODFRAY HC. **Meat: The future series—Alternative proteins**. WORLD ECONOMIC FORUM; 2019. Available from: https://www.weforum.org/reports/meat-the-future-seriesalternative-proteins.

HANNAN J. Meatsplaining: The Animal Agriculture Industry and the Rhetoric of Denial. Sydney (NSW), Australia: Sydney University Press; 2020.

HASKELL MJ, AZEVEDO M, NAIR P. Antibiotic resistance is lower in Staphylococcus aureus isolated from antibiotic-free raw meat as compared to conventional raw meat. **PLoS One**. 2018;13(12). doi:10.1371/journal.pone.0206712.

HEIDEMANN M, K K, GAUTHIER C, ROTH C. Uncoupling meat from animal slaughter and its impacts on human-animal relationships. **Front Psychol.** 2020;11:1824. doi:10.3389/fpsyg.2020.01824.

HERRERO M, THORNTON PK, MASON-D'Croz D, et al. Innovation can accelerate the transition towards a sustainable food system. **Nat Food.** 2020;1:266-72. doi:10.1038/s43016-020-0074-1.

KARNIELI O, KALLISH M, ZIMERMAN B. A consensus introduction to serum replacements and serum-free media for cellular therapies. **Cytotherapy**. 2017;19(2):155-69. doi:10.1016/j.jcyt.2016.11.011.

MEC, 2024. Diretrizes Nacionais para a Educação – Ministério da Educação. Available from: portal.mec.gov.br. Accessed August 14, 2024.

MORAIS-DA-SILVA R. Cellular agriculture and the future of alternative proteins: Opportunities and challenges. **Food Sci Technol**. 2021;35(4):567-78. doi:10.1146/annurev-food-063020-123940.

MORAIS-DA-SILVA R, VILLAR EG, REIS GG, SANCTORUM H, MOLENTO CFM. The expected impact of cultivated and plant-based meats on jobs: The views of experts from Brazil, the United States and Europe. **Humanit Soc Sci Commun**. 2022;9(1):2022a. doi:10.1057/s41599-022-01316-z.

MORAIS-DA-SILVA RL, REIS GG, SANCTORUM H, MOLENTO CFM. The social impacts of a transition from conventional to cultivated and plant-based meats: Evidence from Brazil. **Food Policy**. 2022;111:102337. doi:10.1016/j.foodpol.2022b.102337.

ONG KK, WONG KH, Tan JY. Cultivated meat: Current ambiguities with nomenclature. **Trends Food Sci Technol.** 2020;102:223-31. doi:10.1016/j.tifs.2020.02.010.

REIS GG, MOLENTO CFM, M S. Livestock value chain in transition: Cultivated (cellbased) meat and the need for breakthrough capabilities. **Technol Soc**. 2020;62:101286. doi:10.1016/j.techsoc.2020.101286.

SCOLLAN N, C. L. Future research priorities for animal production in a changing world. **Anim Prod Sci**. 2010;51(1):1-5.

SIEGRIST M, B M. Perceived naturalness and evoked disgust influence acceptance of cultured meat. **Meat Sci.** 2018;139:213-9. doi:10.1016/j.meatsci.2018.02.007.

SANTO RE, CHEN Y, A S. Considering plant-based meat substitutes and cell-based meats: A public health and food systems perspective. **Front Sustain Food Syst**. 2020;4:134. doi:10.3389/fsufs.2020.00134.

SPECHT L, LAGALLY C**. Mapping emerging industries: Opportunities in clean meat**. The Good Food Institute; 2017. Available from: https://www.gfi.org/mapping-emergingindustries.

SPECHT L, T J. Opportunities for applying biomedical production and manufacturing methods to the development of the clean meat industry. **Biochem Eng J.** 2018;132:161- 8. doi:10.1016/j.bej.2018.01.015.

STEPHENS N, B M. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. **Trends Food Sci Technol**. 2018;78:155-66. doi:10.1016/j.tifs.2018.04.010.

TOMIYAMA AJ, KAWECKI NS, ROSENFELD DL, Jay JA, RAJAGOPAL D, ROWAT AC. Bridging the gap between the science of cultured meat and public perceptions. **Trends Food Sci Technol**. 2020;104:144-52. Available online August 8, 2020. doi:10.1016/j.tifs.2020.07.019.

TUOMISTO HL, ELLIS MJ, HAASTRUP P. Environmental impacts of cultured meat: alternative production scenarios. In: Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector; 2014. Available from: https://core.ac.uk/download/pdf/38629617.pdf.

WARNER RD. Analysis of the process and drivers for cellular meat production. **Animal**. 2019;13(12):3041-58. doi:10.1017/S1751731119001897.

ZHANG Y, WANG X, LIU S. Challenges and possibilities for bio-manufacturing cultured meat. **Trends Food Sci Technol.** 2020;97:443-50. doi:10.1016/j.tifs.2020.01.026.

ZHAO X, LIU Y, WANG Q, ZHANG L. Cultivated meat as a sustainable alternative: A review. **J Sustain Agric**. 2020;12(4):123-35. doi:10.1016/j.sustag.2020.01.001.

7 FINAL CONSIDERATIONS

Through this thesis titled "From Introduction to the Production of Cultivated Meat in Higher Education in Brazil," it was possible to observe that even with Brazil's growing demand for meat, driven by the increasing population in the country, the emergence of alternative proteins may change the consumption of proteins in the future, which will create the need for a well-structured market to meet this demand.

The thesis provided unequivocal evidence for the hypothesis that acceptance of cultivated meat varies considerably across different regions of Brazil, due to the country's vast size, economic disparities, and rich cultural diversity. There is an urgent need for greater dissemination of information on the topic to promote public acceptance and understanding. Educational initiatives are pivotal in spreading knowledge across society, and this is also the case regarding a basic understanding of cellular agriculture. Among undergraduate students and graduates, there is an interest in learning about cellular agriculture and in acquiring the necessary skills to capitalize on the opportunities that this emerging field is likely to offer. Thus, there is a need for educational programs and practical training to help professionals begin or deepen their understanding of cellular agriculture.

The pioneering initiative in Brazil by the Federal University of Parana is pushing for advancements in the field of cellular agriculture, with progresses in the three pillars of teaching, research, and extension. Such advancements highlight the need for ongoing efforts and a broader expansion of the three pillars, both to accommodate the growing number of students and professionals interested in the field, as well as to support advances in other institutions. Additional research and teaching efforts are necessary to consolidate this field at both undergraduate and graduate levels in Brazil. In terms of education, creating new courses or adapting existing ones across various academic programs seems to be the next logical step.

This work identified a foundational structure within the curricula of Veterinary Medicine, Animal Science, Bioprocess Engineering, Biotechnology, and Food Engineering programs that can aid in preparing professionals for the field of cellular agriculture in Brazil. We identified thirteen compulsory courses that, despite focusing on conventional animal protein production, can be adapted and expanded to relate to knowledge that is relevant for the cultivated meat production system, from upstream inputs to downstream products and market issues. Additionally, we identified five

courses in some of the studied programs with content more directly related to the new cultivated meat production technology, which can serve as a basis for the creation of new courses to be implemented in the curricula of all interested programs.

In general, it is hoped that this thesis will serve as a foundation for new curricular proposals in undergraduate programs to train professionals with additional capabilities to work in the emerging field of alternative proteins, as it is difficult to predict which type of food protein will be in high demand in the coming decades. Will Brazil take a leadership role in cellular agriculture? The answer largely depends on what we do now.

REFERENCES

ABEBE, G. K., ISMAIL, M. R., KEVANY, K., HAILESLASSIE, H. A., PAULEY, T. Canadians' experiences of alternative protein foods and their intentions to alter current dietary patterns. **Journal of Agriculture and Food Research**, v. 18, article 101354, 2024. https://doi.org/10.1016/j.jafr.2024.101354

ALEXANDER, P., BROWN, C., ARNETH, A., DIAS, C., FINNIGAN, J., MORAN, D., & ROUNSEVELL, M. D. A. Could consumption of insects, cultured meat or imitation meat reduce global agricultural land use? **Global Food Security**, v. 15, p. 22-32, 2017. https://doi.org/10.1016/j.gfs.2017.04.001

ANTHIS, J. R., BERENSTEIN, P., BEURRIER, C., BIEHL, C., BIRDIE, P., BURLEY, J., CHANTRE, C., DAVIS, J., DOHADWALA, S., D'ORIGNY, G., ESPÍRITO SANTO, V., ESPITIA, F., GONZALEZ, G., GRANDIC, I., GREEN, C., GROENEWEGEN, L., GUVENILIR, A., HANYU, Y., KANE, M. H., … ZIMMERMAN, J. Modern meat: the next generation of meat from cells. In: SPIROS, K., HALL, S., DARLING, J., & BENAMI, M. (Eds.). 1st ed. Cellular Agriculture Society, 2023.

BARBER, B. Resistance by scientists to scientific discovery: This source of resistance has yet to be given the scrutiny accorded religious and ideological sources. **Science**, v. 134, p. 596–602, 1961. https://doi.org/10.1126/science.134.3479.596

BEN-ARYE, T., LEVENBERG, S. Tissue engineering for clean meat production. **Frontiers in Sustainable Food Systems**, v. 3, article 46, 2019. https://doi.org/10.3389/fsufs.2019.00046

BENNY, A., PANDI, K., UPADHYAY, R. Techniques, challenges, and future prospects for cell-based meat. **Food Science and Biotechnology**, v. 31, n. 10, p. 1225-1242, 2022. https://doi.org/10.1007/s10068-022-01136-6

BEGHO, T., ZHU, Y. Determinants of consumer acceptance of meat analogues: Exploring measures of risk preferences in predicting consumption. **Journal of Agriculture and Food Research**, v. 11, article 100509, 2023. https://doi.org/10.1016/j.jafr.2023.100509

BENTON, Tim G.; BIEG, Carling; HARWATT, Helen; PUDASAINI, Roshan; WELLESLEY, Laura. *Food system impacts on biodiversity loss*. Chatham House, 2021. Disponível em: <2021-02-03-food-system-biodiversity-loss-benton-et-al.pdf>. Acesso em: 3 fev. 2025.

BHAT, Z. F., MORTON, J. D., BEKHIT, A. E. D. A., KUMAR, S., BHAT, H. F. Cultured meat: Challenges in the path of production and 3D food printing as an option to develop cultured meat-based products. **Alternative Proteins**, v. 1, p. 271–295, 2022. https://doi.org/10.1201/9780429299834-9

BHAT, Z. F., BHAT, H., PATHAK, V. Prospects for in vitro cultured meat – a future harvest. In: LANZA, R., LANGER, R., VACANTI, J. (Eds.). Principles of Tissue

Engineering. 4th ed. Boston, MA: Academic Press, p. 1663–1683, 2014. https://doi.org/10.1016/B978-0-12-398358-9.00079-3

BHAT, Z. F., KUMAR, S., SHARMA, A. In vitro meat production: Challenges and benefits over conventional meat production. **Journal of Integrative Agriculture**, v. 14, n. 2, p. 241-248, 2015. https://doi.org/10.1016/S2095-3119(14)60887-X

BISCARRA-BELLIO, J. C., DE OLIVEIRA, G. B., MARQUES, M. C. P., MOLENTO, C. F. M. Demand changes meat as changing meat reshapes demand: The great meat revolution. **Meat Science**, v. 196, article 109040, 2023. https://doi.org/10.1016/j.meatsci.2022.109040

BISCARRA-BELLIO, J. C., PAOLINI, G., MOLENTO, C. F. M. Cellular Agriculture Education in Brazilian Undergraduate Programs: Not as Far as It Seems? Submitted.

BISCARRA-BELLIO, J. C., MENDES, G., MOLENTO, C. F. M. Should Cellular Agriculture Be Taught in Undergraduate Programs in Brazil? Submitted.

BISCARRA-BELLIO, J. C., MENDES, G., OLEGÁRIO, J. C., MOLENTO, C. F. M. Teaching, Research, and Extension in Cellular Animal Science in a Brazilian University. Submitted.

BOGUEVA, D., MARQUES, M., MOLENTO, C. F. M., MARINOVA, D., & PHILLIPS, C. J. C. (2023). Will the cows and chickens come home? Perspectives of Australian and Brazilian beef and poultry farmers towards diversification. **Sustainability**, v. 15(16), article 12380. https://doi.org/10.3390/su151612380

BOMKAMP, R., ZHANG, X., MILLER, K. Scaffolding biomaterials for 3D cultivated meat: Prospects and challenges. **Advanced Science**, v. 9(3), article 2102908, 2022. https://doi.org/10.1002/advs.202102908

BRYANT, C. J. Culture, meat, and cultured meat. **Journal of Animal Science**, v. 98(8), 2020. https://doi.org/10.1093/jas/skaa172

BRYANT, C., & BARNETT, J. (2018). Consumer acceptance of cultured meat: A systematic review. **Meat Science**, v. 143, 8–17. https://doi.org/10.1016/j.meatsci.2018.04.008

BRYANT, C., & BARNETT, J. (2020). Consumer acceptance of cultured meat: An updated review (2018–2020). **Applied Sciences**, v. 10(15), article 5201. https://doi.org/10.3390/app10155201

BOGUEVA, D., MARQUES, M., MOLENTO, C. F. M., MARINOVA, D., & PHILLIPS, C. J. C. (2023). Will the cows and chickens come home? Perspectives of Australian and Brazilian beef and poultry farmers towards diversification. **Sustainability**, v. 15, article 12380. https://doi.org/10.3390/su151612380

CEPEA. (2023). Boletim mercado de trabalho do agronegócio brasileiro: 4º trimestre de 2023. Available at: Boletim MT Agro (usp.br). Retrieved September 2024.

CATTANEO, C., LAVELLI, V., PROSERPIO, C., LAUREATI, M., & PAGLIARINI, E. (2019). Consumers' attitude towards food by-products: The influence of food technology neophobia, education and information. **International Journal of Food Science & Technology**, v. 54, 679-687. https://doi.org/10.1111/ijfs.13978

CHRIKI, S., & HOCQUETTE, J. F. (2020). The myth of cultured meat: A review. **Frontiers in Nutrition**, v. 7, article 7. https://doi.org/10.3389/fnut.2020.00007

CHRIKI, S., PAYET, V., PFLANZER, S. B., ELLIES-OURY, M. P., LIU, J., HOCQUETTE, E., REZENDE-DE-SOUZA, J. H., & HOCQUETTE, J. F. (2021). Brazilian consumers' attitudes towards so-called "cell-based meat". **Foods**, v. 10(11), article 2588. https://doi.org/10.3390/foods10112588

CNN. (2024). Estudo revela Salvador como capital com os piores índices de pobreza, desnutrição e desemprego. Retrieved from: https://www.cnnbrasil.com.br/nacional/estudo-revela-salvador-como-capital-com-os-piores-indices-de-pobreza-desnutrição-e-desemprego/#:~:text=Colunas%20CNN-,Estudo%20revela%20Salvador%20como%20capital%20com%20os,de%20pobreza%2C%20desnutri%C3%A7%C3%A3o%20e%20desemprego&text=Um%20mapa%20de%20desigualdades%20que,desnutri%C3%A7%C3%A3o%20e%20desemprego%20no%20pa%C3%ADs. Accessed June 18, 2024.

CONFEA. Resolução CONFEA nº 1108 de 29/11/2018. **Normas Brasil**, 2018. Available from: https://www.normasbrasil.com.br. Accessed August 14, 2024.

DAGEVOS, H., & VERBEKE, W. (2022). Meat consumption and flexitarianism in the Low Countries. **Meat Science**, v. 192, article 108894. https://doi.org/10.1016/j.meatsci.2022.108894

DE OLIVEIRA, G. A., DOMINGUES, C. H. D. F., & BORGES, J. A. R. (2021). Analyzing the importance of attributes for Brazilian consumers to replace conventional beef with cultured meat. **PLOS One**, v. 16(5), article e0251432. https://doi.org/10.1371/journal.pone.0251432

DOMINGO, J. L., & NADAL, M. (2017). Carcinogenicity of consumption of red meat and processed meat: A review of scientific news since the IARC decision. **Food and Chemical Toxicology**, v. 105, 256–261. https://doi.org/10.1016/j.fct.2017.04.028

DUARTE, S. J. H., MAMEDE, M. V., & ANDRADE, S. M. O. (2009). Opções Teórico-Metodológicas em Pesquisas Qualitativas: Representações Sociais e Discurso do Sujeito Coletivo. **Saúde e Sociedade São Paulo**, v. 18(4), 620-626. https://doi.org/10.1590/S0104-12902009000400006

EGOLF, A., HARTMANN, C., & SIEGRIST, M. (2019). When Evolution Works Against the Future: Disgust's Contributions to the Acceptance of New Food Technologies. **Risk Analysis**, v. 39(7), 1546-1559. https://doi.org/10.1111/risa.1279

ERICKSON, M. C., & DOYLE, M. P. Plant food safety issues: Linking production agriculture with One Health. In: Improving food safety through a One Health

approach: Workshop summary. Washington (DC): National Academies Press; 2012. p. 13-18.

FAO. Food and Agriculture Organization of the United Nations. (2005). **Livestock's long shadow: Environmental issues and options**. FAO. Available from: https://www.fao.org/documents/card/en/c/4a5b6df4-0a6e-4e24-a6ff-0cda4a0b10d0. Accessed August 14, 2024.

FAO. Food and Agriculture Organization of the United Nations. (2015). **FAO statistical pocketbook**. FAO. Available from: https://www.fao.org/documents/card/en/c/4a5b6df4-0a6e-4e24-a6ff-0cda4a0b10d0. Accessed August 14, 2024.

FERNANDES, A., COSTA, L., TEIXEIRA, O., SANTOS, F., REVILLION, J. P., & SOUZA, A. (2021). Consumption behavior and purchase intention of cultured meat in the capital of the "state of barbecue", Brazil. **British Food Journal**, v. 123(9), 3032–3055. https://doi.org/10.1108/BFJ-08-2020-0698

FINISTRELLA, V., GIANNI, N., FINTINI, D., et al. (2024). Neophobia, sensory experience, and child's schemata contribute to food choices. **Eating and Weight Disorders**, v. 29, 25. https://doi.org/10.1007/s40519-024-01657-5

FRESHNEY, R. I. (2016). **Culture of Animal Cells: A Manual of Basic Technique**. 7. ed. Nova York: John Wiley & Sons Inc, 736 p. https://doi.org/1002/9780470649367

FUNDAÇÃO ARAUCÁRIA. (2024). **NAPI - Proteínas Alternativas**. Disponível em: https://www.iaraucaria.pr.gov.br/napi-proteinas-alternativas/. Acesso em: 04 ago. 2024.

GARBIN, V. P., PINTO, P. T., LUZ-FREITAS, M. S., & MOLENTO, C. F. M. (2024). Ética animal e proteínas alternativas: questões atuais em terminologia da língua portuguesa. **Archives of Veterinary Science**, v. 29(1). http://dx.doi.org/10.5380/avs.v29i1

GIBCO. (2020). **Cell Culture Basic Handbook**. Thermo Fischer Scientific. Disponível em: https://assets.thermofisher.com/TFS-Assets/BID/Handbooks/gibco-cell-culture-basics-handbook.pdf

GEIKER, N. R. W., BERTRAM, H. C., MEJBORN, H., DRAGSTED, L. O., KRISTENSEN, L., CARRASCAL, J. R., BÜGEL, S., & ASTRUP, A. (2021). Meat and Human Health-Current Knowledge and Research Gaps. **Foods**, v. 10(7), article 1556. https://doi.org/10.3390/foods10071556

GFI (2016). **The Good Food Institute. The naming of tissue-engineered meat.** The Good Food Institute. Retrieved from: https://www.gfi.org/the-naming-of-clean-meat

GFI (2022). **The Good Food Institute Brasil. Carne cultivada: perspectivas e oportunidades para o Brasil** / Luismar Marques Porto e Fernanda Vieira Berti.

Coordenação de Katherine de Matos e Amanda Leitolis. São Paulo: The Good Food Institute Brasil. Retrieved from: https://www.gfi.org

GFI (2022). **Plano de Ensino para Disciplinas em Proteínas Alternativas.** The Good Food Institute Brasil. Retrieved from: GFI Brasil lança Plano de Ensino para Disciplinas em Proteínas Alternativas - GFI Brasil.

GFI (2024). **The Alternative Protein Project.** The Good Food Institute. Retrieved from: The Alt Protein Project | GFI Brasil.

GIACALONE, D., & JAEGER, S. R. (2023). Consumer acceptance of novel sustainable food technologies: A multi-country survey. **Journal of Cleaner Production**, v. 408, article 137119. https://doi.org/10.1016/j.jclepro.2023.137119

GÓMEZ-LUCIANO, C. A., DE AGUIAR, L. K., URBANO, B., & VRIESEKOOP, F. (2019). Consumers' willingness to purchase three alternatives to meat proteins in the United Kingdom, Spain, Brazil and the Dominican Republic. **Food Quality and Preference**, v. 78, article 103732. https://doi.org/10.1016/j.foodqual.2019.103732

GONÇALVES, J. C. R., & SOBRAL, M. V. (2020). **Cultivo de células: da teoria à bancada.** João Pessoa: Editora UFPB, 166 p. Disponível em: http://www.editora.ufpb.br/sistema/press5/index.php/UFPB/catalog/download/669/839/7054-1?inline=1

GODFRAY, H., AVEYARD, P., GARNETT, T., HALL, J. W., KEY, T. J., LORIMER, J., & JEBB, S. A. (2018). Meat consumption, health, and the environment. **Science**, v. 361, article eaam5324. https://doi.org/10.1126/science.aam5324

GODFRAY, H. C. (2019). **Meat: The future series—Alternative proteins.** World Economic Forum. Available from: https://www.weforum.org/reports/meat-the-future-series-alternative-proteins

GOODWIN, J. N., & SHOULDERS, C. W. (2013). The future of meat: a qualitative analysis of cultured meat media coverage. **Meat Science**, v. 95, 445–450. https://doi.org/10.1016/j.meatsci.2013.05.027

HANNAN, J. (2020). **Meatsplaining: The Animal Agriculture Industry and the Rhetoric of Denial.** Sydney University Press: Sydney, NSW, Australia.

HANSEN, A., JAKOBSEN, J., & WETHAL, U. (2021). New geographies of global meatification: The BRICS in the industrial meat complex (chapter 3). In A. Hansen, & K. L. Syse (Eds.), **Changing meat cultures: Food practices, global capitalism, and the consumption of animals** (pp. 35–59).

HARRISON, R. (1964). **Animal machines.** Vincent Stuart Ltd, London, UK.

HARTMANN, C., & SIEGRIST, M. (2017). Consumer perception and behavior regarding sustainable protein consumption: A systematic review. **Trends in Food Science & Technology**, v. 61, 11-25. https://doi.org/10.1016/j.tifs.2016.12.006

HASKELL, M. J., AZEVEDO, M., & NAIR, P. (2018). Antibiotic resistance is lower in *Staphylococcus aureus* isolated from antibiotic-free raw meat as compared to conventional raw meat. **PLOS One**, v. 13(12). https://doi.org/10.1371/journal.pone.0206712

HEIDEMANN, M. S., MOLENTO, C. F. M., REIS, G. G., & PHILLIPS, C. J. C. (2020a). Uncoupling meat from animal slaughter and its impacts on human-animal relationships. **Frontiers in Psychology**, v. 11. https://doi.org/10.3389/fpsyg.2020.01824

HEIDEMANN, M. S., TACONELI, C. A., REIS, G. G., PARISI, G., & MOLENTO, C. F. M. (2020b). Critical Perspective of Animal Production Specialists on Cell-Based Meat in Brazil: From Bottleneck to Best Scenarios. **Animals: an open access journal from MDPI**, v. 10(9), 1678. https://doi.org/10.3390/ani10091678

HERRERO, M., THORNTON, P. K., MASON-D'CROZ, D., et al. (2020). Innovation can accelerate the transition towards a sustainable food system. **Nature Food**, v. 1(4), 266-272. https://doi.org/10.1038/s43016-020-0074-1

HOCQUETTE, J. F. (2016). Is in vitro meat the solution for the future? **Meat Science**, v. 120, 167-176. https://doi.org/10.1016/j.meatsci.2016.05.013

HOCQUETTE, J. F. (2023). Consumer perception of livestock production and meat consumption; an overview of the special issue "Perspectives on consumer attitudes to meat consumption". **Meat Science**, v. 200, article 109163. https://doi.org/10.1016/j.meatsci.2023.109163

HOPOOD, C. J., & BLEIDORN, W. (2019). Psychological profiles of people who justify eating meat as natural, necessary, normal, or nice. **Food Quality and Preference**, v. 75, 10-14. https://doi.org/10.1016/j.foodqual.2019.02.004

HUBALEK, S., POST, M. J., & MOUTSATSOU, P. (2022). Towards resource-efficient and cost-efficient cultured meat. **Current Opinion in Food Science**, v. 47, article 100885. https://doi.org/10.1016/j.cofs.2022.100885

IBGE (2022). Instituto Brasileiro de Geografia e Estatística (Brazilian Institute of Geography and Statistics). Retrieved from: https://www.ibge.gov.br/cidades-e-estados.html?view=municipio. Accessed on July 23, 2024.

ICE (2023). Índice de Cidades Empreendedoras. Ranking 2023. Retrieved from: https://ice.enap.gov.br/ranking. Accessed on July 23, 2024.

JOY, M. Retrieved from https://www.melaniejoy.org/. Accessed February 11, 2025.

KARNIELI, O., KALLISH, M., & ZIMERMAN, B. (2017). A consensus introduction to serum replacements and serum-free media for cellular therapies. **Cytotherapy**, 19(2), 155-169. https://doi.org/10.1016/j.jcyt.2016.11.011

LEROY, F., SMITH, N. W., ADESOGAN, A. T., BEAL, T., IANNOTTI, L., MOUGHAN, P. J., & MANN, N. (2023). The role of meat in the human diet: Evolutionary aspects

and nutritional value. **Animal Frontiers**, 13(2), 11–18. https://doi.org/10.1093/af/vfac093

LETTI, L. A. J., KARP, S. G., MOLENTO, C. F. M., COLONIA, B. S. O., BOSCHERO, R. A., SOCCOL, V. T., HERRMANN, L. W., PENHA, R. de O., WOICIECHOWSKI, A. L., & SOCCOL, C. R. (2021). Cultivated meat: Recent technological developments, current market, and future challenges. **Biotechnology Research and Innovation**, 5(1), e2021001. https://doi.org/10.4322/biori.202101

LIU, J., CHRIKI, S., KOMBOLO, M., SANTINELLO, M., PFLANZER, S. B., HOCQUETTE, E., ELLIES-OURY, M. P., & HOCQUETTE, J. F. (2023). Consumer perception of the challenges facing livestock production and meat consumption. **Meat Science**, 200, Article 109144. https://doi.org/10.1016/j.meatsci.2023.109144

LOUGHNAN, S., BASTIAN, B., & HASLAM, N. (2014). The psychology of eating animals. **Current Directions in Psychological Science**, 23(2), 104–108. https://doi.org/10.1177/0963721414525781

MALILA, Y., OWOLABI, I. O., CHOTANAPHUTI, T., et al. (2024). Current challenges of alternative proteins as future foods. **npj Science of Food**, 8, 53. https://doi.org/10.1038/s41538-024-00291-w

MANCINI, M. C., & ANTONIOLI, F. (2019). Exploring consumers' attitude towards cultured meat in Italy. **Meat Science**, 150, 101-110. https://doi.org/10.1016/j.meatsci.2018.12.014

MARQUES, S. C. C., MAUAD, J. R. C., DOMINGUES, C. H. F., BORGES, J. A. R., & SILVA, J. R. (2022). The importance of local food products attributes in Brazil consumer's preferences. **Future Foods**, 5, Article 100125. https://doi.org/10.1016/j.fufo.2022.100125

MARQUES, M., MORAIS-DA-SILVA, R. L., BISCARRA-BELLIO, J. C., UETA, M. H., & MOLENTO, C. F. M. (2024). Global and regional policies for cultivated meat. In C. R. SOCCOL, C. F. M. MOLENTO, G. G. REIS, & S. G. KARP (Eds.), **Cultivated meat: Technologies, Commercialization and Challenge**. Springer. https://doi.org/10.1007/978-3-031-55968-6_18

MEC, 2024. Diretrizes Nacionais para a Educação – Ministério da Educação. Available from: portal.mec.gov.br. Accessed August 14, 2024.

MEECHAN, PAUL J., & POTTS, JEFFREY (2020). Biosafety in microbiological and biomedical laboratories. HHS publication, nº (CDC) 300859. https://stacks.cdc.gov/view/cdc/97733

MENDES, G., & BISCARRA-BELLIO, J. C., MOLENTO, C. F. M. How much do opinions regarding cultivated meat vary within the same country? The cases of Salvador and São Paulo, Brazil. (Submitted).

MICHEL, F., HARTMANN, C., & SIEGRIST, M. (2021). Consumers' associations, perceptions, and acceptance of meat and plant-based meat alternatives. **Food**

Quality and Preference, 87, Article 104063. https://doi.org/10.1016/j.foodqual.2020.104063

MINISTÉRIO DA SAÚDE (2000). Manual de Procedimentos Básicos em Microbiologia Clínica para Controle de Infecção Hospitalar. Brasília: Agência Nacional de Vigilância Sanitária, Gerência Geral de Serviços de Saúde e Gerência de Controle de Riscos à Saúde, Módulo I, 56 p. Disponível em: https://bvsms.saude.gov.br/bvs/publicacoes/manual_procedimentos_microbiologiaclinica_controle_infechospitalar.pdf

MOLINARO, E. M., CAPUTO, L. F. G., & AMENDOEIRA, M. R. R. (2010). Conceitos e métodos para formação de profissionais em laboratórios de saúde. 2. v. Rio de Janeiro: EPSJV: IOC, 254 p.

MORAIS-DA-SILVA, R. L., REIS, G. G., SANCTORUM, H., & MOLENTO, C. F. M. (2022a). The social impact of the transition from conventional to cultivated and plant-based meats: evidence from Brazil. **Food Policy**, 111, 102337. https://doi.org/10.1016/j.foodpol.2022.102337

MORAIS-DA-SILVA, R. L., VILLAR, E. G., REIS, G. G., & others. (2022b). The expected impact of cultivated and plant-based meats on jobs: The views of experts from Brazil, the United States, and Europe. **Humanities and Social Sciences Communications**, 9, 297. https://doi.org/10.1057/s41599-022-01316-z

MORAIS-DA-SILVA, R. L., REIS, G. G., SANCTORUM, H., & MOLENTO, C. F. M. (2022). The social impact of cultivated and plant-based meats as radical innovations in the food chain: Views from Brazil, the United States, and Europe. **Frontiers in Sustainable Food Systems**, 6, Article 1056615. https://doi.org/10.3389/fsufs.2022.1056615

MORAIS-DA-SILVA, R. L. (2021). Cellular agriculture and the future of alternative proteins: Opportunities and challenges. **Food Sci Technol**, 35(4), 567-578. https://doi.org/10.1146/annurev-food-063020-123940

MUGABE, D., HANLEY, L., NEWMAN, L., NEWMAN, K., & FRASER, E. D. G. (2024). The potential for cellular agriculture to advance sustainable development goals. In **Cellular Agriculture: Technology, Society, Sustainability and Science** (pp. 361-377). https://doi.org/10.1016/B978-0-443-18767-4.00020-2

NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE. (2017). Preparing for future products of biotechnology. Washington (DC): National Academies Press. https://doi.org/10.17226/24605

NEWELL, R., & GLAROS, A. (2024). Chapter 3 - Sustainable food systems, development paths, and scenarios for cellular agriculture. In E. D. G. FRASER, D. L. KAPLAN, L. NEWMAN, & R. Y. YADA (Eds.), **Cellular Agriculture** (pp. 29-45). Academic Press. https://doi.org/10.1016/B978-0-443-18767-4.00022-6

NEZLEK, J. B., & FORESTELL, C. A. (2019). Food neophobia and the Five Factor Model of personality. **Food Quality and Preference**, 73, 210-214. https://doi.org/10.1016/j.foodqual.2018.11.007

NGUYEN, J., FERRARO, C., SANDS, S., & LUXTON, S. (2021). Alternative protein consumption: A systematic review and future research directions. **International Journal of Consumer Studies**, 46, 1691-1717. https://doi.org/10.1111/ijcs.12797

NOBRE, F. S. (2022). Cultured meat and the sustainable development goals. **Trends in Food Science & Technology**, 124, 140-153. https://doi.org/10.1016/j.tifs.2022.04.011

ONG, S., CHOUDHURY, D., & NAING, M. W. (2020). Cell-based meat: Current ambiguities with nomenclature. **Trends in Food Science & Technology**, 102, 223-231. https://doi.org/10.1016/j.tifs.2020.02.010

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, Article 105058. https://doi.org/10.1016/j.appet.2020.105058

PAKSERESHT, A., KALIJI, S. A., & CANAVARI, M. (2022). Review of factors affecting consumer acceptance of cultured meat. **Appetite**, 170, Article 105829. https://doi.org/10.1016/j.appet.2021.105829

PANDURANGAN, M., & KIM, D. H. (2015). A novel approach for in vitro meat production. **Applied Microbiology and Biotechnology**, 99, 5391–5395. https://doi.org/10.1007/s00253-015-6671-5

PASITKA, L., WISSOTSKY, G., AYYASH, M., & others. (2024). Empirical economic analysis shows cost-effective continuous manufacturing of cultivated chicken using animal-free medium. **Nature Food**, 5, 693–702. https://doi.org/10.1038/s43016-024-01022-w

PHILLIPS, C., MOLENTO, C., BOGUEVA, D., & MARINOVA, D. (2024). Planetary health and animal and plant dietary proteins, in PREEDY, V. R. (Ed.) **Plant and Animal Proteins in Health and Disease Prevention**, Taylor and Francis, Milton Park, UK. Unpublished results

POORE, J., & NEMECEK, T. (2018). Reducing food's environmental impacts through producers and consumers. **Science**, 360(6392), 987–992. https://doi.org/10.1126/science.aaq0216

POST, M. J. (2014a). Cultured beef: medical technology to produce food. **J. Sci. Food Agric.**, 94, 1039–1041. https://doi.org/10.1002/jsfa.6474

POST, M. J. (2014b). An alternative animal protein source: cultured beef. **Ann N Y Acad Sci.**, Nov; 1328:29-33. https://doi.org/10.1111/nyas.12569

POST, M. J., LEVENBERG, S., KAPLAN, D. L., GENOVESE, N., FU, J., BRYANT, C. J., NEGOWETTI, N. E., VERZIJDEN, K., & MOUTSATSOU, P. (2020). Scientific, sustainability, and regulatory challenges of cultured meat. **Nat Food**, 1, 403-415.

QIAN, F., RIDDLE, M. C., WYLIE-ROSETT, J., & HU, F. B. (2020). Red and Processed Meats and Health Risks: How Strong Is the Evidence? **Diabetes Care**, 43(2), 265-271. https://doi.org/10.2337/dci19-0063

R CORE TEAM. (2023). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

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. **Technology in Society**, 62, 101286. https://doi.org/10.1016/j.techsoc.2020.101286

REIS, G. G., HEIDEMANN, M. S., MATOS, K. H. O. D., & MOLENTO, C. F. M. (2020). Cell-based meat and firms' environmental strategies: New rationales as per available literature. **Sustainability**, 12(22), 9418. https://doi.org/10.3390/su12229418

REIS, G. G., VILLAR, E. G., GIMENEZ, F. A. P., MOLENTO, C. F. M., & FERRI, P. (2022). The interplay of entrepreneurial ecosystems and global value chains: Insights from the cultivated meat entrepreneurial ecosystem of Singapore. **Technology in Society**, 71, 102116. https://doi.org/10.1016/j.techsoc.2022.102116

RUZGYS, S., & PICKERING, G. J. (2020). Perceptions of cultured meat among youth and messaging strategies. **Frontiers in Sustainable Food Systems**, 4, Article 122. https://doi.org/10.3389/fsufs.2020.00122

SÁNCHEZ-SABATÉ, R., BADILLA-BRIONES, Y., & SABATÉ, J. (2019). Understanding attitudes towards reducing meat consumption for environmental reasons: A qualitative synthesis review. **Sustainability**, 11(22), 1-38. https://doi.org/10.3390/su11226295

SANTO, R. E., CHEN, Y., & S., A. (2020). Considering plant-based meat substitutes and cell-based meats: A public health and food systems perspective. **Frontiers in Sustainable Food Systems**, 4, 134. https://doi.org/10.3389/fsufs.2020.00134

SCHNEIDER, K. (2013). Concentrating on healthy feeding operations: the national school lunch program, "cultured meat," and the path to a sustainable food future. **Journal of Land Use & Environmental Law**, 29(1), 145–184. http://www.Jstor.Org/stable/43741145

SCOLLAN, N., & C. L. (2010). Future research priorities for animal production in a changing world. **Animal Production Science**, 51(1), 1-5.

SEPTIANO, F., SUNG, B., DUONG, C., & CONROY, D. (2023). Are two reasons better than one? How natural and ethical appeals influence consumer preferences for clean meat. **Journal of Retailing and Consumer Services**, 71, Article 103225. https://doi.org/10.1016/j.jretconser.2022.103225

SIDDIQUI, S. A., KHAN, S., MURID, M., ASIF, Z., OBOTUROVA, N. P., NAGDALIAN, A. A., BLINOV, A. V., IBRAHIM, S. A., & JAFARI, S. M. (2022a). Marketing strategies for cultured meat: A review. **Applied Sciences**, 12, Article 8795. https://doi.org/10.3390/app12178795

SIDDIQUI, S. A., KHAN, S., FAROOQI, M. Q. U., SINGH, P., FERNANDO, I., & NAGDALIAN, A. (2022b). Consumer behavior towards cultured meat: A review since 2014. **Appetite**, 179, Article 106314. https://doi.org/10.1016/j.appet.2022.106314

SIDDIQUI, S. A., BAHMID, N. A., KARIM, I., MEHANY, T., GVOZDENKO, A. A., BLINOV, A. V., NAGDALIAN, A. A., ARSYAD, M., & LORENZO, J. M. (2022c). Cultured meat: Processing, packaging, shelf life, and consumer acceptance. **LWT – Food Science and Technology**, 172, Article 114192. https://doi.org/10.1016/j.lwt.2022.114192

SIEGRIST, M., SÜTTERLIN, B., & HARTMANN, C. (2018). Perceived naturalness and evoked disgust influence acceptance of cultured meat. **Meat Science**, 139, 213-219. https://doi.org/10.1016/j.meatsci.2018.02.007

SIEGRIST, M., & HARTMANN, C. (2020). Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. **Appetite**, 155, Article 104814. https://doi.org/10.1016/j.appet.2020.104814

SLADE, P. (2018). If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. **Appetite**, 125, 428–437. https://doi.org/10.1016/j.appet.2018.02.030

SOCCOL, C. F. M., MOLENTO, G. G., REIS, G. G., & KARP, S. G. (2024). Cultivated meat: Technologies, commercialization, and challenge. **Springer**. https://doi.org/10.1007/978-3-031-55968-6_18

SPECHT, L., & T. J. (2018). Opportunities for applying biomedical production and manufacturing methods to the development of the clean meat industry. **Biochemical Engineering Journal**, 132, 161-168. https://doi.org/10.1016/j.bej.2018.01.015

SPECHT, L., & LAGALLY, C. (2017). Mapping emerging industries: Opportunities in clean meat. **The Good Food Institute**. Available from: https://www.gfi.org/mapping-emerging-industries

STEPHENS, N. S., AIKING, H., & VAN DER WEELE, C. (2018). Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. **Trends in Food Science & Technology**, 78, 155–166. https://doi.org/10.1016/j.tifs.2018.04.010

STOUT, A. J., YUEN, J. S. K., TEJEDASALDANA, Y., FRASER, E. D. G., & KAPLAN, D. L. (2024). Education and training. In **Cellular Agriculture: Technology, Society, Sustainability and Science**, 487-513. https://doi.org/10.1016/B978-0-443-18767-4.00004-4

TEIXEIRA, C. D., MARCHIONI, D. M., MOTTA, V. W. L., CHAVES, V., GOMES, S., & JACOB, M. C. C. (2024). Flexitarians in Brazil: Who are they, what do they eat, and why? **Appetite**, 192, Article 107093. https://doi.org/10.1016/j.appet.2023.107093

TOMIYAMA, A. J., KAWECKI, N. S., ROSENFELD, D. L., JAY, J. A., RAJAGOPAL, D., & ROWAT, A. C. (2020). Bridging the gap between the science of cultured meat and public perceptions. **Trends in Food Science & Technology**, 104, 144–152. https://doi.org/10.1016/j.tifs.2020.07.019

TUBB, C., & SEBA, T. (2020). Rethinking food and agriculture 2020–2030: The second domestication of the cow, and the collapse of industrial livestock farming. **RethinkX**. Retrieved from: https://www.rethinkx.com/food-and-agriculture. http://dx.doi.org/10.1089/ind.2021.29240.ctu

TUCKER, C. A. (2014). The significance of sensory appeal for reduced meat consumption. **Appetite**, 81, 168–179. https://doi.org/10.1016/j.appet.2014.06.022

TUFTS UNIVERSITY. (2024). Undergraduate minor in cellular agriculture. **Tufts University**. Available from: https://cellularagriculture.tufts.edu/education/undergraduate-minor-cellular-agriculture. Accessed August 14, 2024.

TUOMISTO, H. L., ELLIS, M. J., & HAASTRUP, P. (2014). Environmental impacts of cultured meat: alternative production scenarios. **Proceedings of the 9th international conference on life cycle assessment in the agri-food sector**. https://core.ac.uk/download/pdf/38629617.pdf

TUOMISTO, H. L., & RYYNÄNEN, T. (2024). Environmental impacts of cultivated meat. In: SOCCOL, C. R., MOLENTO, C. F. M., REIS, G. G., & KARP, S. G. (eds) **Cultivated Meat**. Springer, Cham. https://doi.org/10.1007/978-3-031-55968-6_14

TSVAKIRAI, C., NALLEY, L., RIDER, S., VAN LOO, E., & TSHEHLA, M. (2023). The alternative livestock revolution: Prospects for consumer acceptance of plant-based and cultured meat in South Africa. **Journal of Agricultural and Applied Economics**, 55, 710-729. https://doi.org/10.1017/aae.2023.36

USDA (2021). Economic Research Service. Brazil once again becomes the world's largest beef exporter. Retrieved from: https://www.ers.usda.gov/amber-waves/2019/july/brazil-once-again-becomes-the-world-s-largest-beef-exporter/. Accessed June 13, 2024.

VALENTE, J. D. P. S., FIEDLER, R. A., HEIDEMANN, M. S., & 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(8), Article e0221129. https://doi.org/10.1371/journal.pone.0221129

VAN DER WEELE, C. N., & DRIESSEN, C. (2019). How normal meat becomes stranger as cultured meat becomes more normal: Ambivalence and ambiguity below the surface of behavior. **Frontiers in Sustainable Food Systems**, 3, 69. https://doi.org/10.3389/fsufs.2019.00069

VAN DIJK, B., JOUPPILA, K., SANDELL, M., & KNAAPILA, A. (2023). No meat, lab meat, or half meat? Dutch and Finnish consumers' attitudes toward meat substitutes, cultured meat, and hybrid meat products. **Food Quality and Preference**, 108, Article 104886. https://doi.org/10.1016/j.foodqual.2023.104886

VAN LOO, E. J., CAPUTO, V., & LUSK, J. L. (2020). Consumer preferences for farm-raised meat, lab-grown meat, and plant-based meat alternatives: Does information or brand matter? **Food Policy**, 95, Article 101931. https://doi.org/10.1016/j.foodpol.2020.101931

VERBEKE, W., MARCU, A., RUTSAERT, P., GASPAR, R., SEIBT, B., FLETCHER, D., et al. (2015). "Would you eat cultured meat?" Consumers' reactions and attitude formation in Belgium, Portugal, and the United Kingdom. **Meat Science**, 102, 49–58. https://doi.org/10.1016/j.meatsci.2014.11.013

WALTER LEAL FILHO, V., RUIZ VARGAS, V., SALVIA, A. L., BRANDLI, L. L., PALLANT, E., KLAVINS, M., RAY, S., MOGGI, S., MARUNA, M., CONTICELLI, E., AYANORE, M. A., RADOVIC, V., GUPTA, B., SEN, S., PAÇO, A., MICHALOPOULOU, E., SAIKIM, F. H., KOH, H. L., FRANKENBERGER, F., KANCHANAMUKDA, W., DA CUNHA, D. A., MOHAMMED AKIB, N. A., CLARKE, A., WALL, T., & VACCARI, M. (2019). The role of higher education institutions in sustainability initiatives at the local level. **Journal of Cleaner Production**, 233, 1004-1015. https://doi.org/10.1016/j.jclepro.2019.06.059

WARNER, R. D. (2019). Analysis of the process and drivers for cellular meat production. **Animal**, 13(12), 3041-3058. https://doi.org/10.1017/S1751731119001897

WASCHULIN, V., & SPECHT, L. (n.d.). Cellular agriculture: An extension of common production methods for food. The Good Food Institute.

WEINRICH, R., STRACK, M., & NEUGEBauer, F. (2020). Consumer acceptance of cultured meat in Germany. **Meat Science**, 162, Article 107924. https://doi.org/10.1016/j.meatsci.2019.107924

WEIS, T. SFSGEC. (2015). Meatification and the madness of the doubling narrative. **Canadian Food Studies/La Revue canadienne des études sur l'alimentation**, 2(2), 296-303. https://doi.org/10.15353/CFS-RCEA.V2I2.105

WILKS, M., & PHILLIPS, C. J. C. (2017). Attitudes to in vitro meat: A survey of potential consumers in the United States. **PLOS ONE**, 12(2), Article e0171904. https://doi.org/10.1371/journal.pone.0171904

WILKS, M., PHILLIPS, C. J. C., FIELDING, K., & HORNESEY, M. J. (2019). Testing potential psychological predictors of attitudes towards cultured meat. **Appetite**, 136, 137–145. https://doi.org/10.1016/j.appet.2019.01.027

ZHANG, Z. (2023a). The impact of the artificial intelligence industry on the number and structure of employments in the digital economy environment. **Technological Forecasting and Social Change**, 197, 122881. https://doi.org/10.1016/j.techfore.2023.122881

ANNEXES

ANNEX 1. PUBLISHED ARTICLE AT MEAT SCIENCE IN 2023 TITLED “DEMAND CHANGES MEAT AS CHANGING MEAT RESHAPES DEMAND: THE GREAT MEAT REVOLUTION"

Meat Science 196 (2023) 109040

Contents lists available at ScienceDirect

Meat Science

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

Demand changes meat as changing meat reshapes demand: The great meat revolution

Jennifer C. Biscarra-Bellio, Gabriela B. de Oliveira, Maria C.P. Marques, Carla F.M. Molento *

Cellular Animal Science Laboratory, Federal University of Paraná, Rua dos Funcionários, 1540, 80035-050 Curitiba, Paraná, Brazil

ARTICLE INFO

Keywords:
Alternative protein
Brazil
Cultivated meat
Veganism
Vegetarianism

ABSTRACT

As consumer acceptance and overall demand for the different types of meat are important determinants of the new balance between conventional and alternative meats, our goal was to approach the changes in meat demand, as affected by the increasingly available alternative meats coupled to the challenges of conventional meat including the meat paradox, with emphasis on the Brazilian scenario. Then, some aspects of the demand for alternative meats are presented, with a brief historical background. As the decisions taken in the present shape this unprecedented revolution in the way we produce and choose whether to eat meat and, if so, which one, the details of the transition to alternative meat chains in Brazil are yet to be written. It seems even more difficult to predict which food protein items will be in higher demand in the next decades, as new products will likely present themselves for their quality as food items as well as for their ethical and environmental attributes.

1. Introduction

The global human population is constantly increasing and developing, and along with these processes some additional challenges may arise. An example is the steady increase in meat demand, a contributor to environmental degradation (Sanchez-Sabate, Badilla-Briones, & Sabaté, 2019). Animal production contributes to gas emissions deriving from land-use changes – especially deforestation – caused by expansion of pastures and arable land for feed crops. According to the World Economic Forum (2019), agriculture is responsible for 10–12% of greenhouse gas emissions, with meat, poultry and dairy farming producing nearly three quarters of that percentage. Other concerns are related to welfare conditions for most animals raised under industrialized farming conditions and the scale of their slaughter (Webster, 2013). In 2018, an estimated 68.8 billion chickens, 1.5 billion pigs and 302 million cattle were slaughtered for meat production (Ritchie & Roser, 2019). In addition, the number of aquatic animals worldwide involved is difficult to estimate, although the dimension of the industry may be perceived by the 150 million tonnes of seafood which were used for human consumption in 2016 (FAO, 2018). In Brazil, 29,7 million cattle, 6 billion chickens and 49,3 million pigs were slaughtered in 2020 (IBGE, 2021). Animal production activities are such that the total biomass of terrestrial animals used for food production is one order of magnitude higher than that of human beings and two orders of magnitude higher than all wild mammals combined (Bar-On, Phillips, & Milo, 2018).

Regardless of the issues associated with conventional meat, the fact is that many people like to eat it, while simultaneously many people care for animals and are concerned with the environmental impacts of meat production. In Brazil, consumer research on opinions and demand for conventional meat have traditionally shown the importance of taste and price; however, recent research suggests that other meat attributes may be gaining importance as well. For example, Marques, Mauad, Domingues, Borges, and da Silva (2022) reported that the most important meat attributes in Brazilian consumer's preferences were healthiness, safety, animal welfare and environmental impact.

Generally, the decisions about eating meat are complex and consumer attitudes seem constantly reshaping with the changes in underlying factors. Examples of such factors are the amount of information accessed by consumers on the practices involved in conventional meat production, – e.g., animal suffering and environmental impacts -; increases in consumer purchase power and the availability, quality and comparative price of conventional meat substitutes. In fact, concerns about the ethics and environmental consequences of conventional meat consumption have led to a rapid expansion in the development of substitutes (Godfray et al., 2018). Such meat substitutes, denominated alternative proteins, include (1) meat cultivated from the multiplication of relevant animal cells in bioreactors, (2) meat analogues produced by molecular combinations of plant ingredients to mimic conventional

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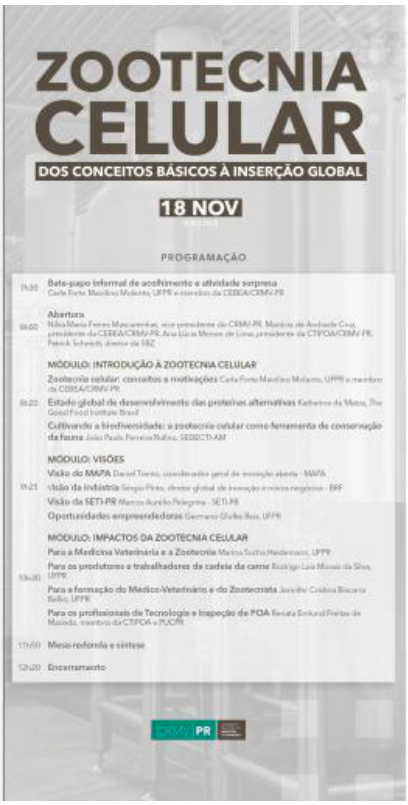
Received 5 June 2022; Received in revised form 3 October 2022; Accepted 14 November 2022
Available online 17 November 2022

ANNEX 2. CERTIFICATE OF PARTICIPATION IN A EVENT TITLED “ZOOTECNIA CELULAR: DOS CONCEITOS BÁSICOS À INSERÇÃO GLOBAL” IN 2021.



SERVIÇO PÚBLICO FEDERAL

Certifico que

Jennifer Biscarra

participou do evento Zootecnia Celular: dos conceitos básicos à inserção global , promovido pelo CRMV-PR, através da Comissão Estadual de Bem-Estar Animal, em plataforma online, no dia 18 de novembro de 2021, com carga horária de 5 horas.

Méd. Vet. Rodrigo Távora Mira
Presidente do CRMV-PR

ANNEX 3. CERTIFICATE OF PARTICIPATION IN THE EVENT TITLED “ECOSSISTEMA EMPREENDEDOR PARA A CARNE CULTIVADA: OPORTUNIDADES E DESAFIOS” IN 2021.

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE EXTENSÃO E CULTURA
COORDENADORIA DE EXTENSÃO

CERTIFICADO

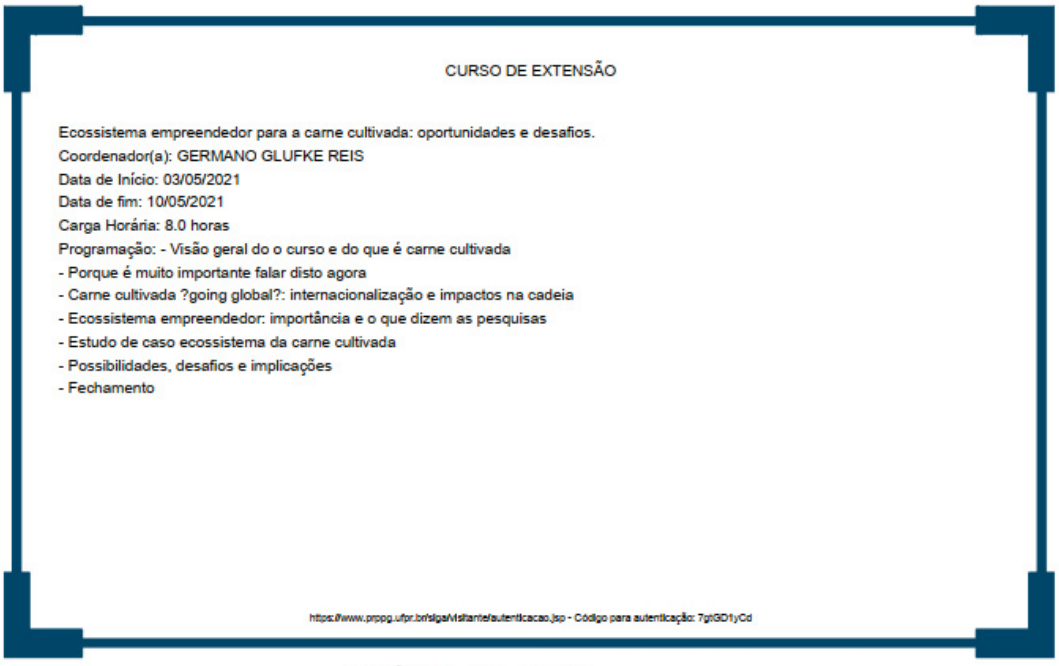
Jennifer C. Biscarra Bellio frequentou o Curso de Extensão "Ecossistema empreendedor para a carne cultivada: oportunidades e desafios." realizado no período de 03/05/2021 a 10/05/2021 promovido pelo(a) Departamento de Administração Geral e Aplicada da Universidade Federal do Paraná, obtendo frequência: 100% e aproveitamento 100, conforme Resolução 57/19 - CEPE.

10 de junho de 2021

Prof. Dr. Rodrigo Arantes Reis
Pró-Reitor de Extensão e Cultura

Profª. Drª. Mayara Elita Carneiro
Coordenadora de Extensão

UFPR PROEC Pró-reitoria de Extensão e Cultura siga UFPR



CURSO DE EXTENSÃO

Ecossistema empreendedor para a carne cultivada: oportunidades e desafios.
Coordenador(a): GERMANO GLUFKE REIS
Data de Início: 03/05/2021
Data de fim: 10/05/2021
Carga Horária: 8.0 horas
Programação: - Visão geral do o curso e do que é carne cultivada
- Porque é muito importante falar disto agora
- Carne cultivada ?going global?: internacionalização e impactos na cadeia
- Ecossistema empreendedor: importância e o que dizem as pesquisas
- Estudo de caso ecossistema da carne cultivada
- Possibilidades, desafios e implicações
- Fechamento

https://www.prppg.ufpr.br/siga/visitante/autenticacao.jsp - Código para autenticação: 7phGD1yCd

UFPR PROEC Pró-reitoria de Extensão e Cultura siga UFPR

ANNEX 4. CERTIFICATE OF PARTICIPATION IN THE EVENT TITLED "NEW MEAT BRAZIL 2021".

CERTIFICADO

Certificamos que

JENNIFER CRISTINA BISCARRA BELLIO

participou da **New Meat Brazil, I Fórum Internacional de Carnes Cultivadas e Proteínas Alternativas,** no dia 21 de setembro, com carga horária total de **8 horas.**

Mídia Oficial

Patrocínio

Colaboração

Apoio

ANNEX 5. CERTIFICATE OF PRESENTED POSTER IN THE EVENT TITLED "SEE-U CONFERENCE: SUSTAINABLE DEVELOPMENT GOALS, A GLOBAL SCIENTIFIC CONFERENCE AT UFPR" IN 2021.

SEE-U

Sustainable Development Goals, a global scientific conference at UFPR

This certificate is presented to

Jennifer C. Biscarra Bellio

For presenting a scientific poster the SEE-U Conference, held from December 1st to 3rd - 2021, organized by International Relations Office at Universidade Federal do Parana.

Title: "Cellular Animal Science and University degrees in veterinary and animal sciences"

Curitiba - December 10th, 2021

Organizing Committee

UFPR INTERNACIONAL

UFPR

Think twice before printing this certificate. Save paper, the environment

ANNEX 6. CERTIFICATE OF INVITED SPEAKER AT THE EVENT TITLED "SEE-U CONFERENCE: SUSTAINABLE DEVELOPMENT GOALS, A GLOBAL SCIENTIFIC CONFERENCE AT UFPR" IN 2021.

SEE-U

Sustainable Development Goals, a global scientific conference at UFPR

This certificate is presented to

JENNIFER C. BISCARRA BELLIO

For sharing his/her knowledge as an invited speaker during the SEE-U Conference, held from December 1st to 3rd, in the Panel session - SDG 12:

Title: "Cellular Animal Science and University degrees in veterinary and animal sciences"

Curitiba - December 10th, 2021

Organizing Committee

UFPR INTERNACIONAL

UFPR

ANNEX 7. CERTIFICATE OF PARTICIPATION IN THE EVENT TITLED "I JORNADA DA CARNE CULTIVADA" IN 2022.

Embrapa
Suínos e Aves

Certificado

Certifico que **Jennifer Cristina Biscarra Bellio** participou do **I Jornada da Carne Cultivada** , realizado em Concórdia/SC, no período de 24 a 25 de agosto de 2022, com carga horária de 16 horas.

Concórdia, 25 de agosto de 2022.

Everton Luis Krabbe
Chefe Geral

Registro

Certificado nº 484/2022. Concórdia/SC, 25/08/2022. Registrado eletronicamente por Marisa Natalina Sandrin Cadorin

PROGRAMAÇÃO
24 de agosto

8h às 8h15 - Recepção
8h15 às 8h30 - Abertura
8h30 às 10h - Palestras
Contextualização da carne cultivada, oportunidades e desafios - Luismar Porto (JBS)
Agenda de inovação para proteínas alternativas no Brasil - Daniel Trento (Mapa)
Aspectos regulatórios de carne cultivada - Alexandre Cabral (GFI)
10h30 às 12h - Palestras
Percepção dos consumidores brasileiros sobre carne cultivada - Alice Munz (IFRS)
Visão do público vegano sobre a carne cultivada - Ricardo Laurino (SVB)
12h às 12h30 - Debates e discussões
13h30 às 14h - Palestra on-line
Composição nutricional da carne tradicional x carne cultivada - Andreza Campos (Cefet-MG)
14h às 16h - Mesa-redonda com equipe de carne cultivada no Brasil
Engenharia de tecidos aplicado a carne cultivada - Fernanda Bertl (JBS)
Biomaterials/Scaffolds - Karla Oliveira
Produção de carne in vitro, biorreatores, bioimpressão - Ana Livia Bovolato
Cultivo de células pluripotentes - Silviene Novikoff
Scaffolds para carne cultivada - Aline da Silva (Cefet-MG)
16h às 17h00 - Debates e discussõese

24 de agosto de 2022

08h30 às 10h - Palestras
Aplicando APPCC na produção de carne cultivada - Carolina Scheibe Anderson (Senai)
Visão empreendedora da primeira startup brasileira de carne cultivada - Bibiana Matte (Ambi Real Food)
Visão das novas empresas e mercado - Sergio Pinto (Celiva Ingredients) (on-line)
10h às 11h - Debates e discussões
11h30 às 13h - Mesa-redonda on-line
Valores nutricionais e sensoriais da carne - Marie-Pierre Ellies-Oury (INRA)
Otimização de Scaffolds e microcarreadores nanofibrosos comestíveis - Mart-Erik Martens (Gelatex Technologies)
Carne impressa em 3D - Luciano Paulino da Silva (Embrapa Recursos Genéticos e Biotecnologia)
13h às 13h30 - Debates e discussão
14h30 às 15h30 - Proposição de projeto de inovação aberta
Oportunidades de pesquisa com proteínas alternativas - Amanda Leitolis (GFI)
Vivian Feddern e Ana Paula Bastos (Embrapa Suínos e Aves)
15h30 às 16h - Debates e discussão
16h às 17h - Considerações finais e encerramento

ANNEX 8. ORAL PRESENTATION OF THE ABSTRACT "AVOIDING THE RISK OF DEEPENING INEQUALITIES IN THE FOOD PRODUCTION CHAIN: AN INITIAL FRAMEWORK FOR HIGHER EDUCATION REGARDING ALTERNATIVE PROTEINS" AT THE ANNUAL INTERNATIONAL CONFERENCE 2022, IN THE PANEL NEW GEOGRAPHIES OF FOOD PROTEIN.

Avoiding the risk of deepening inequalities in the food production chain: an initial frameworkfor higher education regarding alternative proteins

Jennifer Cristina Biscarra Bellio[1], Rodrigo Morais da Silva[2], Carla Forte Maiolino Molento[1]

[1]Animal Welfare Laboratory, Federal University of Parana

[2]Business and Administration School, Federal University of Parana

Although the benefits of alternative proteins are clear, the transition to the new production model may bring numerous challenges for meat and grain-producing countries, especially those in the global south. One of the challenges is the high degree of technological sophistication of the new chain, which may require workers with higher qualifications. Globally, there are initiatives for inserting cellular animal science content into higher education, with actions related to new courses and new programs. Considering this context, we aim to provide an initial framework for the adaptation of Brazilian higher education, so that the curricula for professions involved with conventional animal production incorporate relevant knowledge for successful engagement with cellular animal science and plant-based production systems. Initial results show that the current Brazilian curriculum guidelines for veterinary and animal science programs include courses which may accommodate information envisioning cellular animal science. Additionally, the offering of an independent cellular animal science course may contribute to the basic education and skills for animal scientists and veterinarians to engage with alternative proteins. Students' interest in cellular animal science teaching in Brazil has been high. Education on cellular animal science will likely decrease resistance, accelerate the transition, allowing for higher levels of engagement in Brazil and thus decreasing the risk of exacerbating geographical inequalities. Thus, for countries with strong conventional meat production, improvements in specific curricula may be strategic to counter the risk of novel inequalities arising from alternative protein chains.

Tuesday 25 October 2022

R. dos Funcionários, 1540 - Juvevê, Curitiba - PR, 80035-050

Royal Geographical Society
with IBG
Advancing geography and geographical learning

To whom it may concern

Confirmation of participation in RGS-IBG Annual International Conference 2022

Jennifer Cristina Biscarra Bellio presented the following paper online:

- Avoiding the risk of deepening inequalities in the food production chain: an initial framework for higher education regarding alternative proteins

at the Royal Geographical Society (with IBG) Annual International Conference, taking place at Newcastle University and online from Tuesday 30 August to Friday 2 September 2022.

The paper was a part of the *126, New Geographies of Food Protein* session which took place on Thursday 1 September 2022.

We can confirm we have received full registration fees for Jennifer Cristina Biscarra Bellio's attendance at the conference.

Yours sincerely,

CJ Souch

Catherine Souch, PhD
Head, Research and Higher Education

ac2022@rgs.org

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ANNEX 9. CERTIFICATE OF LECTURE TITLED “ESTRUTURA INICIALPARA EDUCAÇÃO SUPERIOR EM PROTEÍNAS ALTERNATIVAS” IN THE EVENT VI SEMINÁRIO DE DEFESA ANIMAL IN 2022.

Fórum Nacional de Proteção e Defesa Animal

Universidade Federal do Paraná

CERTIFICADO

Conferimos este certificado a

JENNIFER CRISTINA BISCARRA BELLIO

pela participação como PALESTRANTE no **VI Seminário de Defesa Animal** realizado de 02 a 04 de setembro de 2022, no Setor de Ciências Agrárias da Universidade Federal do Paraná - Curitiba/PR.

SÔNIA PERALLI FONSECA
PRESIDENTE
FÓRUM NACIONAL DE PROTEÇÃO E DEFESA ANIMAL

VICENTE DE PAULA ATAÍDE JUNIOR
COMISSÃO CIENTÍFICA
UNIVERSIDADE FEDERAL DO PARANÁ

PROGRAMAÇÃO

02 de setembro de 2022

Sexta-feira 17h00: Recepção e entrega de materiais

BLOCO 1 - CONSCIÊNCIA E SENCIÊNCIA ANIMAL NO DIREITO CONSTITUCIONAL BRASILEIRO

18h00 - Teoria das capacidades jurídicas animais - Professor Doutor Vicente de Paulo Ataíde Junior, UFPR (presencial)

18h30 - Conversa com o público

BLOCO 2 - OS ANIMAIS E O FUTURO

18h40 - Da célula à carne - Amanda Leitolis, The Good Food Institute, GFI (on-line)

19h00 - Carne sem abate e seu impacto para a relação entre seres humanos e animais - Professora Doutora Carla Molento, LABEA, UFPR (presencial)

19h20 - Consulta de percepção e exemplo dos profissionais envolvidos com a carne convencional - Marina Sucha Heidemann (presencial)

19h40 - Estrutura inicial para educação superior em proteínas alternativas - Doutora Jennifer Cristina Biscarra Bellio (presencial)

20h00 - Cenário atual e futuro da cadeia de carne celular - Maria Cecília Pinto Marques (presencial)

20h20 – Conversa com o público

20h45 – Encerramento

03 de setembro de 2022 - Sábado

BLOCO 3 - O DIREITO ANIMAL E AS CAPACIDADES JURÍDICAS DOS ANIMAIS

09h00 - A construção de uma teoria dogmática dos direitos animais no Brasil - Professor Doutor Vicente de Paula AtaídeJunior,UFPR (presencial)

09h20 - Animais em Juízo: fundamentos e casos paradigmáticos recentes – Professor Doutor Rogerio Ramma - Porto Alegre/RS (presencial)

09h40 - A tutela coletiva dos animais - Senhora Ana Paula Vasconcelos, Fórum Animal (presencial)

10h00 -A responsabilidade do dono animal - Professora Monique Mosca, MPMG - Belo Horizonte/MG (presencial)

10h20 – Conversa com o público

10h30 – Recesso

BLOCO 4 - ANIMAIS USADOS NA PRODUÇÃO E NO TRABALHO

11h00 - Desafios para o fim da tração animal – Anelise CardosoRibeiro, Promotora de Justiça de MG (on-line)

11h20 - Abate de jumentos:maus-tratos e riscos sanitários - Professor Yuri Fernandes Lima, UFPR - São Paulo/SP (presencial)

11h40 - O Movimento Brasil sem Carolas - Taylison Alves dos Santos,Fórum Animal (presencial)

12h00 - Exportação de Gado Vivo - Médica veterinária Haiuly Viana, Fórum Animal (on-line)

12h20 - A (in)constitucionalidade das atuais normativas do MAPA sobre animais de produção - Médica veterinária Juliana Rocha da Luz, UFPR(presencial)

12h40 – Conversa com o público

13h00 – Almoço

BLOCO 5 - RELAÇÃO ENTRE BEM ESTAR ANIMAL E MEIO AMBIENTE

14h30 - Agricultura industrial e extinção de espécies - Philip Lymbery, Compassion in World Farming (on-line)

15h00 - Campanha para prevenção de futuros pandemias - Luiz Carlos Sarmiento, Red LAPA (on-line)

15h30 - Direitos dos Animais, Direitos da Natureza e Direito Ecológico: o Direito Ambiental no Limiar de um Novo Paradigma Ecocêntrico no Antropoceno - Tiago Fensterseifer, UNIPOA (on-line)

16h00 - Panorama de Desastres no Brasil: novos desafios - Doutora Vânia de Fátima Plaza Nunes (presencial)

16h30 - Conversa com o público

16h40 – Recesso

BLOCO 6 - ANIMAIS NA CIÊNCIA

17h10 - Desafios da proteção animal no Conselho Nacional de Controle de Experimentação Animal (CONCEA) - Doutora Vanessa Carli Bones, CRMV PR - Cascavel/PR (presencial)

17h30 - Contextos da Lei 11.794/2008 (Lei Arouca) - Doutor Arthur Henrique de Pontes Regis – Brasília/DF (presencial)

17h50 - Laboratório livre de uso de animais - Médica Veterinária Thaila Corana, LACEN/PR (presencial)

18h10 - Campanhas do Fórum Animal: Ciências sem Joulas - Doutora Karynn Vieira Capile, Fórum Animal (presencial)

18h30 - Conversa com o público

18h50 - Encerramento

19h00 - 20h00: Sessão de autógrafos do livro " Capacidade Processual dos animais: a judicialização do Direito Animal no Brasil" - Prof. Dr. Vicente de Paula Ataíde Junior

04 de setembro de 2022 - Domingo

BLOCO 7 - MAUS-TRATOS AOS ANIMAIS

7h00 - O crime de maus-tratos contra animais – Doutor José Barreto de Macedo Junior, Delegado da Polícia Civil/PR (presencial)

9h30 - Tráfico de animais silvestres – Roberto Cabral, IBAMA - Brasília/DF (on-line)

10h00 - Aspectos técnicos periciais – Médica veterinária Esther Espejo, Fórum Animal (presencial)

10h30 - Políticas Municipais de Atendimento a Animais Vítimas de Maus-Tratos – Professor Francisco José Garcia Figueiredo, UFPR (presencial)

11h00 – Conversa com o público

11h10 – Recesso

BLOCO 8 - ANIMAIS DE COMPANHIA

11h40 - Programa de Manejo Populacional em Curitiba - PR – Doutora Vivien Morikawa, Rede de Proteção Animal, Curitiba (presencial)

12h00 - Abandono de animais - Médica veterinária Michele Brugnerotto, SESA do Paraná e UFPR (presencial)

12h20 - Estratégias para prevenir a criação e diminuir a devolução de animais - Médica veterinária Ana Lucia Bolson, UFPR (presencial)

12h40 – Conversa com o público

13h00 – Encerramento

CARGA HORÁRIA TOTAL: 16 HORAS

ANNEX 10. CERTIFICATE OF POSTER PRESENTATION IN THE EVENT VI ANIMAL DEFENSE SEMINAR INTLITED "ESTRUTURA INICIAL PARA EDUCAÇÃO SUPERIOR EM PROTEÍNAS ALTERNATIVAS NO BRASIL" IN 2022.

Fórum Nacional de Proteção e Defesa Animal

Universidade Federal do Paraná

CERTIFICADO

Conferimos este certificado às autoras

GEORGIA PAOLINI, JENNIFER CRISTINA BISCARRA BELLIO E CARLA FORTE MAIOLINO MOLENTO

pelo resumo "Estrutura inicial para educação superior em proteínas alternativas no Brasil" apresentado na forma de pôster no **VI Seminário de Defesa Animal** realizado de 02 a 04 de setembro de 2022, no Setor de Ciências Agrárias da Universidade Federal do Paraná - Curitiba/PR.

SÔNIA PERALLI FONSECA
PRESIDENTE
FÓRUM NACIONAL DE PROTEÇÃO E DEFESA ANIMAL

VICENTE DE PAULA ATAÍDE JUNIOR
COMISSÃO CIENTÍFICA
UNIVERSIDADE FEDERAL DO PARANÁ

ANNEX 11. CERTIFICATE OF POSTER PRESENTATION IN THE EVENT VI ANIMAL DEFENSE SEMINAR TITLED "INTENÇÃO DE CONSUMO DE CARNE CELULAR NO BRASIL" IN 2022.

Fórum Nacional de Proteção e Defesa Animal

Universidade Federal do Paraná

CERTIFICADO

Conferimos este certificado às autoras

JENNIFER CRISTINA BISCARRA BELLIO, GABRIELA BUSSI DE OLIVEIRA E CARLA FORTE MAIOLINO MOLENTO

pelo resumo "Intenção de consumo de carne celular no Brasil" apresentado na forma de pôster no **VI Seminário de Defesa Animal** realizado de 02 a 04 de setembro de 2022, no Setor de Ciências Agrárias da Universidade Federal do Paraná - Curitiba/PR.

SÔNIA PERALLI FONSECA
PRESIDENTE
FÓRUM NACIONAL DE PROTEÇÃO E DEFESA ANIMAL

VICENTE DE PAULA ATAÍDE JUNIOR
COMISSÃO CIENTÍFICA
UNIVERSIDADE FEDERAL DO PARANÁ

ANNEX 12. PARTICIPATION IN THE DEVELOPMENT OF THE TEACHING PLAN FOR COURSES IN ALTERNATIVE PROTEINS, CREATED BY THE GOOD FOOD INSTITUTE BRAZIL IN 2022.

Programas de graduação e pós-graduação

Os conteúdos elencados neste Modelo Conceitual se aplicam a composição de disciplinas em cursos de graduação e pós-graduação nas áreas de Ciências Agrárias, Ciências Biológicas e Engenharias, como: Ciência de Alimentos, Zootecnia, Agronomia, Gestão Ambiental, Medicina Veterinária, Biologia, Biotecnologia, Farmácia, Engenharia de Alimentos, Engenharia Química, Engenharia de Produção, Engenharia de Bioprocessos e outras relacionadas.

Colaboradores

O GFI agradece a todos os profissionais que gentilmente aceitaram o convite para contribuir com o aprimoramento do Plano de Ensino para Disciplinas em Proteínas Alternativas - Modelo Conceitual:

- Dr. Acácio Zielinski - UFSC
- Dra. Ana Paula Dionísio - EMBRAPA
- Dra. Ana Carla Sato - UNICAMP
- Dra. Carla Molento - UFPR
- Dra. Carolina Picone - UNICAMP
- Dra. Jaciane Ienczak - UFSC
- Ma. Jennifer Biscarra - UFPR
- Dra. Kamilla Swiech - BioImprove Consultoria em Biotecnologia Farmacêutica
- Dra Luciana Andrade - UFMG
- Dr. Rodrigo Silva - UFPR
- Dr. Wendel Silveira - UFV

ANNEX 13. ORAL PRESENTATION FROM THE ACCEPTED ABSTRACT TITLED "THE POTENCIAL RELEVANCE OF ASSOCIATIONS FOR THE PROGRESS OF CELLULAR AGRICULTURE: THE CASE OF CELL AGRI BRAZIL" AT THE FIRST INTERNATIONAL CONFERENCE OF THE PORTUGUESE ASSOCIATION FOR CELLULAR AGRICULTURE IN 2023.

CellAgri Portugal Conference Abstract Notification | Oral Presentation

INL - Conference Office <conference.office@inl.int>
Qui, 27/7/2023 11:44
Para:Rodrigo Luiz Morais da Silva <rodrigo.morais.silva@ufpr.br>

Dear Carla Forte Maiolino Molento,

Thank you for submitting your abstract for the CellAgri Portugal Conference.

On behalf of the organizing team, we are honoured to announce that your proposal "The potential relevance of associations for the progress of cellular agriculture: the case of Cell Agri Brazil" has been selected as Oral Presentation.

If you didn't register yet, please do it here by entering the following speaker voucher key in the registration form: **CELLAGRICONFERENCE#** .

We remind you that you can book a reduced-fee room at the Meliá Braga Hotel with the "CellAgri Portugal" promo code (Single room: 102€/ Double room: 117€).

Kind Regards,

INL Conference Office

Id: 1047
Key: 00151591A2
Theme: Sustainability and Impact
Presentation: Oral Presentation

Title: The potential relevance of associations for the progress of cellular agriculture: the case of Cell Agri Brazil

Author's: Rodrigo Luiz Morais-Da-Silva (Brazil)[1]; Juliana Do Canto Olegário (Brazil)[1]; Jennifer Cristina Biscarra Bellio (Brazil)[1]; Carla Forte Maiolino Molento (Brazil)[1]
Affiliaton's: 1 - Federal University of Paraná
Keyword's: cellular agriculture, stakeholder association, Brazil

Abstract

Cellular agriculture is part of a range of alternative proteins that have the potential to create a new technological paradigm in the food production chain. New cell-cultivated foods tend to be more sustainable (Sinke and Odegard, 2021), beneficial for animals (Heidemann et al., 2020), and potentially positive from the perspectives of public health and food security (Ong et al., 2021). However, significant socioeconomic challenges may arise due to the impending changes in the traditional production chain (Morais-da-Silva et al., 2022).

In this context, associations for the acceleration of the progress of cellular agriculture may play a central role in driving this transformation, having emerged in recent years primarily in developed countries. The aim of our proposal is to discuss the relevance of such associations in developing countries, which are typically major food producers. For this purpose, we study the case of the Cell Agri Brazil Association. Brazil is one of the largest producers and exporters of conventional meat (FAO, 2021) and heavily relies on the agribusiness sector, which accounts for approximately a quarter of the country's Gross Domestic Product (CEPEA-CNA, 2021).

Cell Agri Brazil was recently created with the main goal of contributing to the acceleration of the development of the alternative protein production chain. Its mission includes bringing together various stakeholders focused on supporting public policies to ensure a fair transition for all, gathering the scientific community, establishing a more efficient flow of information within Brazil and with other countries. It is hoped that the association will play a central role in fostering the replacement of animal use in food production, disseminating knowledge, and promoting the normalization of alternative proteins to raise awareness about the problems with conventional animal proteins. Although Cell Agri Brazil is in its early stages, we expect that its actions will contribute to a profound, fast and equitable transformation in the food production sector, leaving no one behind. In addition, other countries may reflect on our proposal as a model to create their own associations tailored to their specific needs and realities. Finally, Cell Ag Brazil is expected to contribute to international communication across similar societies, by engaging with supranational societies such as the Cellular Agriculture Europe and their initiatives.

Acknowledgments

The author CFMM received a research productivity grant from the Brazilian National Research and Postgraduate Council. All authors acknowledge the funding from the State of Paraná government for supporting the New Research Arrangement on Innovation in Alternative Proteins.

References

CEPEA-CNA, 2021. **PIB do agronegócio alcança participação de 26,6% no PIB brasileiro em 2020**. Piracicaba.

FAO, 2021a. **Livestock Primary** . URL http://www.fao.org/faostat/en/#data/QL (accessed 28.6.23).

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.

Morais-Da-Silva, R. L.; Reis, G. G.; Molento, C. F. M. The social impacts of a transition from conventional to cultivated and plant-based meats: Evidence from Brazil. **Food Policy**, v. 111, p. 102337, 2022.

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.

Sinke, P., Odegard, I., 2021. **LCA of cultivated meat Future projections for different Scenarios**.

Ong, K. J., Johnston, J., Datar, I., Sewalt, V., Holmes, D., & Shatkin, J. A. Food safety considerations and research priorities for the cultured meat and seafood industry. **Compr Rev Food Sci Food Saf**. v. 20, p. 5421– 5448, 2021.

ANNEX 14. CERTIFICATE OF PARTICIPATION IN EXTENSION PROJECT TITLED "ZOOTECNIA CELULAR: BIFE SEM BICHO? CONHECENDO CARNE, OVOS, LEITE E DERIVADOS SEM SOFRIMENTO E ABATE DE ANIMAIS" IN 2023.

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE EXTENSÃO E CULTURA
COORDENADORIA DE EXTENSÃO

CERTIFICADO

JENNIFER CRISTINA BISCARRA BELLIO participou como VOLUNTÁRIO(A) no(a) Projeto de Extensão "ZOOTECNIA CELULAR: BIFE SEM BICHO? CONHECENDO CARNE, OVOS, LEITE E DERIVADOS SEM SOFRIMENTO E ABATE DE ANIMAIS" coordenado por CARLA FORTE MAIOLINO MOLENTO, cumprindo 192h de atividades no período de 01/02/2023 a 31/12/2023, promovido pelo(a) Setor de Ciências Agrárias da Universidade Federal do Paraná.

03 de Julho de 2024

Profª. Drª. Mayara Elita Braz Carneiro
Pró-Reitor(a) de Extensão e Cultura

Profª. Drª. Mabel Karina Arantes Alves
Coordenador(a) de Extensão

UFPR PROEC Pró-reitoria de Extensão e Cultura siga UFPR

ANNEX 15. CERTIFICATE OF VOLUNTEER PARTICIPATION IN EXTENSION PROJECT TITLED “DIVULGA BEA” IN 2023.

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE EXTENSÃO E CULTURA
COORDENADORIA DE EXTENSÃO

CERTIFICADO

JENNIFER CRISTINA BISCARRA BELLIO participou como VOLUNTÁRIO(A) no(a) Projeto de Extensão "DIVULGA BEA" coordenado por CARLA FORTE MAIOLINO MOLENTO, cumprindo 416h de atividades no período de 01/01/2023 a 31/12/2023, promovido pelo(a) Setor de Ciências Agrárias da Universidade Federal do Paraná.

03 de Julho de 2024

Profª. Drª. Mayara Elita Braz Carneiro
Pró-Reitor(a) de Extensão e Cultura

Profª. Drª. Mabel Karina Arantes Alves
Coordenador(a) de Extensão

UFPR PROEC Pró-reitoria de Extensão e Cultura siga UFPR

ANNEX 16. CERTIFICATE OF PARTICIPATION IN THE EVENT TITLED "II ENCONTRO DE ZOOTECNIA CELULAR CRMV-PR E UFPR" IN 2023.

CRMV | PR

CONSELHO REGIONAL DE MEDICINA VETERINÁRIA

SERVIÇO PÚBLICO FEDERAL

CERTIFICADO

Certificamos que **Jennifer Cristina Biscarra Bellio** participou do ***II Encontro de Zootecnia Celular CRMV-PR e UFPR***, realizado pelo Conselho Regional de Medicina Veterinária do Estado do Paraná, através da sua Comissão Estadual de Bem-estar Animal (CEBEA), em plataforma online, no dia 17 de agosto de 2023, com carga horária total de 5 horas.

Curitiba, 17 de agosto de 2023.

Méd. Vet. Rodrigo Távora Mira
Presidente do CRMV-PR

EVENTO ONLINE

II ENCONTRO DE
ZOOTECNIA CELULAR
CRMV-PR E UFPR

17AGO
8H às 13H

INSCRIÇÕES GRATUITAS
www.crmv-pr.org.br

PROGRAMAÇÃO

8h **ABERTURA**

8h20 às 9h25 **O FUTURO DO CONSUMO DE PROTEÍNAS**

9h25 às 10h30 **BENEFÍCIOS E DESAFIOS DA ZOOTECNIA CELULAR**

10h30 às 11h35 **ESTADO ATUAL DA ZOOTECNIA CELULAR**

11h35 **MESA REDONDA E SÍNTESE**

12h20 **ENCERRAMENTO**

ANNEX 17. CERTIFICATE OF PARTICIPATION IN THE EVENT TITLED "1º WEBINAR DE CARNE CULTIVADA DO AMAZONAS" IN 2023.

CERTIFICADO
DE PARTICIPAÇÃO

Certificado concedido à:

Jennifer Biscarra

pela participação no evento on-line "1º Webinar de Carne Cultivada do Amazonas" realizado no dia 16 de maio de 2023 com duração de 4(quatro) horas.

Manaus, 26 de Junho de 2023

João Paulo Ferreira Rufino
Coordenador do Evento

ANNEX 18. CERTIFICATE OF PARTICIPATION IN THE EVENT TITLED “PROTEÍNAS ALTERNATIVAS E CENÁRIOS DISRUPTIVOS: REFLEXÕES COM BASE EM INICIATIVAS EM CURSO NA UNIÃO EUROPEIA” IN 2024.

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
PRÓ-REITORIA DE EXTENSÃO E CULTURA
COORDENADORIA DE EXTENSÃO

CERTIFICADO

JENNIFER CRISTINA BISCARRA BELLIO frequentou o(a) Evento de Extensão "PROTEÍNAS ALTERNATIVAS E CENÁRIOS DISRUPTIVOS: REFLEXÕES COM BASE EM INICIATIVAS EM CURSO NA UNIÃO EUROPEIA ", coordenado por GERMANO GLUFKE REIS, realizado no período de 22/11/2023 a 22/11/2023, promovido pelo(a) Setor de Ciências Sociais Aplicadas da Universidade Federal do Paraná, obtendo frequência 100% e aproveitamento 100, cumprindo 2h conforme Resolução 57/19 - CEPE.

18 de Março de 2024

Profª. Drª. Mayara Elita Braz Carneiro
Pró-Reitor(a) de Extensão e Cultura

Profª. Drª. Mabel Karina Arantes Alves
Coordenador(a) de Extensão

Evento de Extensão

PROTEÍNAS ALTERNATIVAS E CENÁRIOS DISRUPTIVOS: REFLEXÕES COM BASE EM INICIATIVAS EM CURSO NA UNIÃO EUROPEIA
Coordenador(a): GERMANO GLUFKE REIS
Data de Início: 22/11/2023
Data de Finalização: 22/11/2023
Atividades vinculada ao participante:
- Proteínas Alternativas e cenários disruptivos: reflexões com base em iniciativas em curso na União Europeia
1)A cadeia de valor das proteínas a base de plantas: o status quo da União Europeia
2) Cenários e graus de disrupção no agro e na indústria de alimentos
3) Debate com moderadores: 2h

https://extensao.ufpr.br/publico/autenticacao.jsf - Código para autenticação: 9AB7C32C588629

ANNEX 19. ACCEPTED ABSTRACT: “A GLIMPSE ON STUDENT PERCEPTIONS OF EDUCATION IN CELLULAR ANIMAL SCIENCE IN A BRAZILIAN UNIVERSITY" AT THE SECOND INTERNATIONAL CONFERENCE OF THE PORTUGUESE ASSOCIATION FOR CELLULAR AGRICULTURE IN SEPTEMBER 2024.

Gmail Jennifer Biscarra <jenniferbiscarra@gmail.com>

ID52 - Accepted Abstract Email - II INTERNATIONAL CONFERENCE OF THE PORTUGUESE ASSOCIATION FOR CELLULAR AGRICULTURE

II INTERNATIONAL CONFERENCE OF THE PORTUGUESE ASSOCIATION FOR CELLULAR AGRICULTURE <noreply@admeus.org> 5 de setembro de 2024 às 07:01
Responder a: cellagriportugal@gmail.com
Para: Jennifer Cristina Biscarra Bellio <jenniferbiscarra@gmail.com>

Date 2024-09-05

Dear Sir / Madam Jennifer Cristina Biscarra Bellio

Your abstract "**A Glimpse On Student Perceptions Of Education In Cellular Animal Science In A Brazilian University** " was accepted for presentation at the **2nd International Conference of Cellular Agriculture Portugal**.

We will send you information about the presentation later on.

Kind regards,

CellAgri Portugal

ANNEX 20. CO-AUTHORSHIP OF THE CHAPTER "GLOBAL AND REGIONAL POLICIES FOR CULTIVATED MEAT" IN THE BOOK CULTIVATED MEAT: TECHNOLOGIES, COMMERCIALIZATION AND CHALLENGES. SPRINGER NATURE. PUBLISHED IN 2024.

Global and Regional Policies for Cultivated Meat

Maria Marques, Rodrigo Luiz Morais-da-Silva, Jennifer C. Biscarra-Bellio, Mariana Hase Ueta, and Carla Forte Maiolino Molento

Abstract The objective of this chapter is to study how public policies and governance actions may be addressed to support and accelerate the transition to cell-based foods as more sustainable and ethical means of protein production and consumption. In this regard, we assessed different impacts of public policies as maintainers of the current production system, the structure of policies for transformative innovations to be applied to cultivated meat, and the structural dimensions of planning, including supranational, national, and subnational plans. Besides, the selected concepts of governance actions such as dialogue among stakeholders, transparency, and inclusion were introduced, as they are regarded as essential for facilitating a successful transition. Finally, we address the challenges for the development of cell-based meat and conclude by emphasizing that public policies and governance actions are central to this transition, guiding investments, funding and decisions while considering social, ethical, and technological aspects.

Keywords Public policies · Transformative innovation policy · Planning · Governance actions · Cultivated meat

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M. H. Ueta
Department of Social Sciences, Wageningen University & Research, Wageningen, The Netherlands

C. F. M. Molento
Animal Welfare Laboratory & Cellular Animal Science Laboratory, Federal University of Paraná, Curitiba, Paraná, Brazil

C. R. Soccol et al. (eds.), *Cultivated Meat*,
https://doi.org/10.1007/978-3-031-55968-6_18

ANNEX 21. CERTIFICATE OF PARTICIPATION AT THE ORGANIZATION OF THE EVENT TITLED "I INTERNATIONAL CONFERENCE & I NAPI ALTERNATIVE PROTEINS MEETING" IN 2024.

ANNEX 22. CERTIFICATE OF PARTICIPATION AT THE EVENT TITLED "I INTERNATIONAL CONFERENCE & I NAPI ALTERNATIVE PROTEINS MEETING" IN 2024.

Verifique o código de autenticidade 53845831.567478.7.3.897498340678968 em https://www.even3.com.br/documentos

CERTIFICATE
OF PARTICIPATION

Certificamos que

Jennifer Cristina Biscarra Bellio

participou com êxito como membro da organização do evento I Conferência Internacional Cell Ag Brazil e I Encontro NAPI Proteínas Alternativas - I International Cell Ag Brazil Conference & I NAPI Alternative Proteins Meeting realizado em 08/07/2024 a 11/07/2024, na cidade de Curitiba, contabilizando carga horária total de 200 horas.

Curitiba, 08/07/2024 a 11/07/2024

Cell Ag Brazil

Carla Forte Maiolino Molento
President

Proteínas Alternativas NAPI

Paula Toshimi Matumoto Pintro
Vice president

ANNEX 23. CERTIFICATE OF PRESENTATION OF THE WORK TITLED "CELLULAR AGRICULTURE: WHO WANTS TO LEARN ABOUT THIS NEW TECHNOLOGY?" AT THE I INTERNATIONAL CONFERENCE & I NAPI ALTERNATIVE PROTEINS MEETING" IN 2024.

Verifique o código de autenticidade 53849458.567478.967295.3.8975749406709506154B em https://www.even3.com.br/documentos

CERTIFICATE
OF PRESENTATION

Certificamos que o trabalho

Cellular agriculture: who wants to learn about this new technology?

dos autores Jennifer Cristina Biscarra Bellio, Gabriel Mendes e Carla Forte Maiolino Molento foi apresentado como **Pôster** por Gabriel Mendes no evento I Conferência Internacional Cell Ag Brazil e I Encontro NAPI Proteínas Alternativas - I International Cell Ag Brazil Conference & I NAPI Alternative Proteins Meeting realizado em 08/07/2024 a 11/07/2024, na cidade de Curitiba.

Curitiba, 08/07/2024 a 11/07/2024

Cell Ag Brazil

Carla Forte Maiolino Molento
President

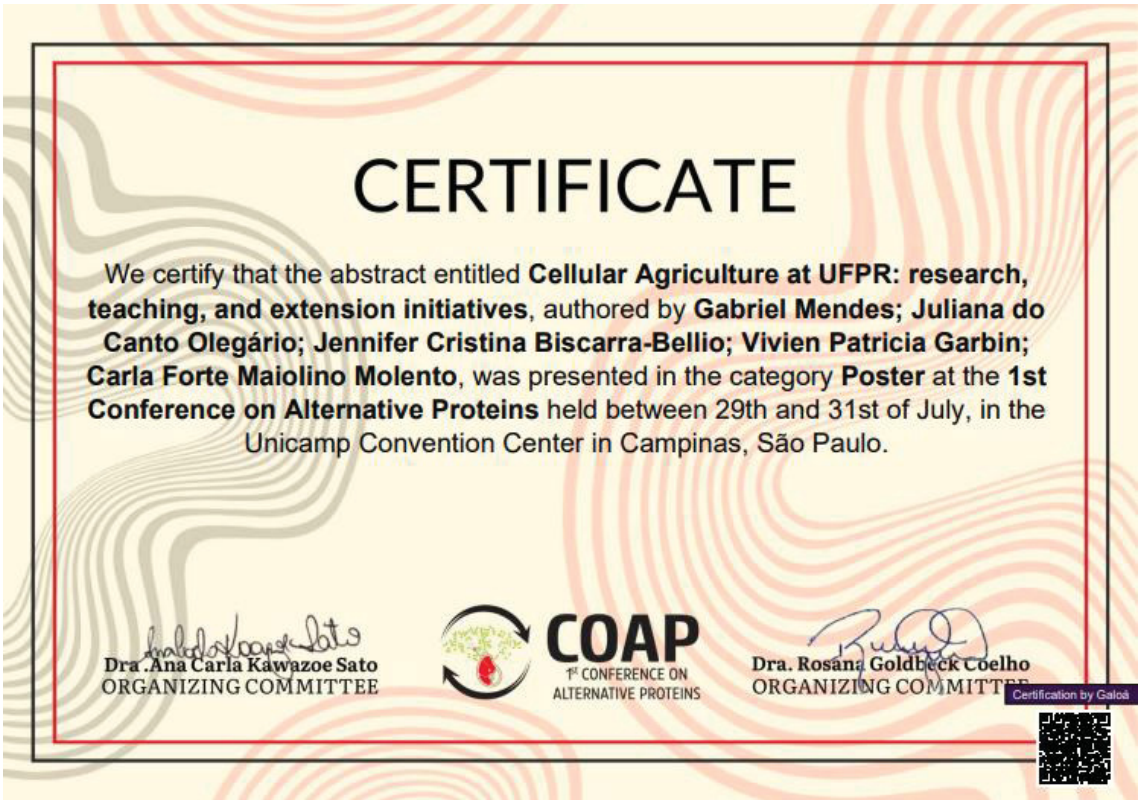
Proteínas Alternativas NAPI

Paula Toshimi Matumoto Pintro
Vice president

ANNEX 24. CERTIFICATE OF ACCEPTED ABSTRACT TITLED “BIFE SEM BICHO: CONHECENDO A CARNE, OVOS, LEITE E DERIVADOS SEM SOFRIMENTO E MORTE DE ANIMAIS” AT THE VII SEMINÁRIO DE DEFESA ANIMAL IN 2024.

ANNEX 25. CERTIFICATE OF ACCEPTED ABSTRACT TITLED “INTENÇÃO DE CONOSUMO DE CARNE CELULAR NAS CIDADES DE SALVADOR E SÃO PAULO” AT THE VII SEMINÁRIO DE DEFESA ANIMAL IN 2024.

ANNEX 26. ACCEPTED ABSTRACT TITLED "CELLULAR AGRICULTURE AT UFPR: RESEARCH, TEACHING, AND EXTENSION INITIATIVES" AT THE 1ST CONFERENCE ON ALTERNATIVE PROTEINS IN 2024.



CERTIFICATE

We certify that the abstract entitled **Cellular Agriculture at UFPR: research, teaching, and extension initiatives**, authored by **Gabriel Mendes; Juliana do Canto Olegário; Jennifer Cristina Biscarra-Bellio; Vivien Patricia Garbin; Carla Forte Maiolino Molento**, was presented in the category **Poster** at the **1st Conference on Alternative Proteins** held between 29th and 31st of July, in the Unicamp Convention Center in Campinas, São Paulo.

Dra. Ana Carla Kawazoe Sato
ORGANIZING COMMITTEE

COAP
1st CONFERENCE ON ALTERNATIVE PROTEINS

Dra. Rosana Goldbeck Coelho
ORGANIZING COMMITTEE

Certification by Galoá