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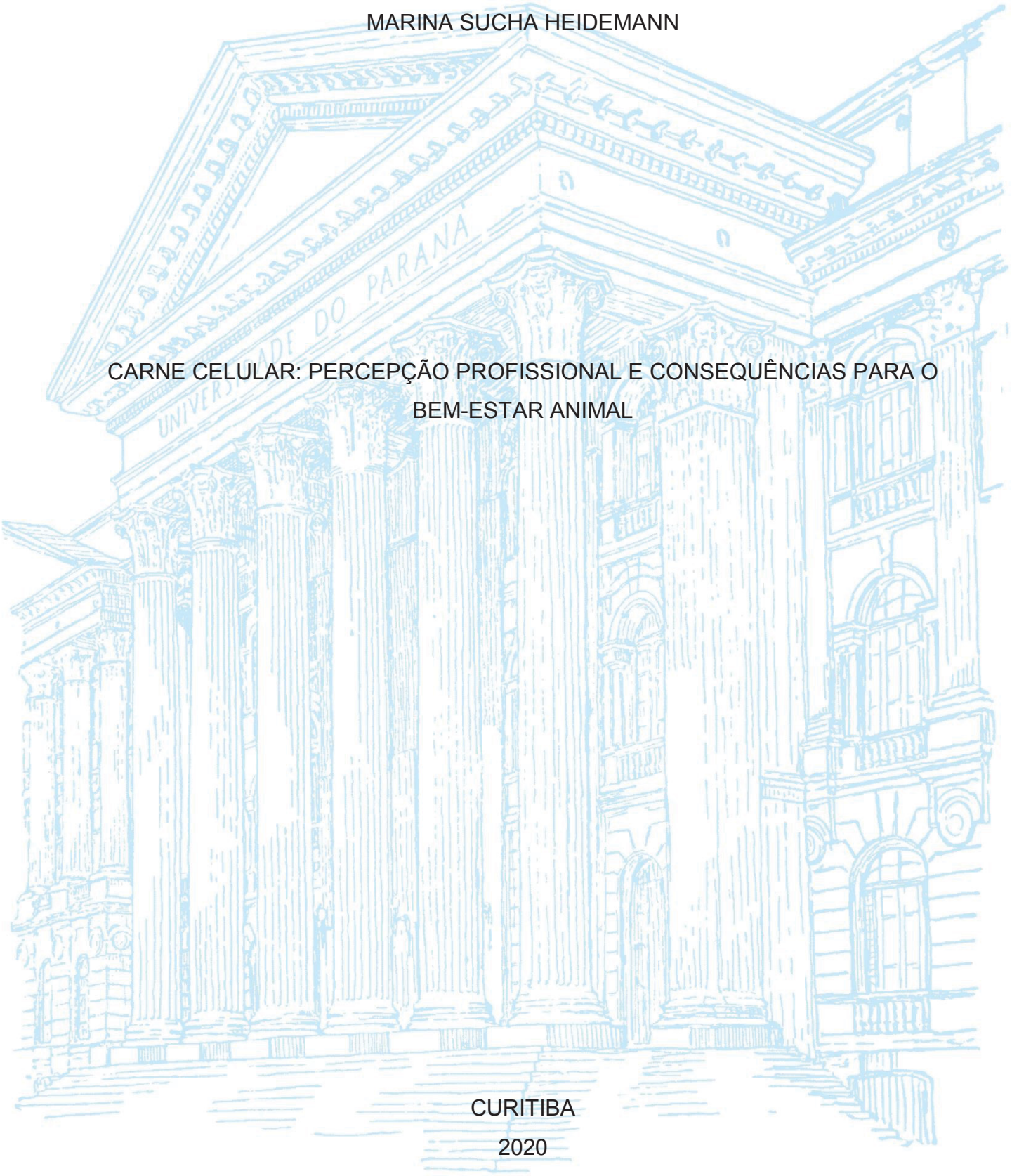

CARNE CELULAR: PERCEPÇÃO PROFISSIONAL E CONSEQUÊNCIAS PARA O BEM-ESTAR ANIMAL

CURITIBA

2020

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Dissertação apresentada ao curso de Pós-Graduação em Ciências Veterinárias, Setor de Ciências Agrárias, Universidade Federal do Paraná, como requisito parcial à obtenção do título de Mestre 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 em CIÊNCIAS VETERINÁRIAS da Universidade Federal do Paraná foram convocados para realizar a arguição da dissertação de Mestrado de **MARINA SUCHA HEIDEMANN** intitulada: **CARNE CELULAR: PERCEPÇÃO PROFISSIONAL E CONSEQUÊNCIAS PARA O BEM-ESTAR ANIMAL**, 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.

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To a brighter future for the nonhuman animals.

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“The people who are crazy enough to think that they can change the world,

are the ones who do."

Steve Jobs

RESUMO

O crescimento contínuo da população exigirá inovações na produção de alimentos. A carne celular é um método alternativo de produção de carne que possibilitará benefícios ao meio ambiente, à saúde humana e ao bem-estar animal. Embora muitas *startups* em todo o mundo venham avançando na tecnologia da carne celular, o Brasil ainda se mantém conservador em relação a sua inclusão no país. A técnica consiste em extrair células de um tecido muscular animal e promover a proliferação e diferenciação *in vitro* de células em carne, em meio de cultura apropriado. Cultivar células para produzir carne é uma inovação disruptiva que pode mudar a cadeia da carne, especialmente o setor de produção animal. Desta forma, este estudo teve como objetivo estudar o impacto da carne celular para o bem-estar animal, considerando a percepção de profissionais. Como o papel dos especialistas em produção animal é essencial para o desenvolvimento da nova cadeia de carne celular, este estudo compreendeu a percepção de médicos veterinários e zootecnistas brasileiros em relação à carne celular e identificou pontos de resistência para propor estratégias de mitigação. Além disso, como o método de produção de carne sem abate pode modificar as relações humano-animal, objetivamos discutir possíveis consequências para o bem-estar animal e o contexto ético destas mudanças. Esta dissertação é distribuída em quatro capítulos: (1) Apresentação; (2) Perspectiva crítica dos especialistas em produção animal sobre carne celular no Brasil: do gargalo aos melhores cenários; (3) O desacoplamento entre carne e abate de animais e seu impactos nas relações humano-animal; e (4) Considerações Finais. O segundo capítulo traz resultados inéditos sobre a percepção de médicos veterinários e zootecnistas brasileiros em relação à carne celular. A falta de conhecimento sobre o tema e a associação com a artificialidade foram destacados como pontos negativos, de forma que as estratégias proposta para mitigar a resistência foram o ensino de ponta e motivação para especialistas em produção animal se engajarem e contribuírem para a nova cadeia. O estudo sobre os impactos da carne celular nas relações humano-animal contemplou as implicações da introdução de uma porcentagem de carne celular no mercado de carne, tendo em vista o bem-estar animal dos animais remanescentes na produção e a perspectiva ética de desacoplar a carne da necessidade da criação e abate de animais. Em geral, este trabalho contribui para o conhecimento sobre a opinião de profissionais da produção animal em relação à carne celular, bem como sobre as possíveis implicações desta tecnologia nas nossas relações com os animais não-humanos.

Palavras-chave: 1. Bem-estar animal 2. Carne celular 3. Relações humano-animais.

ABSTRACT

The continued growth in population will require innovations in food production. Cell-based meat is an alternative method of meat production that will provide benefits to the environment, human health and animal welfare. Although many start-ups worldwide have been advancing in cell-based meat technology, Brazil is still conservative regarding its inclusion in the country. The technique consists of extracting cells from an animal muscle tissue and promoting the proliferation and differentiation *in vitro* of cells in meat, in an appropriate culture medium. Growing cells to produce meat is a disruptive innovation that may change the meat chain, especially the animal production sector. Thus, this work aimed to study the impact of cell-based meat for animal welfare, considering the perception of professionals. As the role of specialists in animal production is essential for the development of the new cell meat chain, this study includes the perception of Brazilian veterinarians and animal scientists regarding cell-based meat and identified points of resistance to propose mitigation strategies. In addition, as the method of meat production without slaughter may modify human-animal relationships, we aim to discuss possible consequences for animal welfare and the ethical context of these changes. This dissertation is divided into four chapters: (1) Presentation; (2); (3) Uncoupling meat from animal slaughter and its impacts on human-animal relationships; and (4) Final Considerations. The second chapter shows unprecedented results on the perception of Brazilian veterinarians and animal scientists in relation to cell-based meat. The lack of knowledge on the subject and the association with artificiality were highlighted as negative points; therefore, the strategies proposed to mitigate resistance were higher education and motivation for animal production specialists to engage and contribute to the new chain. The study on the impacts of cell-based meat on human-animal relations contemplated the implications of introducing a percentage of cell-based meat in the meat market, in view of the animal welfare of animals remaining in production and the ethical perspective of uncoupling meat from the need to raise and slaughter animals. In general, this work contributes to report the knowledge respecting the opinion of animal production professionals in relation to cell-based meat, as well as regarding possible implications of this technology in our relations with non-human animals.

Keywords: 1. Animal welfare 2. Cell-based meat 3. Human-animal relationships

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1 PRESENTATION

In 2050 the population is expected to be around 10 billion (UN, 2017). Thus, researchers have been working on sustainable and efficient ways to produce food for future high demand. Cell-based meat is an alternative method to produce meat from cultivating cells rather than the conventional system of raising and slaughtering animals (POST, 2012; PANDURANGAN; KIM, 2015). Cultivated meat products are near to reach the market (MOUAT et al., 2019; TUBB; SEBA, 2019), since many start-ups around the world have been developing this technology (STEPHENS et al., 2018) and have been making efforts to accelerate the access of this product to consumers. However, there is no report of cell-based meat research in Brazil and this discussion is still in the beginning.

The cell-based meat production starts with a biopsy from an animal to extract satellite cells, which are the primary adult stem cells of muscle and have the potential to repair the tissue (KADIM et al., 2015). Later, the myogenesis or the muscle regeneration includes two different stages: proliferation or multiplication of cells (myoblasts) and differentiation into myotubes (DATAR; BETTI, 2010; POST, 2012). Both phases are developed *in vitro*, using suitable cultured medium consisting of nutrients and growth factors (PANDURANGAN; KIM, 2015). The technique has still some challenges to overcome, such as the use of animal-derived serum as growth promoter in the culture medium; continued recycling metabolic waste mechanisms; matching meat sensory characteristics, like taste and texture; and provide scalability and cost reduction (POST, 2012; PANDURANGAN; KIM, 2015; SPECHT et al., 2018; STEPHENS et al., 2018).

Cell-based meat is a disruptive innovation that may potentially transform the conventional meat chain, especially regarding the first segment related to raising and slaughtering animals. Hence, the role of professionals engaged in animal production may change in the future. Many articles have described consumers attitudes regarding cell-based meat (LAESTADIUS; CALDWELL, 2015; HOCQUETTE et al., 2015; VERBEKE et al., 2015; WILKS; PHILLIPS, 2017; SLADE, 2018; MANCINI ; ANTONIOLI, 2019; VALENTE et al., 2019; WEINRICH et al., 2019). However, as the cell-based meat chain evolves, it is essential to understand the perception of the animal production specialists due to their significant influence in the development of this new technology. Therefore, the second chapter of this work is an analysis of the

perception of veterinarians and animal scientists regarding cell-based meat in Brazil, evaluating their knowledge of the subject and identifying the negative views to propose strategies of mitigation.

There are several advantages of cell-based meat in relation to the environment, human health and animal welfare. First, cell-based meat may potentially reduce the land use, water footprint and greenhouse gases release (TUOMISTO; TEIXEIRA DE MATTOS, 2011; TUOMISTO et al., 2014). Also, the cultured meat is developed in laboratories with a high controlled environment. Hence, this process is likely to be less exposure to pathogen contamination (LANGELAAN et al., 2010; SPECHT et al., 2018), enhancing food safety of meat. Finally, cell-based meat may potentially improve animal welfare, considering the reduction of animals involved in meat production (STEPHENS et al., 2018). Hence, the third chapter of this work evaluates the implications on human-animal relationships regarding the introduction of cell-based meat, in light of direct animal welfare consequences and ethics approach considering uncoupling meat from animal production.

The data presented in chapter two was approved for publication in the journal Animals (ANNEX 1), and chapter three was published as a paper to the journal Frontiers in Psychology (ANNEX 2). Additional content regarding cell-based meat and global value chains implications was published with the contribution of the author to the journal Technology in Society (ANNEX 3). Also, the author contributed with the first article about consumer attitudes regarding cell-based meat in Brazil, published in 2019 by Plos One (ANNEX 4). An abstract was presented in the event “Parana’s Horizons of Animal Welfare”, on the novel cell-based meat global value chain (ANNEX 5). In addition, the author presented six lectures regarding cell-based meat technology (ANNEX 6 to 11), and contributed as co-author to three other abstracts regarding animal welfare issues during the Masters’ degree: the first was on quality of the animal welfare approach in official documents and technical reports and it was awarded first prize in the event “V Seminary of Animal Defence: Civil Society and Public Power Challenges” (ANNEX 12); the second and third were presented in the International Animal Welfare Science Symposium “Advancing Animal Welfare Science: How do we get there? Who is it good for?”, on sheep farmers’ perception of sheep welfare in Southern Brazil, and motivation for chasing behaviour displayed by community dogs (ANNEX 13 and 14).

Overall, this dissertation shows original results on the opinion of animal production specialists regarding cell-based meat and suggests different future scenarios for the emergence of cell-based meat in the meat chain, which may result into direct changes in both farm and wild animals, as well as ethical inquiries.

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2 CRITICAL PERSPECTIVE OF ANIMAL PRODUCTION SPECIALISTS ON CELL-BASED MEAT IN BRAZIL: FROM BROTTLENECK TO BEST SCENARIOS

RESUMO

Recentemente, muitos estudos sobre a percepção do consumidor acerca da carne celular foram publicados. No entanto, a opinião dos profissionais envolvidos na produção animal também parece relevante. Em particular, veterinários e zootecnistas podem ser atores importantes na nova produção de carne celular, agindo como proponentes ou barreiras para esta grande melhoria para o bem-estar dos animais de produção. Portanto, nosso objetivo é analisar o conhecimento e a perspectiva de veterinários e zootecnistas brasileiros em relação à carne celular. Veterinários (76,8%; 209/272) e zootecnistas (23,2%; 63/272) responderam a uma pesquisa online. Regressão logística, classes latentes e modelos logit foram utilizados para avaliar as respostas objetivas, e o método do Discurso do Sujeito Coletivo foi utilizado para interpretar as respostas abertas. Dentre os especialistas, mulheres (62,5%; 170/272), veterinários (76,8%; 209/272), vegetarianos (7,0%; 19/272) e veganos (1,1%; 3/272) foram mais favoráveis à carne celular. A falta de conhecimento e a conexão com artificial, palavra espontânea mais frequente associada à carne celular por todos os entrevistados, foram os principais pontos negativos destacados. Assim, parece fundamental oferecer ensino de ponta a veterinários e zootecnistas em relação à carne de base celular, já que o engajamento nesta nova tecnologia pode atenuar a resistência e seus impactos negativos para os profissionais, a sociedade, os animais e o meio ambiente.

Palavras-chave: 1. Bem-estar animal 2. Carne cultivada 3. Carne sem abate 4. Produção animal 5. Proteção animal

ABSTRACT

Recently, many studies regarding consumer perception of cell-based meat have been published. However, the opinion of the professionals involved in animal production also seems relevant. In particular, veterinarians and animal scientists may be important players in the new cell-based meat production, acting as proponents or barriers to this major improvement for farm animal welfare. Therefore, our aim is to analyse the knowledge and perspective of Brazilian veterinarians and animal scientists regarding cell-based meat. Veterinarians (76.8%; 209/272) and animal scientists (23.2%; 63/272) responded to an online survey. Logistic regression, latent class and logit models were used to evaluate objective answers, and the Discourse of the Collective Subject method was used to interpret open-ended answers. Specialists who were women (62.5%; 170/272), veterinarians (76.8%; 209/272), vegetarians (7.0%; 19/272) and vegans (1.1%; 3/272) were more supportive of cell-based meat. Lack of knowledge and the connection with artificiality, the most frequent spontaneous word associated with cell-based meat by all respondents, were the main negative points highlighted. Thus, it seems fundamental to offer higher education to veterinarians and animal scientists regarding cell-based meat, since engaging them with this novel technology may mitigate both the resistance and its negative consequences for the professionals, society, the animals involved and the environment.

Keywords: 1. Animal protection 2. Animal welfare 3. Animal production 4. Cultivated meat 5.Cultured meat 6. Slaughter-free meat

2.1 INTRODUCTION

Currently, it is widely recognised that new technologies and systemic innovation are critical for the profound transformation the food system needs (HERRERO et al., 2020). Cell-based meat is an alternative to conventional meat that does not require the husbandry and slaughtering of animals (PANDURANGAN; KIM, 2015). As such, there are evident benefits to farmed animals, as billions of lives may be spared the intrinsic suffering inherent to intensive industrial animal production systems and slaughter. Moreover, the increasingly questioned paradox of humane slaughter (BROWNING; VEIT, 2020) may finally be completely bypassed. Indeed, the development of alternative meats may be related to a significant change in our relationship with nonhuman animals, with greater benefits than the prima facie effects on farm animals; this has been discussed in detail in (HEIDEMANN et al., 2020).

The new cell-based technology may radically change the meat production chain that currently depends on the production of livestock on farms, their slaughter, processing, and marketing, as the new production process is based on tissue engineering, initially developed for biomedical purposes (SPECHT et al., 2018; STEPHENS et al., 2018). It begins with an animal biopsy and extraction of satellite cells, followed by cell proliferation and differentiation in a bioreactor, the final product of which is muscle tissue. Besides the already mentioned benefits to animal welfare [6], there are additional relevant gains in other areas, such as a reduction in environmental impact (TUOMISTO; TEIXEIRA DE MATTOS, 2011) and improvements in human health (DATAR; BETTI, 2010). However, there are challenges yet to be overcome, such as the adjustment of the production process from small amounts for biomedicine to a meat production scale (STEPHENS et al., 2018), alternative culture and growth media with nonanimal ingredients (SPECHT et al., 2018; DATAR; BETTI, 2010), price (WILKS; PHILLIPS, 2017), flavour and appearance (POST, 2012), among others. In addition, there are controversial aspects regarding social and economic implications of cell-based meat production, and the consideration of these aspects seems key to providing equality between all actors in this new chain (STEPHENS et al., 2018). Additionally, in terms of energy consumption, a risk of higher demand for cell-based meat production has been postulated (TUOMISTO; TEIXEIRA DE MATTOS, 2011).

In spite of the challenges ahead, the introduction of cell-based meat for human consumption is reportedly close to occurring (MOUAT; PRINCE; ROCHE, 2018). Large companies of the meat industry (e.g., Tyson Foods, Cargill) have been investing in this novel technology, as well as several startups that have been created worldwide (FROGGATT; WELLESLEY, 2020). Moreover, recent forecasting reports have estimated a 30% reduction of the conventional meat in the US by 2030 (TUBB; SEBA, 2019), and by the year 2040, 35% of the global meat production may be cultivated (GERHARDT et al., 2019)[14]. Thus, cell-based meat is likely to bring radical changes to the meat production sector, and it seems wise to examine its implications for society in general, for animals, as well as for the global meat business.

Recent research has focused on debating consumer attitudes regarding cell-based meat. For instance, many respondents perceived the environmental, human health and animal welfare benefits of cultured meat simultaneously to a general concern in relation to the unnaturalness of cell-based meat (HOCQUETTE, 2015; LAESTADIUS; CALDWELL, 2015; VERBEKE; SANS; VAN LOO, 2015; SIEGRIST; SÜTTERLIN, 2017; WILKS; PHILLIPS, 2017; BRYANT et al., 2019; VALENTE et al., 2019; WEINRICH; STRACK; NEUGEBAUER, 2020). However, nothing is known regarding the opinions of relevant actors in the meat chain, such as professionals and specialists who are currently involved in the production of conventional meat.

Since the introduction of cell-based meat and other alternative protein sources in the meat market is likely to occur (TUBB; SEBA, 2019), the roles and activities of those actors are most likely to be reconfigured, and new professional opportunities may arise. This is the case of veterinarians and animal scientists, who have key roles in the conventional meat production chain. For decades, both professionals have been responsible for the reproduction, growth, development and economic efficiency of farm animals, as well as the technology of meat and other animal-derived products (RAUN, 1968; PEREIRA, 2004); more recently, animal welfare and sustainability issues have become additional responsibilities. Additionally, veterinarians have an important contribution to One Health surveillance, promoting healthy animals and controlling the processing and distribution of animal-derived products (SMITH, 2001; COCH; FRENCH, 1948). Then, as cell-based meat products reach the markets in the next few years, their duties may concentrate on activities such as genetics, nutrition, health, management and development of cells, as well as processing, package,

marketing, control, and inspection of cultured meat products. Moreover, since the technology is just being realised, completely new roles may emerge as the new chain matures. Thus, their activities are expected to face substantial changes ahead, which will likely to be shaped by their attitudes now. However, it is not yet known how they envision these coming changes and their possible consequences. We argue that understanding their impressions is important because they may be directly involved in developing and promoting the new chain, e.g., by establishing novel cell-based meat products, by their involvement in both the creation and overseeing of regulations regarding animal products, and by their virtually omnipresent activities in the meat chain. On the other hand, they may also be a major source of resistance to change (COCH; FRENCH, 1948; BURNES, 2015), hindering the pace of this new meat industry. In addition, the knowledge extent of this particular group, regarding cell-based technology and its implications for the meat chain, is not known; this aspect is particularly relevant given that a lack of understanding may be the major cause for innovation-specific resistance (NYSVEEN et al., 2017).

Brazil is a major producer and consumer of meat. According to the Brazilian Association of Meat Exporting Industries, the livestock sector was responsible for 8.7% of the national GDP in 2019, and around 80% of production was consumed by the domestic market, with a per capita consumption estimated at 42 kg/year (ABIEC, 2019). However, despite this tradition in meat consumption, consumers seem increasingly open to alternative proteins. For instance, 14% of Brazilians declared themselves vegetarians in 2019, in comparison to 8% in 2012, and 63% stated their interest in decreasing meat consumption (GAZETA DIGITAL, 2019). Thus, meat processing firms have diversified their product portfolio in order to offer alternative proteins. Seara, for instance, a main Brazilian producer of processed meat foods, has recently experienced success with plant-based products which have sold six times more than initially forecasted by the company (PAIVA, 2019), leading to investments towards expanding this product line. As for cell-based meat, Valente and associates (VALENTE et al., 2019) stated that 63.6% of Brazilian consumers would eat cultured meat, while local meat processing companies have high-quality production, distribution and marketing capabilities that enable them to successfully join ventures with cultured meat producers (REIS et al., 2020). Consequently, the overall scenario is positive for the introduction of alternative proteins such as cell-

based meat to the Brazilian market, which is likely to bring novel opportunities and changes for the activities of animal production specialists.

Thus, as the role of veterinarians and animal scientists seems relevant to the future of the cell-based meat industry and its overarching consequences. The aim of this work is to explore and compare the perception of Brazilian veterinarians and animal scientists regarding cell-based meat and to understand eventual points of resistance in order to support strategies for their mitigation. We hypothesise that these professionals are not familiar with the concept of cell-based meat and present resistance motivations to this technology.

2.2 MATERIAL AND METHODS

This research was approved by the Ethics Committee on Research on Humans of the Health Sciences Sector Campus of the Federal University of Paraná, Brazil, and is registered under the number 3040865/2018.

2.2.1 Development of the research instrument

A Portuguese online questionnaire was developed on the Google Forms platform, with an estimated duration of 15 min per respondent, in order to evaluate the perception of veterinarians and animal scientists regarding cell-based meat. This instrument was elaborated according to a literature review on cell-based meat (DATAR; BETTI, 2010; KADIM et al., 2015; STEPHENS et al., 2018) and related questionnaires (HOCQUETTE et al., 2015; WILKS; PHILLIPS, 2017; MANCINI; ANTONIOLI, 2019).

The survey was composed of a total of 47 questions: 30 multiple-choice and 17 open-ended questions. Questions on knowledge of cell-based and other meat alternatives as well as their benefits and harms, comparison between conventional and cell-based meat production systems in relation to environmental impact, human health and animal welfare, respondent views on the time for cell-based meat introduction to the Brazilian market, and the perception of cell-based meat impacts to veterinarians, animal scientists and bioprocess engineers were asked. Responses to most questions were compulsory before accessing the next one, with the exception of questions 35, 37, 39, 41, 43, 46 and 47, which were optional. Between Questions

14 and 15, there was a short explanation of the concept of cell-based meat, as follows: "*Cell-based meat is produced by cell multiplication, using cells extracted once from the live animal, later grown in the laboratory*."

The questionnaire was refined with an online survey, followed by an interview with a committee of experts. The interview aimed to collect suggestions on both the development and the application of the questionnaire regarding possible errors, lack of clarity or ambiguities (MUÑIZ; FONSECA-PEDRERO, 2019), as well as bias avoidance. To that end, according to Lynn (1986), five specialists were interviewed: three veterinarians, one animal scientist and one bioprocessing engineer. Professionals were selected according to their experience, areas of expertise, career time and knowledge of the methodology of questionnaire construction; none of them had specific interests on cell-based meat. They received an invitation to participate in an interview including an initial application of the questionnaire and immediate discussion of the instrument, allowing for a detailed review of the method of application, duration and content of the questionnaire (ALEXANDRE; COLUCI, 2011).

2.2.2 Survey sample

The online survey was featured via social media and email in a random sampling method. Data were collected from 20 February to 1 April 2019. The total number of respondents was 297, of which 291 agreed to participate in the study. Only responses from veterinarians and animal scientists were used, eliminating 16 respondents with other backgrounds. Additionally, data from three respondents were eliminated since two did not answer all the questions and one was a student. Thus, the total respondents considered in this work was 272, most of which were veterinarians (76.8%; 209/272) and all the others were animal scientists (23.2%; 63/272). Regarding respondent gender, 170 respondents were women (62.5%) and 102 men (37.5%); 136 (65%) women and 73 (35%) men were veterinarian respondents, and 34 (54%) women and 29 (46%) men were animal scientists. In addition, 266 respondents declared their age, which varied between 22 to 71 years, with most of them concentrated in the range between 22 and 35 years of age (57.1%, 152/266). In relation to years since graduation, most respondents graduated between 0–10 (150; 55.1%) years ago, while the rest graduated 11–46 years ago (122;

44.9%). In addition, most of the respondents graduated from Southern Brazil (77.6%; 211) courses: Parana (65.1%; 177), Santa Catarina (5.1%; 14), and Rio Grande do Sul (7.4%; 20).

2.2.3 Statistical analysis

The data related to the questions "*Do you know a way for producing meat that does not involve raising animals?*" and "*Do you know what cell-based, also known as lab-grown, artificial, in vitro, synthetic, clean or slaughter-free meat is?*" were submitted to logistic regression (LR) analysis. The objective was to investigate the possible association with the factors sex, age, years since graduation, profession and meat consumption. Since age and years of graduation were strongly correlated (linear correlation equals to 0.96; $p < 0.001$), we considered only years since graduation for further analyses. Initially, an LR model was fitted, including all factors under investigation; then, factors with no significant effects were successively removed. Significance was assessed by the likelihood ratio test, considering a significance level of 5%. For the variables remaining, the respective effects are presented as odds ratios and the respective confidence intervals (95%). A similar analysis was applied to the question "*Should Brazil invest in cell-based meat production?*".

Latent class analysis (LCA) was applied to analyse two groups of questions. The first group was composed of the questions related to the benefits and harms of both conventional and cell-based production. The second group consisted of the questions regarding the environment, human health, animal welfare and efficiency of production for both conventional and cell-based meat. LCA is a multivariate statistic applied to categorised data to identify patterns in the values and groups of individuals with similar results. In the present study, the objective was to identify common patterns of responses (LCs) to the sets of related questions. Next, the respondents were grouped according to the answers to the original questions in each of the LCs obtained. Conditional to the LCs produced, the answers to the original questions were independent.

The number of LCs extracted is a key result of the analysis. Solutions starting with one to four LCs were tested and compared using the Bayesian information criterion (BIC); the solution that produced the smallest value was selected. After

choosing the number of LCs, the results were plotted by means of the probabilities in each of the classes. It is noteworthy that at this stage of the analysis, as with the data extraction process, the results were classified into three categories: “positive”, “neutral” and “negative”. For example, very inefficient and inefficient were grouped into a single response. In order to identify factors associated with the LC obtained, each individual was classified into the one with the highest probability, according to his or her original answers, and the data was also submitted to LR analysis. The same method was applied regarding the knowledge of alternative sources or investment in the area. The results are presented in the form of odds ratios and the respective confidence intervals.

Finally, the answers on respondent perception regarding the probable positioning of veterinarians, animal scientists and bioprocess engineers in relation to cell-based meat were grouped into three categories: “favourable”, “neutral” and “unfavourable”. A multinomial LR, specifically the generalised logit model (LM), was used due to a variable response with the three categories. The selection of variables and the results presented were similar to those described previously, in the case of binary LR. As every respondent expressed his or her opinion for the positioning of each professional class, a random effect of respondents with normal distribution of zero mean and constant variance, corresponding to the effect of the respondent, was incorporated into the model.

All analyses were performed using the statistical environment R (R CORE TEAM, 2016), version 3.6.0. The poLCA package (LINZER; LEWIS, 2011) was used to analyse LCs and the ordinal design for the fit of generalised LMs, and the ggplot2 package was used in the construction of the plots. In addition, the arm package was used in the LR adjustment, using Bayesian estimation.

2.2.4 Analysis of responses to open-ended questions

Four open-ended questions (15, 39, 41 and 43) were analysed using the Discourse of the Collective Subject (DCS) method (DUARTE; MAMEDE; DE ANDRADE, 2009). Question 15 was analysed individually, and questions 39, 41 and 43, which were optional and approached respondents’ hypotheses to the reasons for the probable positioning of veterinarians, animal scientists and bioprocess engineers in relation to cell-based meat, were analysed together.

DCS is a qualitative–quantitative method that uses central ideas to represent collective interpretation (LEFÈVRE; LEFÈVRE, 2006; DUARTE; MAMEDE; DE ANDRADE, 2009). Hence, key expressions were extracted from the answers and synthesised into central ideas, which generated categories of attitudes. The frequency of a category's appearance represents the collective opinion of the group. A single response may be present in more than one category; thus, the total frequency of category is higher than total responses.

For question 15, every word with a complete meaning as a central idea was used, such as "artificial", "health", and "colour". When answers were presented as sentences, they were synthesised into central ideas. For example, "possibility of greater market acceptance" was transformed to "possibility, market, acceptance". Adjectivised nouns (e.g., "animal welfare") were maintained to guarantee the full meaning intended by respondents. Lastly, the website Word It Out (https://worditout.com) was used to present the words with sizes proportional to their frequency in the dataset. Only words that appeared two or more times were used; words which were mentioned only once were not used to preserve clarity within the word cloud.

For the answers on respondent perception regarding the probable positioning of veterinarians, animal scientists and bioprocess engineers in relation to cell-based meat, key expressions of respondent sentences were incorporated into central ideas and measured for their frequency. For example, "Animal production is part of the attributions of these professionals" was synthesised to the central idea of "field of work". Thus, interpretative and theoretical validities (HAYASHI; ABIB; HOPPEN, 2019) were used to establish these categories in order to minimise bias.

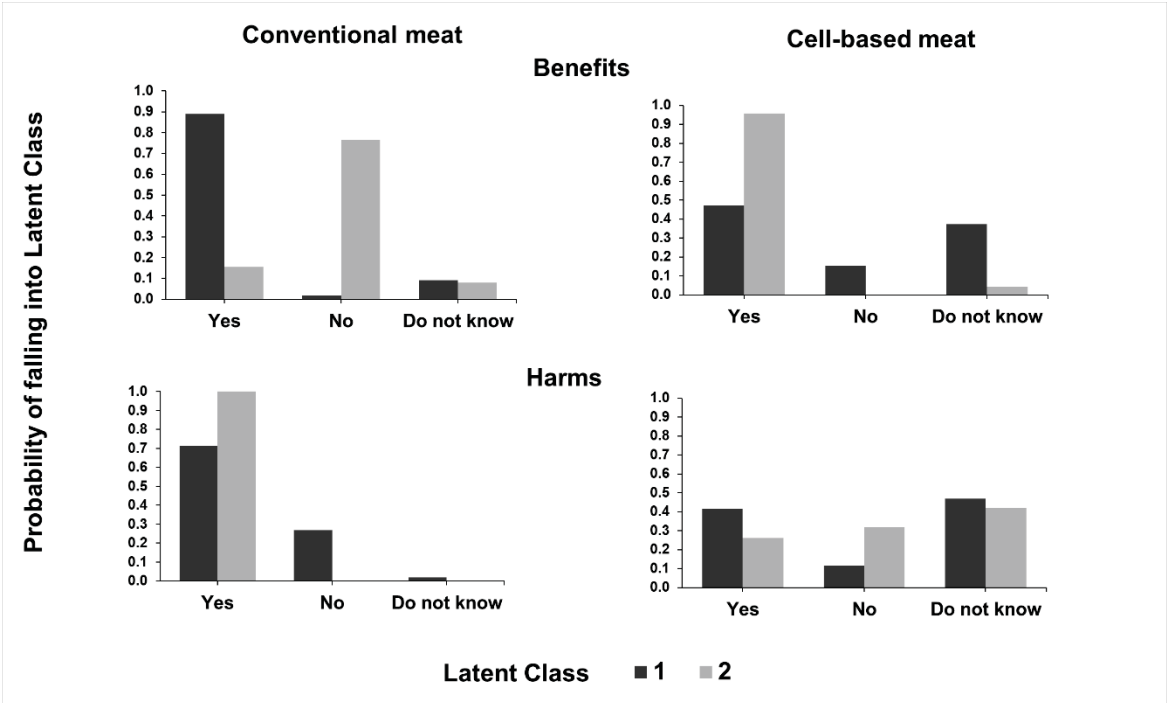
2.3 RESULTS

Regarding the participants' eating habits, 91.9% consumed meat (250/272), 65.6% (164/272) declared daily meat consumption, 7.0% (19/272) were vegetarians and 1.1% (3/272) were vegans. Regarding alternatives to conventional meat production, 122 (44.8%) respondents were not aware of any other method. In relation to Question 13 "*Do you know what cell-based, also known as lab-grown, artificial, in vitro, synthetic, clean or slaughter-free meat is?",* 74.2% (202/272) had heard of the subject.

For the LR analysis applied to the question about alternatives to traditional meat production, the only significant variable was the frequency of meat consumption (p = 0.021). Individuals who did not consume meat presented higher odds of responding positively than those who consumed meat daily (OR = 3.00; CI (95%) = 1.047, 8.594). However, there was no difference between nonconsumers and daily meat-eaters in relation to those with intermediate meat consumption frequency, who consumed meat but not on a daily basis. For question 13, none of the studied variables was statistically significant. For the last question evaluated with LR, "*Should Brazil invest in cell-based meat production?*", the frequency of meat consumption (p < 0.001) was again a significant variable: vegetarians and vegans presented higher odds of responding yes than daily (OR = 25,920; CI (95%) = 4,623, 265,310) and casual meat-eaters (OR = 7.4320, CI (95%) = 1.2196, 79.0199).

In relation to the LCA for the two groups of questions, the solution with two LCs (Classes 1 and 2) was the best for both, based on BIC values. The first group of questions concerns the benefits and harms related to conventional and cell-based meat (FIGURE 1).

FIGURE 1 – BENEFITS AND HARMS OF CONVENTIONAL AND CELL-BASED MEAT IN EACH LATENT CLASS ACCORDING TO 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS RESPONDING TO AN ONLINE QUESTIONNAIRE. LATENT CLASS 1 (217 RESPONDENTS) PRESENTS A MORE PROCONVENTIONAL PERCEPTION, AND LC 2 (55 RESPONDENTS), A MORE PRO-CELL-BASED MEAT PERCEPTION.



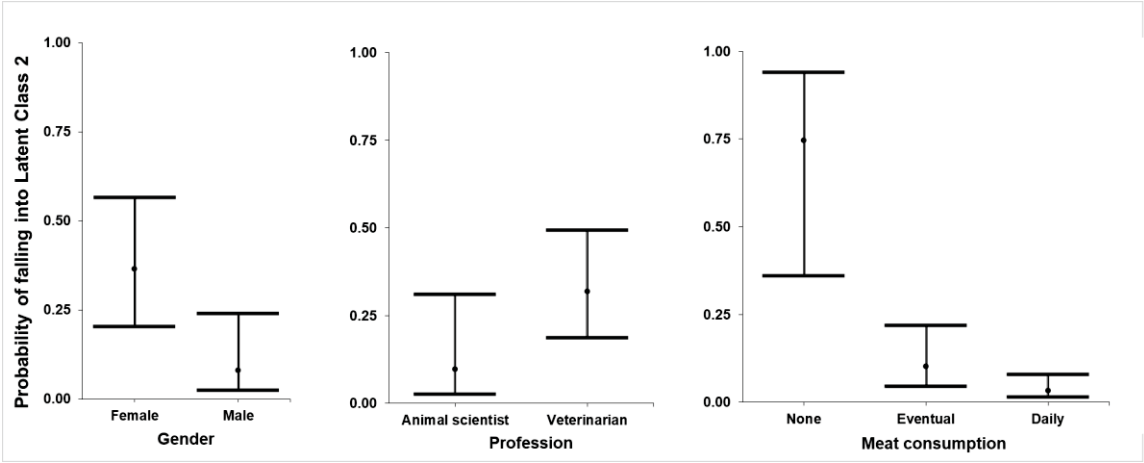
Latent Class 1 (79.8%; 217/272) is defined by a pattern of responses that characterises individuals who are more likely to perceive benefits of conventional meat production (proconventional meat) and tend not to see benefits in the production of cell-based meat or express lack of knowledge about the subject. In addition, they are less likely to express problems with conventional production if compared to LC 2 responses. On the other hand, LC 2 (20.2%; 55/272) is composed of a pattern of responses that describes individuals who are more likely to express benefits in terms of cell-based meat production (pro-cell-based meat), who tend to see fewer benefits in conventional meat production. In addition, there is practical unanimity in LC 2 responses regarding the existence of problems in the conventional meat production system. Individuals of the two groups showed quite heterogeneous responses to cell-based meat harms; for this variable, it was not possible to discriminate individuals from both classes. The LR results are shown in TABLE 1.

TABLE 1 – RESULTS OF THE LOGISTIC REGRESSION MODEL FOR THE CHANCES PRODUCED BY LATENT CLASS (LC) ANALYSIS FOR THE GROUP OF QUESTIONS RELATED TO BENEFITS AND HARMS OF CONVENTIONAL AND CELL-BASED MEAT, ACCORDING TO THE RESPONSES TO AN ONLINE QUESTIONNAIRE BY 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS. LC 2 PRESENTS A MORE PRO-CELL-BASED PERCEPTION.

Demographic data	**Contrast**	**Odds ratio (LC 2/LC1)**	**Confidence Interval (95%)**
Gender	Men as compared to women	0.131	0.036-0.384
Profession	Veterinarians as compared to animal scientists	5.224	1.483-25.231
Meat consumption	Partial as compared to vegetarians and vegans	0.041	0.008-0.154
Meat consumption	Daily as compared to vegetarians and vegans	0.012	0.002-0.047

There were lower odds of men belonging to LC 2, which corresponds to a trend to identify more benefits than harm in cell-based meat production and the opposite for conventional meat production (OR = 0.131). There are higher chances of veterinarians belonging to LC 2 in relation to animal scientists (OR = 5.224) and lower chances of casual and daily consumers of animal meat belonging to LC 2 when compared to those who did not consume meat (FIGURE 2).

FIGURE 2 – ADJUSTED RESPONDENT PROBABILITY OF FALLING INTO LATENT CLASS 2 (PRO-CELL-BASED MEAT, 55 RESPONDENTS) FOR THE GROUP OF QUESTIONS RELATED TO THE BENEFITS AND HARMS OF CONVENTIONAL AND CELL-BASED MEAT PRODUCTION, ACCORDING TO THE RESPONSES TO AN ONLINE QUESTIONNAIRE BY 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS.



For the second group of questions (FIGURE 3), 151 (55.5%) were classified as LC 1 and 121 (44.5%) as LC 2, and it was possible to determine the characteristics of the two LC profiles. Again, LC 1 presents a pattern of responses of individuals more likely to support conventional production. This is expressed more sharply in relation to the favourable responses to the impact on human health and to the efficiency of production. The perception of the same LC is less favourable in relation to environmental impacts and animal welfare issues relative to conventional production. As for the production efficiency of cell-based meat, LC 1 respondents show less probability than LC 2 respondents of manifesting themselves positively. Additionally, they are more likely to be unaware of the effects of cell-based meat. The opposite characteristics were seen in LC 2 respondents, identified as individuals with a more favourable perception of cell-based meat production, more knowledgeable on this subject and with a more unfavourable view of the conventional production system. This latter aspect is more evident, especially when dealing with the environmental and animal welfare impacts of conventional meat production. TABLE 2 presents the results of the LR adjusted to the classification of the individuals produced by the LCA.

FIGURE 3 – PERCEPTIONS OF ISSUES RELATED TO THE ENVIRONMENT, HEALTH, ANIMAL WELFARE AND EFFICIENCY OF PRODUCTION OF CONVENTIONAL AND CELL-BASED MEAT IN EACH LATENT CLASS (LC) BY 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS ACCORDING TO AN ONLINE QUESTIONNAIRE. LC 1 (151 RESPONDENTS) PRESENTS A MORE PROCONVENTIONAL PERCEPTION AND LC 2 (121 RESPONDENTS) A MORE PRO-CELL-BASED PERCEPTION.

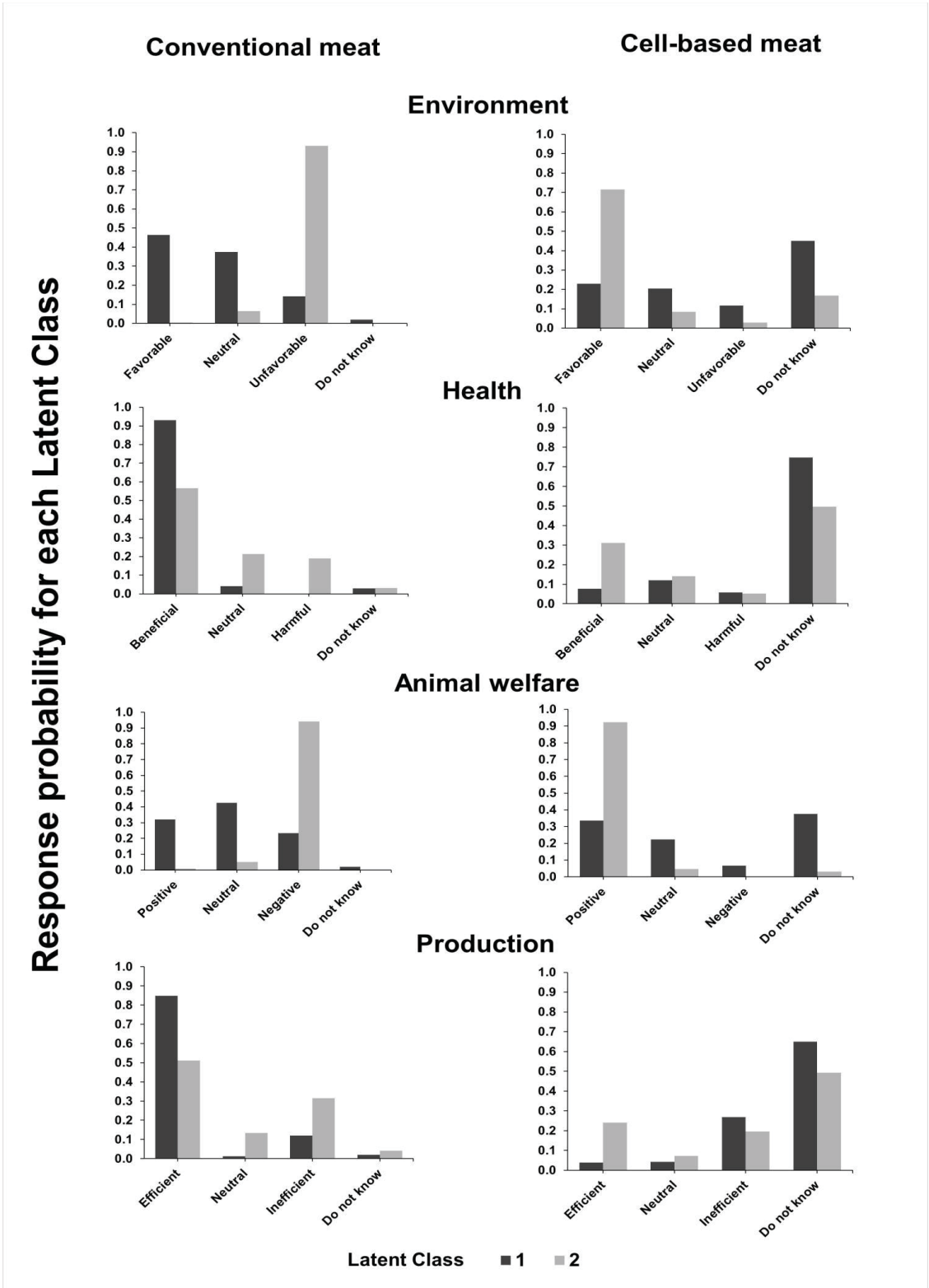
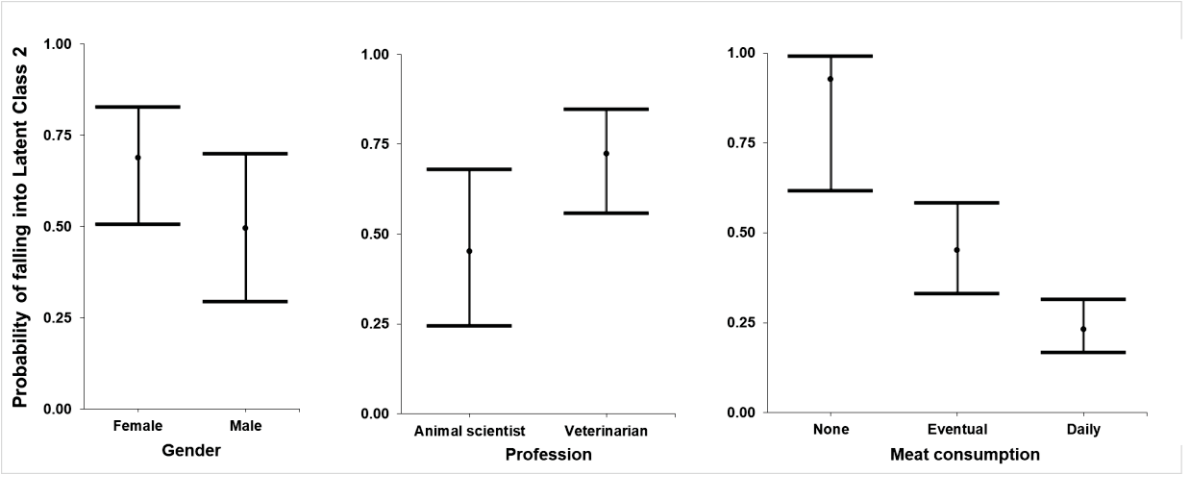


TABLE 2 – RESULTS OF THE LOGISTIC REGRESSION MODEL ON THE CHANCES PRODUCED BY LATENT CLASS (LC) ANALYSIS FOR THE GROUP OF QUESTIONS RELATED TO THE ENVIRONMENT, HEALTH, ANIMAL WELFARE AND EFFICIENCY OF PRODUCTION OF CONVENTIONAL AND CELL-BASED MEAT, ACCORDING TO THE RESPONSES TO AN ONLINE QUESTIONNAIRE BY 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS; LATENT CLASS 2 PRESENTS A MORE PRO-CELL-BASED CONVICTION.

Demographic data	**Contrast**	**Odds ratio (LC2/LC1)**	**Confidence Interval (95%)**
Gender	Men as compared to women	0.426	0.231-0.754
Profession	Veterinarians as compared to animal scientists	3.291	1.637-6.846
Meat consumption	Partial as compared to vegetarians and vegans	0.069	0.008-0.382
Meat consumption	Daily as compared to vegetarians and vegans	0.024	0.003-0.126

The results indicate a lower chance of men belonging to LC 2 (OR = 0.426), as well as greater chances for veterinarians in relation to animal scientists (OR = 3.291); there is also less chance for respondents with occasional consumption and for respondents with daily consumption to belong to LC 2 in relation to those who did not consume meat (FIGURE 4).

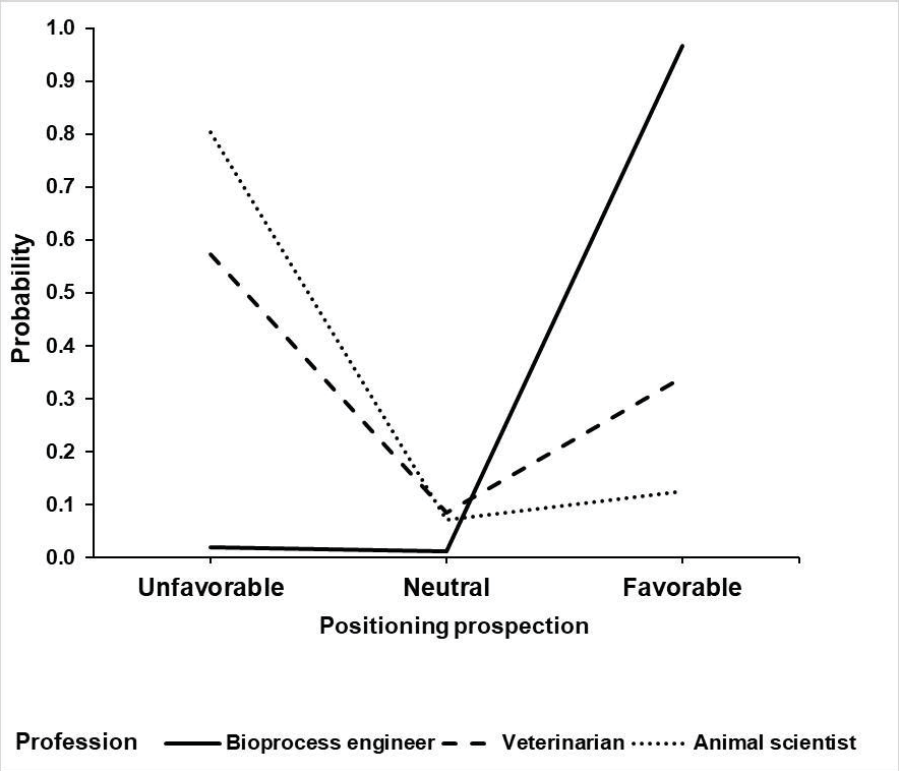
FIGURE 4 – ADJUSTED RESPONDENT PROBABILITY OF FALLING INTO LATENT CLASS 2 (PRO-CELL-BASED MEAT, 121 RESPONDENTS) FOR THE GROUP OF QUESTIONS RELATED TO THE ENVIRONMENT, HEALTH, ANIMAL WELFARE AND EFFICIENCY OF PRODUCTION OF CONVENTIONAL AND CELL-BASED MEAT, ACCORDING TO THE RESPONSES TO AN ONLINE QUESTIONNAIRE BY 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS.



The LM analysis performed was on respondent perception of the probable position professionals will assume regarding the production of cell-based meat. Two different models were fitted: first, the respondent's profession was not considered; secondly, the interaction between the respondent's profession and the respondent's

field of work was included. The likelihood ratio test indicated no significant difference in the adjustments for these models (p = 0.254), resulting in no significant interaction effect. Therefore, it can be assumed that veterinarians and animal scientists shared similar perceptions as to the future expectations of the three professions in relation to cell-based meat. Figure 5 presents the probabilities fitted by the model for the respondent's perception of the positioning of veterinarians, animal scientists and bioprocess engineers in relation to the production of cell-based meat. The results indicate that expectations regarding the positioning were different depending on the professional category. In the opinion of interviewees, bioprocess engineers tend to be more positive towards the production of cell-based meat than veterinarians (OR = 7.224), and animal scientists are more likely to be unfavourable towards it (OR = 3.012) than veterinarians. Finally, animal scientists are expected to be far more unfavourable than bioprocess engineers (OR = 197.325).

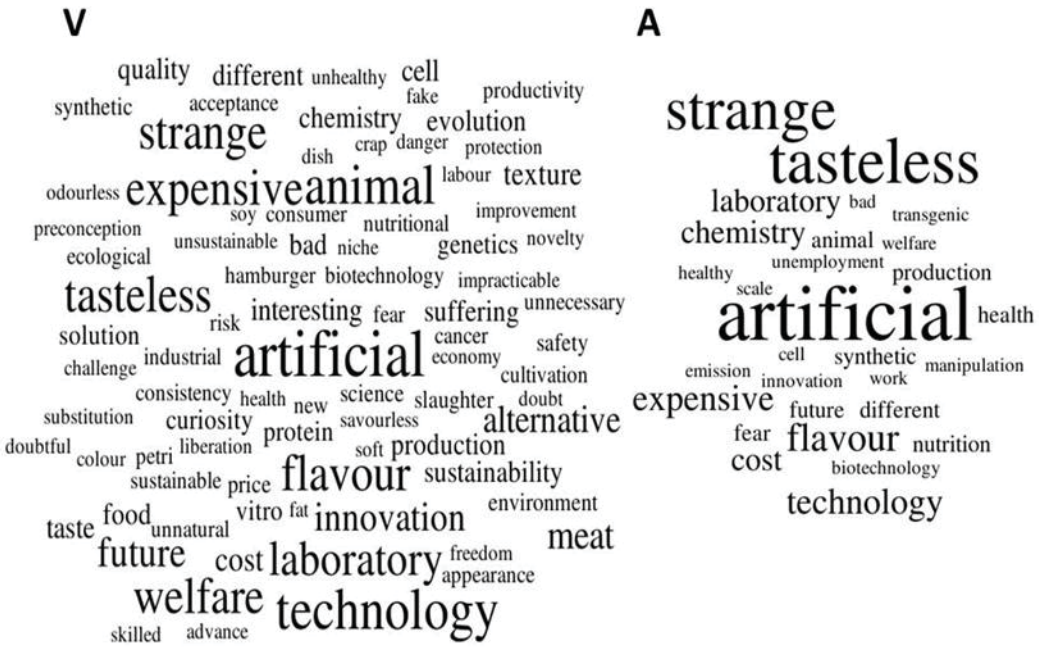
FIGURE 5 – ADJUSTED LOGIT MODEL FOR THE PERCEPTION OF THE PROBABLE POSITION THAT VETERINARIANS, ANIMAL SCIENTISTS AND BIOPROCESS ENGINEERS WILL ASSUME REGARDING THE PRODUCTION OF CELL-BASED MEAT, ACCORDING TO AN ONLINE QUESTIONNAIRE BY 209 BRAZILIAN VETERINARIANS AND 63 ANIMAL SCIENTISTS.



Regarding the DCS analysis, the three words declared by veterinarians and animal scientists were counted and combined into word clouds in Figure 6. The ten most frequent words for veterinarians (V) were artificial (4.5%; 27/605), technology (3.6%; 22/605), animal (3.5%; 21/605), tasteless (3.1%; 19/605), strange (3.1%; 19/605), flavour (3.1%; 19/605), expensive (3.0%; 18/605), welfare (3.0%; 18/605), laboratory (2.8%; 17/605) and future (2.3%; 14/605). For animal scientists (A), they were artificial (8.8%; 16/181), tasteless (7.2%; 13/181), strange (6.6%; 12/181),

flavour (3.9%; 7/181), technology (3.3%; 6/181), expensive (3.3%; 6/181), laboratory (2.8%; 5/181), chemistry (2.8%; 5/181), cost (2.8%; 5/181) and production (1.7%; 3/181).

FIGURE 6 – WORD CLOUDS COMPOSED BY WORDS WHICH APPEARED TWO OR MORE TIMES IN ANSWER TO THE QUESTION "*WHAT COMES TO YOUR MIND WHEN YOU THINK OF CELL-BASED MEAT?*", ACCORDING TO 209 BRAZILIAN VETERINARIANS (V) AND 63 ANIMAL SCIENTISTS (A) IN A QUESTIONNAIRE.



Finally, TABLE 3 presents the DCS analysis of responses regarding respondent perceptions of potential motivations for probable positioning for veterinarians, animal scientists and bioprocess engineers in relation to cell-based meat. Veterinarians, who assume the veterinary class will be unfavourable to cell-based meat, stated reasons related to field of work (25), job losses (28) and tradition (16) as main justifications. In relation to the prediction of favourable positioning, the main reasons cited were animal welfare (15) and job offers (5). Next, veterinarians previewing the unfavourable position of animal scientists mentioned field of work (35) and job losses (25). Lastly, veterinarian respondents predicted a favourable view from bioprocess engineers due to field of work (40), opportunities (22) and job offers (19). Similarly, animal scientists estimated an unfavourable position from veterinarians because of field of work (4) and job losses (3), and, regarding a favourable view, the main reason cited was animal welfare (3). Additionally, animal scientists who predicted unfavourable positioning from their own professional class

cited reasons related to the field of work (12), job losses (6) and the quality of cell-based meat (4); neutral expectations were related to the emergence of a new market (5) and animal welfare (2). Finally, this group presumed a favourable positioning from bioprocess engineers for reasons related to field of work (15) and job offers (7).

TABLE 3 – DISCOURSE OF THE COLLECTIVE SUBJECT RESULTS FOR ANSWERS ON THE PERCEPTION OF 209 BRAZILIAN VETERINARIANS (V) AND 63 ANIMAL SCIENTISTS (A) REGARDING PROBABLE POSITIONING OF VETERINARIANS, ANIMAL SCIENTISTS AND BIOPROCESS ENGINEERS (B) IN RELATION TO CELL-BASED MEAT, ACCORDING TO AN ONLINE QUESTIONNAIRE.

Respondent/ Question Target	Respondent Perception of Probable Positioning	Central Idea	Examples of Excerpts in the Original Text of Respondents	Central Ideas Frequency
V/V	Unfavourable (*n* = 65)	field of work	“Meat production systems are areas of practice of the veterinarian”	25
		job losses	“They will think this is a threat to the jobs for that class”	28
		tradition	"Many veterinarians are not opened to novelties and are reluctant to accept …"	16
		other ideas		21
	Neutral (*n* = 23)	field of work	“It depends on the field of work”	4
		more study	“It depends on more studies”	3
	Favourable (*n* = 22)	animal welfare	“More and more professionals in the area are concerned with animal welfare...”	15
		job offers	“… animal protein production is broad and not restricted only to the farm and production …”	5
		health and safety	“… rigorous quality control which increases the quantity and reduces the risks of the product”	4
		other ideas		4
V/A	Unfavourable (*n* = 65)	field of work	“They are the professionals that act mainly in animal production”	35
		job losses	“Reduction of demand for services”	25
		tradition	“Old concepts”	7
		other ideas		9
	Neutral (*n* = 12)	no changes	“It will not affect the profession”	2
		field of work	“… many professionals will be conflicted because they depend on animal production”	2
		other ideas		6
	Favourable (*n* = 8)	new area	“Opportunity for a new area of activity”	3
		animal welfare	“Aims at animal welfare”	2
		environment	“Because it is important to seek alternatives to reduce the environmental impact of agriculture”	2
		other ideas		1
V/B	Unfavourable (*n* = 5)	unfamiliarity	“It is not meat”	1
		field of work	“… these professionals also encompass the improvements to conventional meat production systems”	1
	Neutral (*n* = 1)	more studies	“We must wait for the evaluation of results”	1
	Favourable (*n* = 79)	field of work	“… will obtain the greatest benefit because this field is essential …”	40
		opportunities	“The technology tends to be more interesting for this group”	22

		job offers	“It will expand their labour market”	19
		other ideas		2
A/V	Unfavourable (*n* = 12)	field of work	“The animal production is part of the attributions of these professionals”	4
		job losses	“It will directly reach the jobs of these professionals”	3
		other ideas		5
	Neutral (*n* = 4)	field of work	“Those who work in production will be unfavourable. Who works with pets will be favourable”	2
		other ideas		2
	Favourable (*n* = 6)	animal welfare	“The slaughter of animals will decrease”	3
		other ideas		3
A/A	Unfavourable (*n* = 27)	field of work	“They will feel their profession is under threat”	12
		job losses	“Because they cannot work in the meat labs”	6
		quality of cell-based meat	“We do not have studies guaranteeing the quality of this product”	4
		benefits of conventional meat	“Because they know the importance of animal production for the functioning of societies and nature”	3
		other ideas		1
	Neutral (*n* = 5)	emergence of market	“I believe that cell-based meat will serve another group of consumers, which has been increasing considerably, not interfering with consumers of conventional meat”	5
		animal welfare	“It stimulates the consumption of meat by niches concerned with animal welfare”	2
	Favourable (*n* = 3)	technology	“After some time, the production technologies will be consolidated”	2
		job offers	“Another job opportunity”	1
A/B	Unfavourable (*n* = 3)	negative image of conventional meat	“Propagation of a product in which people will make an even more negative image of conventional meat …”	1
		competition	“… Many of these professionals are in the same job market as veterinarians and animal scientists”	1
	Neutral (*n* = 1)	field of work	“Another area of work”	1
	Favourable (*n* = 22)	field of work	“Because it will expand its area of operation”	15
		job offer	“Possibility of working in this area and new job offers”	7
		other ideas		2

2.4 DISCUSSION

Most respondents in this study were veterinarians (76.8%; 209/272), which may be related to the higher number of veterinarians throughout Brazil as compared to animal scientists. For example, in Parana, South Brazil, there are 11,422 veterinarians registered in the Regional Council of Veterinary Medicine in comparison to 666 animal scientists (36 CRMV-PR, personal communication, 29 October 2018). Additionally, there are 35 veterinary and 9 animal science programs in the State of Parana (MEC, 2020). In Brazil, both veterinary medicine and animal science graduation programs are 5-year university degrees that follow secondary school, and both programs approach traditional meat production systems as obligatory content during graduation years. The first initiative for the teaching of cell-based production systems in the country was through a course entitled “Introduction to Cellular Animal Science”, offered for the first time in August 2020, at postgraduate level, by the Veterinary Sciences Postgraduation Program at Federal University of Parana. Thus, Brazilian-graduated veterinarians and animal scientists did not receive formal education regarding cell-based meat during their university years.

The respondent invitation methodology may have resulted in more veterinarian respondents as we were welcome by official veterinary institutions and corporations, such as the National Association of Small Animal Veterinary Clinics in Parana. Other reasons, such as the level of interest in the topic of the questionnaire, may also have played a role for a higher number of veterinarian respondents. Additionally, most respondents were women (62.5%), young (22–35 years of age: 57.1%; 152/266) and recently graduated (0–10 years: 150; 55.1%). The higher number of women and young people may be related to the involvement of these groups in animal welfare and their higher willingness to try alternative proteins (DE BACKER; HUDDERS, 2015; GRAÇA; OLIVEIRA; CALHEIROS, 2015). Additionally, there are higher numbers of female veterinarians and animal scientists in Brazil (CRMV-DF, 202).

The variation observed in the answers related to alternatives to conventional meat and Brazilian investment in cell-based meat across respondents with a different frequency of meat consumption ($p = 0.021$ and $p < 0.001$, respectively) seems coherent since vegetarians and vegans are likely to explore more alternatives for animal proteins than meat consumers; therefore, they tend to associate meat with

meat analogues such as soy (HOPKINS, 2015; SLADE, 2018). Although this group might have lower interest in consuming cell-based meat (HOPKINS, 2015; RADNITZ; BEEZHOLD; DIMATTEO, 2015; SLADE, 2018; VALENTE et al., 2019), they show more support for it (WILKS; PHILLIPS, 2017), probably due to ethical issues (RADNITZ; BEEZHOLD; DIMATTEO, 2015).

Subsequently, LCA of the first group of questions produced LC 1 (79.8%, %; 217/272), with a tendency to support conventional meat, and LC 2, with a trend to support cell-based meat (20.2%; 55/272). The heterogeneity expressed by both LCs about problems in the production of cell-based meat is probably associated with unfamiliarity with the subject, as seen per the high percentage of “do not know” answers in relation to the problems of cell-based meat. Likewise, other studies with consumers reported that most people did not know (VALENTE et al., 2019) or did not have enough knowledge (MANCINI; ANTONIOLI, 2019) on cell-based meat to criticise it. It is relevant to notice that responses from LC 1 also described problems in the conventional production of meat, indicating that in general, people are aware of the negative impacts of conventional meat (GRAÇA; OLIVEIRA; CALHEIROS, 2015; SABATE; SABATÉ, 2019). On the other hand, LC 2 positive responses to the benefits of cell-based meat may be related to the direct and intrinsic implication of this new method of meat production, which reduces the number of slaughtered animals (BHAT; KUMAR; BHAT, 2015). Additionally, the greater chances of women belonging to LC 2 may be related to the sensibility of women in relation to animal welfare (RUBY; HEINE, 2011). Similarly, the lower chances of meat-eaters being in LC 2 may also be related to the lack of knowledge regarding meat substitutes, which might be related to a belief in other solutions such as reducing meat consumption or eating organic foods (LAESTADIUS; CALDWELL, 2015).

LCA for the second group of questions provided a similar pattern for proconventional meat respondents (55.5%; 151/272) in LC 1 and for respondents supporting cell-based meat (44.5%; 121/272) in LC 2. Both classes recognised the benefits of conventional meat to human health, which is likely related to the nutritional value of meat (MCNEILL; VAN ELSWYK, 2012; GODFRAY et al., 2018). Similarly, they recognised the efficiency of the conventional production of meat. In this case, the perception may be related to the role of the professions surveyed in animal production, the importance of livestock to the Brazilian economy (IBGE, 2017)

and the significant investments in research for the efficiency of the conventional systems of meat production over the last decades.

Respondents classified as LC 1 showed lower perception in relation to negative environmental and animal welfare impacts of conventional production, despite broad consensus on these issues in the literature (FAO, 2006; 2018). Although awareness of the impacts of meat consumption and production to the environment and animal welfare have been raised [49], there remain conflicts of ideas, which may also relate to incoherence between consciousness and actual changes in behaviour (POHJOLAINEN et al., 2016), such as reducing meat consumption to help the environment. Specifically, in relation to animal welfare issues, responses tend to align with the concept of the “meat paradox” (GRAÇA; OLIVEIRA; CALHEIROS, 2015; VERBEKE; SANS; VAN LOO, 2015), in which people eat meat but do not want to harm animals. On the other hand, responses in LC 2 tend to consider cell-based meat as an alternative to the environmental and animal welfare impacts, as found in previous studies with consumers (VERBEKE; SANS; VAN LOO, 2015; WILKS; PHILLIPS, 2017; MANCINI; ANTONIOLI, 2019). Moreover, the majority of respondents marked “do not know” for questions regarding health and production efficiency in relation to cell-based meat. These results were expected, given the initial stage, essentially experimental, of cell-based meat production and the challenges of escalating it (STEPHENS et al., 2018).

Regarding the demographic characteristics of respondents grouped in each LC, the same pattern as with the first LCA appeared, with women, veterinarians, vegetarians and vegans more likely to belong to LC 2; therefore, they have more positive perceptions related to cell-based meat regarding the environment and animal welfare. According to Ruby and Heine (2011), women are more engaged in animal protection and are more concerned with animal welfare and environmental issues, which make them more prone to transition to meatless diets. Likewise, De Backer and Hudders (2015) recognised the relationship between animal welfare empathy and meatless diets. Additionally, Sanchez-Sabate and Sabaté (2019) noted the willingness to reduce meat for environmental reasons in the Western population. Considering the available knowledge, it seems that respondents in LC 2 may present a higher perception of cell-based meat as an alternative to conventional meat production that is more ethical and less damaging to the environment.

As for the perception of respondents regarding the probable positioning of our target professions, both veterinarians and animal scientists believed that bioprocess engineers will be the most positive professionals for cell-based meat due to their knowledge of the field and the possibility of new jobs. On the other hand, as we hypothesised, veterinarians and animal scientists predicted that their own classes will show resistance to cell-based meat. In their opinions, these professionals may feel threatened by the loss of their work in animal production and tend to assume that they do not have opportunities in the cell-based meat industry. This pattern may reflect the resistance to change as a motivation problem rather than skill (COCH; FRENCH, 1948), as well as the mainstream education and specialisation of those professionals, which focus on well-established knowledge and concepts. This, in turn, may be a major cause for resistance in general when professionals are exposed to new discoveries (BARBER, 1961), such as biotechnology. Thus, our results suggest that the use of strategies to stimulate the specialists involved, such as communication of the need for change and group participation in planning the changes (COCH; FRENCH, 1948) and higher education in biotechnology and other subjects related to tissue engineering, may mitigate resistance in both the veterinary and animal science programs.

However, Seth Bannon, one of the investors of the cell-based startup Memphis Meats, reported in the book “Clean Meat: How growing meat without animals will revolutionize dinner and the world” (SHAPIRO, 2018) that, “traditionally, we’ve domesticated animals to harvest their cells for food or drink. Now we’re starting to domesticate cells themselves”. Therefore, similar attributions to veterinarians and animal scientists regarding animal production may prospect into cell-based production, such as cellular nutrition and genetics. In addition, Reis et al. (2020) suggested that beyond the demand for biotechnology, there is also a need for business development and management capabilities, knowledge of the food chain, product innovation and networking skills. Therefore, there is a variety of opportunities for the engagement of knowledge stemming from the traditional meat industry.

In the qualitative analysis, the word clouds showed that veterinarians and animal scientists strongly associate cell-based meat with the word “artificial”. Thus, this seems to be a critical point of resistance to this innovation. Mitigation strategies are warranted since the major consequence of negating or slowing-down the

development of cell-based meat will likely be the loss of meat market shares and increased dependence on foreign technology. The results seem coherent as the conceptualisation of cell-based meat and unnaturalness is also reported in articles focusing on consumer opinion (VERBEKE; SANS; VAN LOO, 2015; SIEGRIST; SÜTTERLIN, 2017; MANCINI; ANTONIOLI, 2019). It is noted throughout the literature that the word “artificial” is widely used to refer to cell-based meat, which is a problem since it has a negative connotation (BRYANT; BARNETT, 2019). Bryant et al. (2019) suggested that a discussion about the unnaturalness of conventional meat is the best strategy to prevent negative attitudes concerning cell-based meat and its perceived artificiality. Secondly, respondents seemed to worry about the sensory characteristics of cell-based meat, mentioning the words “tasteless” and “flavour”. Likewise, many consumer studies show respondent concerns about the flavour and appearance of cell-based meat, in how well it mimics conventional meat (HOCQUETTE et al; 2015; LAESTADIUS; CALDWELL, 2015; WILKS; PHILLIPS, 2017). Even though many startups have been working on improving the technology to reach best possible consumer acceptance, there are important challenges to be overcome, such as advancements in final product structure to provide different textures to cell-based meat [6]; in this sense, a long way ahead seems needed, considering the diversity of conventional meat products in animal species, breed, as well as the variety of cuts available. Additionally, the word “strange” seems to have a negative connotation, perhaps associated with food neophobia, i.e., the fear of new foods. Thus, Wilks et al. (2019) [61] suggest negative attitudes regarding cell-based meat because it is a novel food and not yet available for human consumption. This may be attenuated by increasing the knowledge of this new production system since we are less likely to fear what we understand (VERBEKE; SANS; VAN LOO, 2015).

The word clouds presented different characteristics when veterinarian responses were compared to animal scientist ones. First, veterinarians cited a broader range of terms, a fact that may be explained by the higher number of veterinarian respondents. However, more research is needed to better understand the views of each professional group. In addition, the words “animal” and “welfare” appeared more frequently in the veterinarian responses than in those of the animal scientists. This may be related to higher cognitive dissonance, due to the obligatory and perhaps more exclusive animal production contents studied during that course,

as similarly reported in consumer studies (GRAÇA; OLIVEIRA; CALHEIROS, 2015; LAESTADIUS; CALDWELL, 2015).

Finally, this study is highly original in that it presents the first assessment of what those directly involved in the meat production chain think about the new alternatives to conventional meat. However, it also presents important limitations, which warrant further studies. First, our objective is clearly limited, and other relevant aspects of the disruptive innovation of cell-based meat remain worth studying, such as the professional perceptions regarding environmental impacts, public health consequences, and the balance of gains and losses in terms of local jobs and economy, depending on whether a country decides to invest in this new production chain or remain resistant to it. Second, our sample size may not be representative of each professional background studied or of all regions in Brazil, which are diverse in geographical, sociological, educational, cultural and other important aspects. Thus, research that includes respondents from other regions of the country, as well as respondents from other countries, is likely to enrich knowledge by presenting new perceptions and allowing additional conclusions. In addition, the number of veterinarians we were able to engage in our survey was more than three times higher than that of animal scientists, which may have influenced our results. For example, both the number of terms in the word clouds and the number of central ideas in respondent justifications presented more variety for the veterinarian responses, which has likely been affected by the fact that there were more respondents in this category. As an additional level of complexity, respondents were mainly from the South of Brazil, where there are less animal science courses (18/129) than in other regions of the country, according to the National Register of Higher Education Courses and Institutions [57]. This shows an interaction between the differences amongst Brazilian regions and the representation of professional backgrounds. An additional limitation of our results is that they represent respondents of a predominantly young age group; the effects of such a characteristic on our data set deserve further studies, as it may significantly influence responses. Therefore, our conclusions require caution regarding their generalisation, and knowledge in this field is dependent on additional studies.

2.5 CONCLUSION

This is the first analysis of the perception of veterinarians and animal scientists regarding cell-based meat, approaching a potential bottleneck to the development of animal food production systems which may alleviate most of the animal suffering that exists in intensive industrial animal production chains. Our findings reveal the main reasons for the resistance of veterinarians and animal scientists to cell-based meat in Brazil: lack of knowledge and the perception of a connection between cell-based meat and artificiality. It seems fundamental to generate strategies of motivation and higher education for these professionals in the required capabilities of the cell-based meat chain. Additionally, increasing specific knowledge may foster their engagement in the disruptive innovation represented by cell-based meat, mitigating both the resistance and its negative impacts for the professionals and the animals.

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3 UNCOUPLING MEAT FROM ANIMAL SLAUGHTER AND ITS IMPACTS ON HUMAN-ANIMAL RELATIONSHIPS

RESUMO

O abate define o debate sobre o que é aceitável fazer para os animais em um nível extremamente baixo. Recentemente, houve um investimento considerável no desenvolvimento de carne celular, um processo alternativo de produção de carne que não requer a criação e o abate de animais, em vez de células musculares cultivadas em biorreator. Discutimos os impactos da ética animal da carne celular e vegetal nas interações humano-animal a partir do bem-estar animal e perspectivas do direito, com foco em cenários de produção de carne industrial. Nossa hipótese é que a inserção da carne celular no mercado global de carnes pode aliviar o sofrimento dos animais de produção e, potencialmente, restaurar recursos para a fauna silvestre. Empregamos uma estimativa conservadora da contribuição da carne celular para o mercado global de carne no ano de 2040 para analisar as consequências para as relações humano-animal tanto para animais selvagens quanto para animais de produção. Discutimos os possíveis efeitos de um processo de domesticação de células animais, anteriormente descrito como a segunda domesticação, nas relações human-animal. Consideramos o potencial de reduzir o impacto das mudanças demográficas humanas e do uso da terra na vida animal, em particular se haveria maior disponibilidade de biomassa e terra livre para animais selvagens. Prevemos uma grande redução no sofrimento animal devido à diminuição no número de animais individuais envolvidos na produção de alimentos, o que justifica a adoção da carne celular do ponto de vista utilitário. Para a produção animal convencional de alimentos, é necessária uma consideração mais aprofundada para entender quais sistemas, de alto ou baixo bem-estar, serão mantidos e o impacto da inovação no bem-estar médio dos animais de produção. Além disso, parece provável que haverá menos aceitação da necessidade de sofrimento animal nos sistemas de criação quando a produção de carne for desvinculada da criação e do abate de animais, apoiada em uma perspectiva deontológica da ética animal. Consequentemente, é antecipada a mitigação de barreiras relevantes à proteção animal e ao reconhecimento dos animais como sujeitos pela legislação. Assim, o desenvolvimento das carnes alternativas pode estar relacionado a uma mudança significativa em nossa relação com os animais não humanos, com benefícios maiores do que os efeitos *prima facie* nos animais de fazenda.

Palavras-chave: 1. Carne celular 2. Proteção animal 3. Relação humano-animal 4. Segunda domesticação 5. Sofrimento animal

ABSTRACT

Slaughter sets the debate about what is acceptable to do to animals at an extremely low bar. Recently, there has been considerable investment in developing cell-based meat, an alternative meat production process that does not require the raising and slaughtering of animals, instead using muscle cells cultivated in a bioreactor. We discuss the animal ethics impacts of cell-based and plant-based meat on human-animal interactions from animal welfare and rights perspectives, focusing on industrial meat production scenarios. Our hypothesis is that the insertion of cell-based meat in the global meat market may alleviate farm animal suffering and potentially restore resources for wild fauna. We employed a conservative estimation of the cell-based meat contribution to the global meat market in the year 2040 to analyze the consequences for human-animal relationships for both wild animals and farmed domesticated animals. We discuss possible effects of an animal cell domestication process, previously described as the second domestication, on human-animal relationships. We consider its potential to reduce the impact of human demographic changes and land use on animal life, in particular whether there would be increased biomass availability and free land for wild animals. We anticipate a major reduction in animal suffering due to the decrease in the number of individual animals involved in food production, which justifies the adoption of cell-based meat from a utilitarian perspective. For the conventional animal food production that remains, further consideration is needed to understand which systems, either high or low welfare, will be retained and the impact of the innovation on the average farm animal welfare. Additionally, it seems likely that there will be less acceptance of the necessity of animal suffering in farming systems when meat production is uncoupled from animal raising and slaughter, supported by a deontological perspective of animal ethics. Consequent to this is anticipated the mitigation of relevant barriers to animal protection and to the recognition of animals as subjects by legislation. Thus, the development of the alternative meats may be related to a significant change in our relationship with non-human animals, with greater benefits than the prima facie effects on farm animals.

Keywords: 1. Animal protection 2. Animal suffering 3. Cell-based meat 4. Second domestication 5. Human-animal relationship

3.1 INTRODUCTION

Ever since humans first domesticated animals for the production of food our manipulation of animals for the process has been expanding in scope. Darwin (1861) recognized our growing intervention in animal form and function in his Origin of Species: “Man selects only for his own good”, living as he did in an era and a country in which selective breeding was becoming widely used in agriculture. The next major event in selective breeding came with artificial insemination, allowing so-called superior males to fertilize millions of females; then, embryo transfer, allowing so-called superior female genes to be propagated more widely than through natural births; and, finally, or so we thought, cloning, perfecting the opportunity to perpetuate or even immortalize the genes of just one superior individual. However, over the last few decades a technique for bypassing the animal altogether to produce meat has been in development, by growing muscle cells in vitro, which brings a different set of ethical questions and stances.

The main prompt for the development of these more efficient ways of producing meat is that the human population is expected to grow to 9.1 billion by the year 2050; which coupled with increased affluence that supports greater expenditure on food, requires annual meat production to raise substantially to 470 million tones (FAO, 2012). The need to alleviate food shortages and poverty suggests further intensification of animal production systems (FAO, 2018a), which is often associated with poor animal welfare (BESSEI, 2006; STAFFORD; GREGORY, 2008; GRANDIN, 2018). However, even with the development of incremental technologies for the intensification of production, the necessary gain in future meat production from agriculture may not be achieved (FAO, 2012). In addition, 48 authors from relevant institutions at national and international levels have signed the statement that ‘future technologies and systemic innovation are critical for the profound transformation the food system needs’ (HERRERO et al., 2020). Therefore, disruption of the conventional meat systems seems fundamental. Responses to this situation are under full consideration, as recently there have been much effort and investment in developing animal cell-based and plant-based meat alternatives. Both may potentially uncouple meat from slaughter, although each one faces important challenges, as for example the fact that plant-based alternatives are not exactly meat

and cell-based options are not yet fully free of animal-derived ingredients. However, technology advances may bring the attributes of plant-based substitutes closer to those of conventional meat, as well as solutions for animal-free cell growth media.

Beyond the animal ethics benefits, additional advantages of replacing conventional meat for slaughter-free alternatives are straightforward: gains in environmental aspects, food security, public health and food safety stand as the most clear-cut benefits, out of a long list of possible advantages (GASTERATOS, 2019). Both plant-based and cell-based meat substitutes require less resource input per kilogram of product, as can be inferred from the impressive gains in carrying capacity, i.e. the number of people that could be fed from an agricultural land base, with changes from omnivorous diets to vegetarian or vegan diets (PETERS et al., 2016) and from comparative estimates on cell-based meat production environmental resource use (TUOMISTO; TEIXEIRA DE MATTOS, 2011; RÖÖS et al., 2017). The overall environmental gains of diminishing conventional meat are also evident as the negative effects of the lowest-impact animal products typically exceed those of vegetable substitutes (POORE; NEMECEK, 2018). In addition, the production of cell-based meat in closed bioreactors is expected to be sturdier in terms of climate, as compared to conventional meat, improving food security, which accordingly is one of the drivers for its development (WARNER, 2019). The closed bioreactor environments may also contribute to a reduction in antibiotic use during meat production processes which is a significant problem in conventional meat production due to the development of antibiotic resistance (AIRES-DE-SOUSA, 2017). In relation to nutrition security, an important consideration is that meat is a protein source of the highest biological value, second only to egg and milk proteins (HOFFMAN; FALVO, 2004), while plant-based substitutes requires more research and efforts to approach conventional meat amino acid value as human food. Cell-based meat offers additional advantages in comparison to conventional meat, as its proteins are coded by animal cell DNA, which tends to maintain conventional meat amino acid profile, and its final overall composition may be customized in a tailored way, such as low cholesterol risk by using mostly poly and monounsaturated fatty acids, for example. Finally, both meat alternatives offer virtually zero risk of zoonotic diseases, as pathogens are intrinsically absent in the production process. Thus, innovative meat products tend to significantly reduce human suffering and financial

costs associated to both prevention and treatment actions required by the conventional meat chain regarding bacterial diseases such as those caused by Salmonella, Escherichia coli O157:H7, methicillin resistant Staphylococcus aureus (MRSA) and bovine tuberculosis. In addition, dangerous virus mutations such as the new subtypes H5N1 and H7N9 of Type A Influenza virus, popularly known as bird flu, the subtype H1N1, known as swine flu, and the recent SARS-CoV-2, the coronavirus causing Covid-19, would be impossible with the consumption of alternative meats. This is a major benefit as these diseases are causing major human mortality and current control measures are seriously disrupting human society.

Unlike the classic plant-based substitutes for meat, which used whole vegetable ingredients such as peas and other beans, many of the new plant-based meat analogues are structurally similar to meat (JOSHI; KUMAR, 2015), as they are molecularly constructed. Even though they differ in composition, these substitutes preserve certain properties and sensory attributes of meat, such as texture and flavor (DEKKERS et al., 2018). The process of formulating these products includes a comprehensive molecular analysis of plant proteins in search of compounds that simulate animal meat (LAGALLY et al., 2017). Another emerging technology is the use of genetically modified bacteria and yeasts to generate organic molecules for the production of gelatin, collagen, milk, egg white, etc. through fermentation (STEPHENS et al., 2018). To produce cell-based meat, the same fundaments of tissue engineering technology that have been perfected in the last few decades are used, including the proliferation and differentiation of specific stem cells for each tissue required to match meat compounds, such as muscle and fat (DATAR; BETTI, 2010; POST, 2012; BEN-ARYE; LEVENBERG, 2019; ZHANG et al., 2020). Thus, the resultant meat is potentially the same as that from farm animals, but made through a slaughter-free process. Start-up companies working with cell-based technology may be considered disruptive as they use different and potentially fewer resources to develop an improved method of producing meat, which in turn may potentially transform the food chain. Thus, a new set of capabilities beyond the evident biotechnological knowledge required will characterize the cell-based meat global value chain (REIS et al., 2020). Furthermore, cell-based meat may change historical concepts, perceptions and practices in the context of human-animal relationships. The domestication of animals as sources of food over the last ten thousand years

has changed human society and the role animals play in it. Recently, with the beginning of cell-based technology, a new domain is possible: the domestication of cells rather than animals (SHAPIRO, 2018; TUBB; SEBA, 2019). Similar to the events of the first domestication, cells rather than animals may in future be genetically selected, raised and fed an optimal diet.

The development of cell-based meat and other cellular agriculture techniques may therefore be considered ‘disruptive innovations’, i.e. likely to remodel the different sectors of the industry or services (CHRISTENSEN et al., 2015). These technologies also encompass the three attributes that define radical innovations (DAHLIN; BEHRENS, 2005): uniqueness, novelty, and likely to influence future innovations. They employ unique and novel processes for producing meat, i.e. processes which are different from previous and current ones, and may redefine the future technology used in the meat and agribusiness chains as a whole. In relation to animal products, a disruption may be dependent on whether consumers have attitudes that lead them to search for aspects beyond quality and price to include ethical aspects, regarding animal welfare and the environmental impact of meat, for example (GODDARD et al., 2019). This occurs mostly in the early stages of the disruption, since in the medium-term product quality likely improves and acceptance tends to increase, especially if prices decline, which will almost certainly occur as new technologies are developed. If such a disruption to our food chain eventuates, a change in human-animal relationships is likely to occur, as for the first-time it will be possible to challenge the concept of necessary animal suffering and killing without compromising meat consumption. Pressure from the animal production industry has been limiting farm animal protection laws (SCHWARTZ, 2020), which commonly prohibit only unnecessary suffering in farm animals. This is designed to shield harmful practices in animal production systems from inclusion in the list of crimes against animals, or even more deeply, from the very recognition of farm animal suffering and abuse. Most of all, the acceptance of the slaughtering of animals for food sets any debate about what is acceptable to do to animals at an extremely low bar. Many forms of animal abuse that are associated with legitimate goals, such as scientific experimentation and food production, are sustained by institutions with important social credibility. Therefore, it seems that society will allow certain contexts

of animal cruelty without question (FLYNN, 2012), because a genuine benefit from the practices is perceived.

Accordingly, cruelty to animals is often legally focused on the avoidance of unnecessary suffering (RADFORD, 2001), which is defined as avoidable and purposefully caused. This is considered to infringe moral principles (HURNIK; LEHMAN, 1982). In addition, there are many different interpretations of animal suffering, depending on the country, culture and animal species in question (LUNDMARK et al., 2014), including which animal species are considered edible (HERZOG; FOSTER, 2010; JOY, 2011). Although farm procedures causing pain and distress imply suffering, most policymakers interpret them as necessary, e.g. beak trimming of turkeys and laying hens, castration of piglets (LUNDMARK et al., 2014), as they prevent behavior problems in high density stocking and consequently economic losses. Thus, legislation regarding animal suffering is contradictory due to the inconsistency in policymaker conclusions (LUNDMARK et al., 2018). This is one example of ways through which traditional meat production axioms tend to naturalize or even to extol animal suffering and killing; this normalization process may generalize and is likely not restricted to those animals used in food production activities. However, animal ethics is gaining unprecedented recognition in current western societies. The dilemma about how we use animals, and if we ‘use’ them at all has become a major ontological, epistemological, moral and political force, and it may be that a profound anthropological shift is underway (BURGAT, 2015). It is our view that a basic hindrance for this anthropological shift is the persistent motivation to eat meat. Thus, the development of a system that makes meat production possible without animal suffering is likely to cause profound changes in the human-animal relationship.

In this paper, we discuss the ethical impacts of alternatives to conventional meat on human-animal interactions from an animal point of view, focusing on industrial meat production scenarios. Our hypothesis was that the insertion of plant-based and cell-based meat in the global meat market may alleviate farm animal suffering and partly restore habitat for wild native fauna, in addition to creating new possibilities for animal ethics and protection, as it relieves the need to accommodate the necessary animal suffering and killing that accompany modern animal production practices.

3.2 MATERIALS AND METHODS

3.2.1 Scenario forecasting

The evidences suggest that alternative meat production methods will become a reality, leaving little room to speculate whether they will hold an important position in the food industry, rather only questions regarding time frame. The market share of plant-based meat substitutes has consistently increased since it was launched, with data from the United States showing that retail sales of plant-based foods grew 11.4 percent in 2019, within a context of overall food retail growth of 2.2% (PBFA, 2020), and more recently the Covid pandemic outbreak resulted in a further increase in sales of plant-based meat substitutes, likely caused by perceived high product safety regarding zoonotic diseases and the many difficulties related to Covid outbreaks within slaughterhouses. Regarding cell-based meat, even though it is not yet on the market, the increasing number of start-ups with robust and increasing investments dedicated to its development constitutes a sign of accelerated development. In the United States, the Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) have recently engaged in conversations regarding cell-based meat labeling and regulation, essentially to align on a joint regulatory framework between the two agencies (CONGRESSIONAL RESEARCH SERVICE, 2018; USDA, 2019a). In Europe, newly developed foods, such as cultivated meat, are regulated under the Novel Food Regulation supported by the European Food Safety Agency (EFSA), with labelling regulations from Food Information to Consumers (FIC) (FROGGATT; WELLESLEY, 2019).

These movements by such institutions seem powerful indications of the relevance of this new industry. However, there are uncertainties as to the exact proportions of total meat market to be substituted, which are challenging for scenario forecasting. For instance, although recent research has shown that cell and plant-based meat substitutes may be accepted or at least tried by consumers in a diversity of countries like Brazil, Germany, Italy, India, China and the USA (VALENTE et al., 2019; WEINRICH, STRACK; NAUGEBAUER, 2020; MANCINI; ANTONIOLI, 2019; BRYANT et al., 2019), some of those products do not exist so far (e.g., cell-based meat products) and more nuanced insights into the cultural and social barriers for

introducing food innovation are still needed (HERRERO et al., 2020), as they can challenge an exclusively technical understanding of dietary changes (NOACK; POUW, 2015). Thus, even though the need for a profound transformation of the food systems is recognized (HERRERO et al., 2020), projections must be cautiously interpreted.

In line with the prevailing uncertainties, we employed a conservative estimation, one that is both cautious and moderate, of the cell-based meat contribution to the global meat market in the year 2040, to analyze its potential consequences for animal welfare and the human-animal relationship. As a recent scientific development, cell-based meat projections are scant in scientific literature; thus, our discussion is based on the prospective agribusiness disruption in global industry and economy for 2020 to 2030 and 2040 presented in reports by Tubb and Seba (2019), an independent team of technology, finance and market experts; and the global consultancy group AT Kearney (GERHARDT et al., 2019), the only available documents with such projections. Due to the limitations in knowledge, at this point a major emphasis on scale rather than absolute numbers seems warranted, thus reducing expectations of precision and error risks. Knowledge is limited and is curbing cell-based meat development, in terms of intrinsic factors such as animal-free culture medium ingredients, scaling-up challenges and final product characteristics. A variety of extrinsic factors may additionally affect the development rate of meat substitutes and are difficult to predict. Examples of external relevant factors are climate change, water shortages, outbreaks of food-borne diseases, as well as the geographical distribution of these putative events, which may differently stress either a faster or a slower development for each plant and cell-based meat alternatives. Furthermore, we highlight again that as potential consumers worldwide have socially engrained relationships to food (HERRERO et al., 2020), expressed as established local habits and traditions, the acceptance of meat substitutes may not be straight forward. Considering all the complexities, however, it seems clear that a major disruptive change is on the horizon, which warrants forecasting efforts from a variety of perspectives. We are specifically interested in understanding how it will change human-animal interactions. For this, a preliminary scenario assumption in terms of the magnitude of the changes is required.

Tubb and Seba (2019) used data from the United States to calculate frameworks and information from The Good Food Institute, a non-governmental organization that supports cell-based studies, to reference their analysis of cell-based products. The report is focused on cattle; however, it includes some information on other food animal production systems, as well as information on clothing and cosmetics. It suggests that the ability of cell-based products to transpose the conventional systems is high, starting with ground meat and reaching afterwards into the integral muscle tissue markets, such as steaks. Precision fermentation of genetic modified micro-organisms may also be utilized to produce specific proteins needed for culture media and to provide animal products other than meat, as milk and eggs. It is estimated that in the year 2030, 30% of the conventional beef in the U.S. will be substituted by cell-based meat, and the cost will be substantially less than that of conventional meat. Independently, Gerhardt et al. (2019) combined opinions from experts in the global agriculture, food and meat industry to conceptualize what alternative sources of meat may be in use in the year 2040. They estimated that cell-based meat will represent 35% of the global meat chain in 2040 and plant-based meat another 25%. Thus, conventional meat may be reduced to 40% of total meat production by the year 2040.

For this paper, we used the Gerhardt et al.'s statistics due to the report's worldwide analysis and more conservative perspective in terms of both percentages and timeframe, comparing its 2040 scenario to the 2030 one considered in the Tubb and Seba (2019). Subsequently, we applied the expected reduction of 60% in traditional animal production for 2040, including 35% cell-based and 25% plant-based meat replacement (GERHARDT et al., 2019), to study the direct impact on number of animals involved and biomass distribution across terrestrial vertebrate animals. Our analyses considered the major production chains involving cattle, pigs and chickens. The 60% was chosen as the most conservative prediction from an extremely limited choice between two publications and, as such, its interpretation is subject to the background consideration of the aforementioned relevant intrinsic and extrinsic factors at play. More extreme percentage substitutions of conventional meat may be considered, as potential lower and upper limits. If technological challenges for cell-based meat development prove too challenging, the respective 35% predicted market share will not be achieved within the considered time frame, which would

leave the overall substitution by 2040 at around the 25% predicted for plant-based alternatives, assuming that there would not be a compensatory emphasis on plant-based developments. Another powerful restrictive condition is the launching of cell-based meat as an animal friendly product before the complete substitution of animal-derived ingredients in the cell culture media. If this occurs without due transparency to consumers, the consequences could include a strong backlash, with the attachment of a strong negative image to any future cell-based meat product. At the other extreme, much higher percentage substitutions may be achieved if technological breakthroughs present themselves before 2040 and if stricter animal protection laws come into effect as a consequence. Some restrictions to harmful animal use when alternatives exist are currently in place in many countries in other contexts, such as the use of animals in science. The same rationale may be put in place considering the raising and killing of animals to produce meat, which would lead to levels of substitution closer to 100%, aided by legal restrictions on animal use which are unlikely to be enacted simultaneously in different countries.

3.2.2 Direct impacts of alternative meats on the environment and vertebrate terrestrial animal biomass distribution

We considered the impacts of the replacement of conventional meat sources with 35% of cell-based and 25% of plant-based meat by the year 2040 on the environment, addressing land, water and energy use, as well as for the vertebrate terrestrial animal biomass. Then we studied biomass impact, considering that biomass is the metric used to quantify carbon usage by different organisms. Based on the estimation of biomass distribution by Bar-On et al. (2018), which measures biomass in gigatons of carbon (1Gt C = 10^{15} g of carbon), we applied the estimated 60% (35% and 25%) reduction of livestock biomass by 2040 (GERHARDT et al., 2019), to estimate the potential biomass release.

3.2.3 Direct impact of meat alternatives on farm animal welfare

The estimation of the reduction in the number of individual farm animals as a consequence of the introduction of 35% of cell-based and 25% of plant-based meat

was based on the predicted global beef, pork and chicken meat production for the year 2040, and the current number of cattle, pigs and chickens. Even though the highest number of individual vertebrate animals involved in food production is that of fish species, which supports the need for urgent action regarding their welfare, data on an individual animal basis is very difficult to estimate, and they were not included in this exercise. Fish are consumed in part because the meat is believed to confer health benefits, and as such the opportunities to value add by improving the health giving credentials of the meat are considered to be less than for terrestrial animals, and therefore less likely to be a target for replacement.

First, we calculated the production for these chains using values from the years 2017, 2019 and 2020 (TABLE 4), which we considered represented current production. Then, we calculated the average of the published prospective world meat production for the years of 2027, 2030 and 2050, to estimate animal meat production for the year 2040 (TABLE 4). In this exercise, the potential dynamics of the interplay amongst the three terrestrial meat production chains across the next decade, namely cattle, pigs and chickens, were considered stable, to reduce complexity in the calculations, even though some change in proportions may occur, as chicken meat production is growing at a faster rate than cattle and pig production. However, we assumed that this dynamic character may not sufficiently change numbers to invalidate our conclusions.

TABLE 4 – MEAT PRODUCTION ESTIMATION, IN MILLION TONES, FOR BEEF, PORK AND CHICKEN

Production chain	**Data source**			**Average**
	FAO	**OECD**	**USDA**	
	70.8 (2017)[1]	72.7 (2019)[2]	61.9 (2020)[3]	68.5
Pork	118.7 (2017)[1]	121.8 (2019)[2]	95.2 (2020)[3]	111.9
	120.5 (2017)[1]	125.3 (2019)[2]	103.5 (2020)[3]	116.4
Total	376.0 (2030)[4] 470.0 (2050)[5]	367.0 (2027)[2]	-	404.3 (2040)[6]

[1]FAO, 2018b; [2]OECD, 2018b; [3]USDA, 2019b; [4]FAO, 2003; [5]FAO, 2012; [6]Our estimation.

Afterwards, we calculated the average stock number for each species using published data from 2017 and 2019 (TABLE 5). Two of the references cited did not present the quantity of pigs (FAO, 2019) and chickens (USDA, 2019b); therefore, we left this data out of the calculation. Also, for cattle, most of the references present data from both the beef and dairy industries; hence, we selected the data from USDA (2019b) which only referred to beef cattle. Later, we calculated the percentage production growth from 2020 to 2040 and applied this number to each previous animal individual population. Finally, we calculated the reduction of individuals in each animal species for the future, following the estimation of 60% by Gerhardt et al. (2019) (TABLE 5).

TABLE 5 – ESTIMATION OF NUMBER OF INDIVIDUAL ANIMALS, IN BILLIONS, BASED ON CATTLE, PIG AND CHICKEN STOCK NUMBER PUBLISHED IN FOUR SOURCES IN 2017-2019, AND IN 2027-2050, AFTER MULTIPLYING BY THE PERCENTAGE INCREASE IN PRODUCTION GROWTH CALCULATED FROM TOTAL ANNUAL MEAT PRODUCTION PER SPECIES AS PER TABLE 4. PRODUCTION LEVELS AFTER APPLYING THE ANTICIPATED REDUCTION OF GERHARDT ET AL (2019) ARE ALSO PROVIDED.

Source		**Animal species**		
		Cattle	**Pigs**	**Chickens**
FAOSTAT	2017	-	1.41	27.82
STATISTA	2017	-	0.78	22.85
FAO, 2019	2017	-	-	18.30
USDA, 2019	2019	0.99	0.77	-
Calculated average	2020	0.99	0.98	22.99
Forecast based on estimation for 2040[1]	2040	1.34	1.34	31.32
Forecast based on 60% substitution by meat alternatives[2]	2040	0.54	0.54	12.53

[1]As calculated by (404.3 x 100)/296.8 (see Table 1) and weighed for the proportion of each animal species; [2]Gerhardt et al., 2019.

The decrease in the number of individual animals involved in meat production was considered a straightforward gain in animal welfare and in animal ethics. The animal welfare gains refer to the reduction of total animal suffering, composed of the summation of individual afflictions, as animals involved in intensive production systems suffer from severe space and consequent behavioral restrictions, health problems resultant from artificial selection for production traits, and submission to painful procedures and stressful management events, such as transport and

slaughter (HARRISON, 1964; WEBSTER, 2005; BROOM; FRASER, 2015). Gains in animal ethics include all the welfare gains in addition to the proportional absence of breaches in animal integrity and dignity, which are inherent to the killing of each sentient individual. In other words, the killing of animals is an important moral issue because of the suffering involved (VIŠAK; GARNER, 2016).

Finally, we envisioned three possibilities for the individual animals that will remain involved in production in 2040: (A) the welfare and number of farm animals if conventional meat production were to remain the sole system in 2040, (B) the average welfare and number of the remaining farm animals if conventional meat were to compete with cell and plant-based meats for low-priced products; and (C) the average welfare and number of the remaining production animals if conventional meat were to compete with cell and plant-based meats for high-priced products. Scenario A is fictitious and presented only for comparison, as in 2020 plant-based alternatives to meat products can already be purchased in many supermarkets, as well as restaurants, including major fast-food chains such as A&W, Burger King, Kentucky Fried Chicken and Subway.

3.2.4 Indirect impacts of alternative meats on the human-animal relationship

The impact of increasing markets for cell-based and plant-based meat on the human-animal relationship was analyzed using two complementary rationales. The first is related to a reduction in the negative impact of conventional meat production on global animal welfare, particularly in intensive raising conditions and during slaughter, which is avoided every time conventional meat is replaced by an alternative product. The second rationale is that, due to the extinction of the meat paradox, there may be fewer people who are desensitized towards animal suffering. The meat paradox is defined by Loughnan et al., (2014) as the simultaneous emotion related to the fact that people tend to dislike hurting animals and, at the same time, to like eating meat.

3.3 RESULTS AND DISCUSSION

According to our analysis of the reduction in the number of animals used in production for the year 2040, we discuss the impacts of alternative meats on the environment and biomass distribution, on farm animal welfare and on the human-animal relationship.

3.3.1 Environmental and vertebrate animal biomass consequences

Livestock production uses extensive areas of land and is responsible for the occupancy of 26% of the terrestrial land, as well as 33% of the total arable land, which is dedicated to crop production for animal feeding (STEINFELD et al., 2006). The expansion of grazing areas and crop planting to feed farm animals has been related to deforesting important ecosystems. For instance, 70% of the deforested area of the Amazon forest is occupied by pastures for grazing animals (STEINFELD et al., 2006). This decreases resources for wildlife (STEINFELD et al., 2006; TUOMISTO; TEIXEIRA DE MATTOS, 2011). According to studies of prospective high-volume cell-based meat production (TUOMISTO; TEIXEIRA DE MATTOS, 2011; MATTICK et al., 2015), large amounts of land, up to 99% of that currently used, will be freed (TUOMISTO; TEIXEIRA DE MATTOS, 2011). The new system of producing meat will surpass the efficiency of land use even when compared to the intensive meat production involving pigs and chickens (MATTICK, 2018). Since cell-based meat production will be conducted in bioreactors, it is likely that there will be major transformations in the industrial production landscapes, which are calculated to be much less dependent on land use. Therefore, some land space will be freed and this may return to wildlife or be used for further expansion of the human population, or both. The latter seems unlikely as land availability does not appear to be a constraining factor on human population growth, with most growth occurring in the urban population (FAO, 1999).

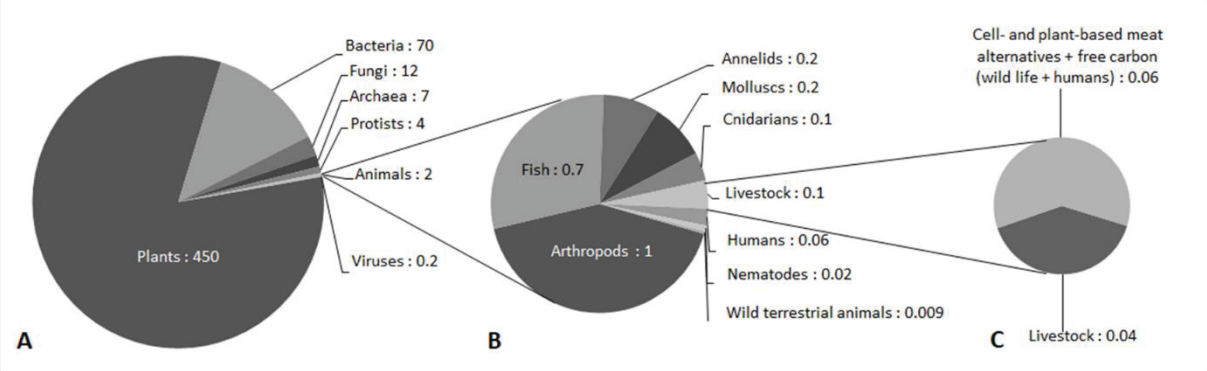
Regarding water consumption, agriculture accounts for 92% of the human fresh water footprint and almost one third of this relates to animal production (GERBENS-LEENES et al., 2013). Additionally, considering the continuous expansion of the livestock population for animal-derived products, any intensification

of production may increase water use due to a greater dependence on concentrate feed (MEKONNEN; HOEKSTRA, 2010). Tuomisto and Teixeira de Mattos (2011) estimated that there would be a reduction of 82-96% in water consumption for each kg of meat produced, comparing cell-based and conventional animal meat production systems. As with all estimations regarding cell-based meat, this number is dependent on assumptions which are not yet all clear; however, the scale makes the estimations relevant, for both land and water use. Even if we consider some inaccuracy in the estimations, a major reduction seems probable. At the same time as land and water use are likely to considerably decline, energy inputs may increase for cell-based meat production due to the greater demand for electricity by laboratories in all phases of the cultured meat production process (TUOMISTO et al., 2014; MATTICK et al., 2015). Hence, improvements in the efficiency of energy use, such as developing clean and renewable alternative sources of energy, will remain an important requirement. As an overall effect of the reduction in the number of individual animals used for meat production, some of the released natural resources will be needed for biomass production for energy generation.

The biomass of carbon in livestock, concentrated in cattle and pigs, is much higher than that in wild mammals: approximately 0.1 Gt C, compared with 0.007 Gt C (BAR-ON et al., 2018). That in domestic poultry, mostly chickens, is in turn greater than that in wild birds: 0.005 and 0.002 Gt C, respectively (BAR-ON et al., 2018). Our assumption is that the reduction of 60% in the number of farm animals when cell-based meats and plant-based alternatives are developed may release 0.06 Gt of carbon biomass (FIGURE 7); this surplus is related to the increase in efficiency characteristic of the alternative forms of meat production. Additional studies describing the biomass requirement for alternative meats are required, since they may give a more precise idea of the carbon amount which may be liberated and thus available for either animal wildlife or expansion of the human population, or both. However, from the figures presented here, it is apparent that today's biomass available for wild terrestrial animals, at around 0.009 Gt C, would be greatly augmented by the reduction in the number of farm animals, which may release 0.06 Gt C by 2040. In other words, the amount of carbon released due to the reduction in the number of farm animals is 6.7 times the amount of carbon currently available for all wild terrestrial animals. Even considering that part of this freed carbon will be

sequestered in the form of cell-based and plant-based meat; the possibilities for partially restoring wildlife biomass seem encouraging.

FIGURE 7 – BIOMASS DISTRIBUTION FOR KINGDOMS (A), ANIMAL GROUPS (B), AS PER BAR-ON ET AL. (2018) AND THE ANALYSIS OF THE IMPACT OF A 60% REDUCTION IN SLAUGHTER-BASED MEAT PRODUCTION (C) (GERHARDT ET AL., 2019) ON THE AVAILABILITY OF BIOMASS (1 GT OF CARBON = 1GT C = 1015 G OF CARBON).



3.3.2 Impact on animal ethics and welfare

Animal ethics is the branch of ethics that relates to human-animal relationships and how human ought to treat other animals. Conversely, animal welfare is based on empirical science, informing humans of the quality of an animal's life, based on the extent of good and bad experiences that the animal is having, has had, or is expected to have (PHILLIPS; KLUSS, 2018). By definition, it is the state of an individual regarding its attempts to cope with its environment (BROOM, 2011), and it is measurable by considering animal's physiology and behavior. Animal cells, extracted from livestock for the purpose of generating cell-based meat, cannot be said to have rights, in the same way as animals, because such rights are based on animals' interests (BEAUCHAMP, 2011). However, the cells may be said to have their own needs, which give them maximum advantage. Animal rights protagonists may further argue that if animals have the right not to have their bodies or parts of their bodies used in biomedical research, because it challenges their body integrity, they may also have the right not to have their muscle cells extracted for cell-based meat production. However, from the perspective of the continuum of attitudes towards animal rights advocated by Beauchamp (2011), such views represent an attitude founded at the extreme end of the animal rights continuum, particularly if there are utilitarian benefits to the species or specific animals involved. Beauchamp

(2011) suggests that rights only merit protection if the benefits accrue to the individual animals themselves, not the species, hence the impact on the animal from whom the cells are extracted merits detailed consideration. In addition to extracted cells, fetal bovine serum is currently used to grow cell-based meat (CHAUVET, 2018). This serum is an excellent source of nutrients and cell-growth factors, and it is collected from fetuses at abattoirs. During slaughter of the cow, the fetal heart is punctured to extract blood, and there is concern that the fetuses may still be alive during the process, which may even be considered an advantage by some because it is possible to extract more blood if the heart is still beating (PHILLIPS, 2018); the blood thus collected is then processed for fetal serum production. Fortunately, it is realistic to expect a non-animal replacement for the fetal bovine serum in the near future (CHAUVET, 2018). Fetal serum substitution is currently under development by adapting cells to chemically defined media, which are fully independent of animal-derived ingredients (MARIGLIANI et al, 2019a). Fetal bovine serum is not the only animal ingredient used in cell culturing; a systematic review of 156 articles featuring 83 different cell culture methods identified the use of several animal-derived products from different species (MARIGLIANI et al, 2019b). A major advancement in this issue came with the publication of the new Organisation for Economic Co-operation and Development Guidance Document on Good In Vitro Method Practices (OECD, 2018a), discouraging the use of serum and presenting a list of serum-free media alternatives, including an animal-product-free media description. The challenges of offering meat that is really cruelty free and that is also perceived to be so may likely be overcome by implementing technology for the use of culture media that is completely free of animal ingredients and by adopting strict transparency so not to risk a breakdown in consumer confidence.

A fundamental objection to the use of animal cells for the production of cell-based meat is that it promotes the concept that animals are a legitimate source of food, a view challenged by many animal rightists. Human cells could equally well be used to produce cell-based meat; however, they would be accepted by few consumers (WILKS; PHILLIPS, 2017). Many surveys worldwide have demonstrated that most people would accept the use of animal cells in cell-based meat and would at least try the product (e.g. in the US, WILKS; PHILLIPS, 2017; in Brazil, VALENTE et al., 2019). The biggest impediments to its more permanent adoption are likely to

be food neophobia, political conservatism and a distrust of scientists (WILKS et al., 2019). A related concern, levied against the use of genetically modified animals, is that humans are ‘playing God and against Nature’ (SAVULESCU, 2011). The concern derives both from a perceived attempt by humans to usurp the role of a higher being and also an overestimation of our ability to manage complex biological systems. The latter is related to people’s distrust of scientists, when it comes to their ability to create new food sources safely (WILKS et al., 2019). A further concern is the slippery slope argument (SAVULESCU, 2011), that assumes that innovations such as cell-based meat will ultimately lead to more damaging innovations that will seriously degrade human society, for example creating cell-based meat based on humans. This concern may be challenged by the idea that each step in our manipulation of life on earth is checked in terms of its benefits for society as a whole. Without central control by government, human life would be ‘poor, nasty, brutish, and short’ (HOBBES, 1651). However faulty this system may be, it is undeniable that human intervention has improved human life quality and quantity throughout many centuries. It is possible and urgent that human intervention care for other sentient beings and for the environment in a more solid and straightforward manner.

Another concern is the detrimental impact that cell-based meat may have on existing livestock numbers worldwide. It has been assumed that cell-based meat would compete with high value meats, not industrially produced low quality meat (COLE; MORGAN, 2013). However, other possibilities must also be considered. In FIGURE 8, the number of individual animals involved in each of the three most relevant global meat chains is presented and the scenarios B and C posit quite different responses of the animal production industries to the insertion of the alternatives to traditional meat in the global market. The validity of this ethical objection depends not so much on which scenario is correct, rather on the answer to the question of whether farm animals’ lives are worth living at all. The ‘life worth living’ concept, which emerged from considerations of the quality of human lives (YEATES, 2017), has been developing from a motivational framework, in which it appeared in its infancy (WEBSTER, 2016), to a more robust concept that can be used to measure, or at least estimate, animals’ quality of life (MELLOR, 2016). If cell-based meat does compete with high-end meat products, appealing to the ethical consumer, these are likely to be derived from livestock with the best welfare, even

considering the limited range of welfare for most farm animals. However, the market for inexpensive, mass produced meat has been growing at the expense of the quality product, and this market may well be one target of cell-based meat manufacturers, given that production costs are expected to decrease and to reach cost parity with conventional meat products in the next five to ten years (TUBB; SEBA, 2019). This mass-produced meat originates from intensive production systems, where it is debatable whether animal lives are worth living. Furthermore, diminishing the use of agricultural land for animal production will free up land where wildlife may be allowed to flourish.

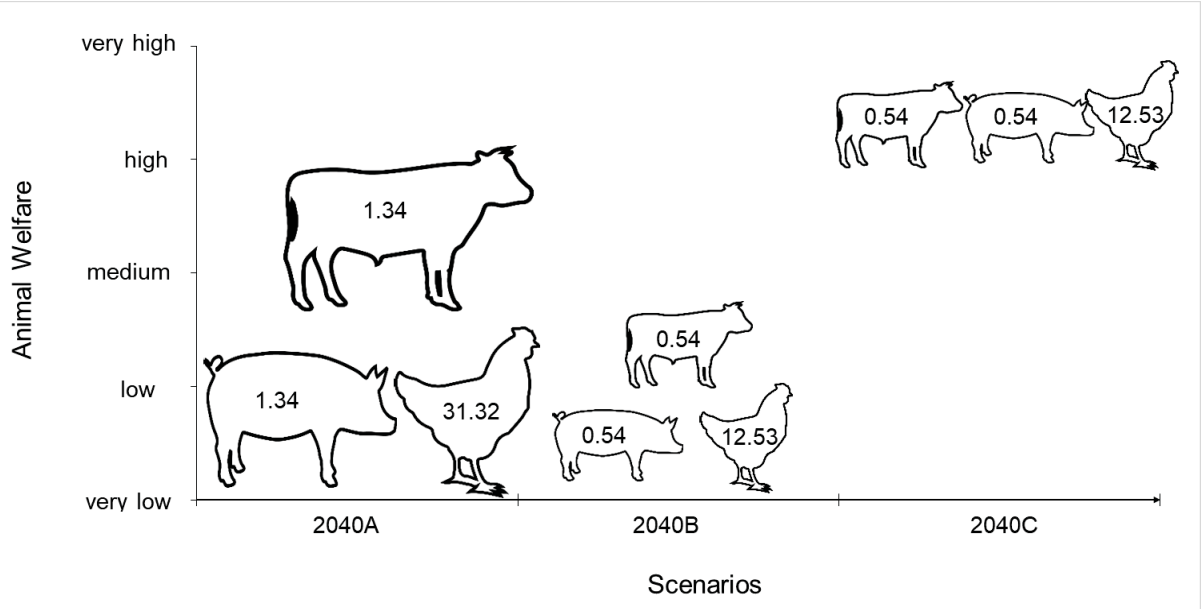
Pressure on wildlife habitat from expanding agricultural production is at least partly responsible for the novel zoonotic wildlife diseases that are emerging (WILKINSON et al., 2018). This substitution of farm animals by other forms of life may dramatically change the distribution of vertebrate animal life on earth (FIGURE 7). Few comparisons of farm and wild animal numbers exist, but in the case of birds the global biomass of domestic poultry is three times that of wild birds, as described above (BAR-ON et al., 2018). Similarly, the biomass of humans and livestock outweighs that of terrestrial wild vertebrates. As it is widely acknowledged that the welfare of farmed livestock is poor (PHILLIPS, 2015), replacement with wildlife that is subjected to fewer anthropogenic pressures is morally justifiable, even desirable from a utilitarian standpoint. From a deontological standpoint, there are additional concerns about the short lives of farm animals, infringing Tom Regan's concept of subject of a life (BEAUCHAMP, 2011), the manipulation of their genetic inheritance as a species, and threats to their future existence caused by limitation of their biodiversity (PHILLIPS, 2015), again suggesting that substitution with wildlife is desirable. There may be concerns that the welfare of wildlife, particularly of prey animals, is also compromised, but then Darwin (1861) had considerable insight: "we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and that the vigorous, the healthy, and the happy survive and multiply". Today, this statement may be recognized as somewhat romanticized; however, it seems relevant to acknowledge animal ethics gains from decreasing animal suffering which is directly anthropogenic.

Scientific assessment of animal welfare has been the object of many scientific papers and has now been summarized in protocols. The most used protocols for the

animal species represented in FIGURE 8 are the respective Welfare Quality Protocols (WELFARE QUALITY®, 2009a, b, c), and they include a variable number of specific measurable indicators for each of the four principles: good feeding, good housing, good health and appropriate behavior. The measured levels for each indicator are composed of the degree of adherence to each principle, which in turn are integrated to calculate a final welfare level for the target situation. Recurrent animal welfare assessment has produced a relatively improved understanding of welfare status for the most common animal production systems. In general, giving livestock access to pasture improves most aspects of their welfare (MEE; BOYLE, 2020) in contrast to increasing use of intensively confined systems employed for most of the pig and broiler chicken industrial farms. For this reason, in current practices involving most of the animal industry, it is possible to distinguish welfare levels of pastured cattle as relatively higher than those of indoor-raised pigs and chickens, as represented in FIGURE 8A and B. This approach simplifies complexities which are inherent to the many field variations that may be observed when assessment is performed, and rather uses a concept of animal welfare potential of each system. However, it relies on our best assumptions of welfare, as per current knowledge. Although many scientific studies have proposed solutions to prevent animal welfare issues, they still persist and even major problems with simple solutions became normal in production systems (GRANDIN, 2018). The intensive systems of pig and chicken industrial production are often related to poor living conditions for the animals, such as high stocking densities and early growth diseases (BESSEI, 2006), and even animal welfare certified systems may not present significant improvement for the animals (REIS; MOLENTO, 2019; SOUZA et al., 2015). Therefore, even though there may also be issues related to the extensive production systems (PETHERICK, 2005) the intensification processes seem to intrinsically reduce the welfare of the animals. In addition, we have only considered straight forward conditions of animal raising and slaughtering and aberrant situations such as overseas live exports were not included; even though these situations are extremely relevant, their inclusion would have blurred the picture due to the level of detail required. Thus, in FIGURE 8A we have distributed cattle, pigs and chickens according to their average animal welfare in industrial production systems described in a simplified but representative way, in terms of what happens to the greatest

number of animals in each species, as well as the number of individuals predicted to be involved in 2040 if no alternative meat were to become significant in the global market.

FIGURE 8 – NUMBER OF INDIVIDUAL ANIMALS IN EACH DEGREE OF ANIMAL WELFARE, IN BILLIONS, CONSIDERING THE ESTIMATED TOTAL NUMBER OF CATTLE, PIGS AND CHICKENS IN 2040, ASSUMING THAT TOTAL GLOBAL MEAT PRODUCTION WILL BE REDUCED TO 40% OF ITS 2019 LEVEL, FOLLOWING THE PROJECTED INSERTION OF 35% CELL-BASED AND 25% PLANT-BASED MEAT PRODUCTION (GERHARDT ET AL., 2019).



Since plant-based and cell-based meat production strategies are virtually animal-free systems (KADIM et al., 2015), if the scale of the forecast turns out roughly correct, a substantial decrease in the number of animals involved in intensive raising practices and slaughter will occur, which will in turn significantly impact the total animal suffering. Even though animals may still be necessary for cell supply, the techniques available to induce cells to proliferate indefinitely or even selection of cells that express immortality may reduce or avoid the need for new samples (STEPHENS et al., 2018). Nevertheless, the welfare of animals involved must be considered (CRONEY et al., 2018). As the number of animals demanded will be only a fraction of that required for slaughter-based meat production, the animals providing cells will probably be kept at higher welfare standards, as measured by accepted assessment protocols (WELFARE QUALITY®, 2009a, b, c) because of their extremely reduced numbers and their high value to the industry. As for the welfare of animals in the remaining conventional meat production in 2040, we present the total number of farm animals per main species and their position in terms of animal welfare, in the unlikely

case of all meat being produced through conventional processes (FIGURE 8A), and we discuss two main scenarios for 2040 (FIGURE 8): (B) average farm animal welfare decreases due to a pressure for low-cost conventional meat; (C) average farm animal welfare increases due to a niche-market developing for traditional meat, and a consequent demand for high quality meat, including the addressing of environmental and animal welfare concerns.

The first scenario (FIGURE 8A) simulates the average total number of cattle, pigs and chickens involved in farm production in 2040 and the welfare of each species. The second scenario (FIGURE 8B) represents a reduction of 60% of animal use in meat production with a decrease in the average welfare of the remaining farm animals, due to a potential increase in economic pressure. Although cell-based meat is still very expensive and consequently generates high-cost products (STEPHENS et al., 2018), future large scale plants and continuous cultivation of cells are expected to considerably reduce the price (SPECHT et al., 2018). Assuming that in 2040 cell-based meat will be widely accessible, there may be a pressure for the remaining slaughter-based meat production to be at lower cost, to compete with the cell-based products. In this case, average farm animal welfare may decrease due to the increased market pressure for intensive cost-effective production. Hence, although the total size of slaughter-based meat production will be smaller, its proportional impact may be worse, both in relation to animal welfare, environmental issues and public health matters, including increased disease risks (e.g. *Salmonella* and *Campylobacter*) and greater use of intensively-farmed land to provide the necessary feed (TUBB; SEBA, 2019). In this context, the current grains and cereals used in animal production will still require extensive land (STEINFELD et al., 2006) even though they are directly edible by humans (LEITZMANN, 2014; FAO, 2018c). This renders conventional meat from grain-based diets intrinsically inefficient in terms of reducing human hunger in the world. The projection for growth in cropped land use is colossal, reaching 3 billion tons of cereals in 2050 (FAO, 2012), in a scenario where alternative meats were not considered. In addition, the animal production sector has been engaged to improve feed conversion so that it is more efficient (STEINFELD et al., 2006), which may result in additional animal welfare problems. One last reason that may force a negative impact of cell-based meat establishment on animal welfare, is a putative stimulation of higher global meat consumption, independent of origin

(cultured or traditional) (STEPHENS et al., 2018), resulting in increased meat demand regardless of production methods.

The third scenario (FIGURE 8C) represents higher welfare for the remaining farm animals through a dominance of cell-based meat in the market of low-priced meat and, consequently, high quality or niche demand for traditional meat. According to consumer acceptance studies, willingness to both try and regularly consume cell-based meat is related to its perceived positive impact on animal welfare and environment (LAESTADIUS; CALDWELL, 2015; WILKS; PHILLIPS, 2017; MANCINI; ANTONIOLI, 2019; VALENTE et al., 2019), but lower costs for this product may also enhance its consumption (GAYDHANE et al., 2018). Therefore, conventional meat may become more expensive, segmented as a luxury food (POST, 2012). Such products are frequently branded and labeled as green, environment and animal-friendly, and consumers are likely to pay premium prices for those attributes (ORSATO, 2009) which, in turn, lead to production systems improvements. This may, consequently, allow for higher animal welfare on the remaining conventional farms. Reasons for higher welfare in this case are related to a greater possibility for the adoption of alternative systems for conventional meat production, such as those using free-range pigs and broiler chickens. Outdoor raising systems for pigs generally improve their health and behavior, since animals enjoy more space, access to natural resources and social contact. It also improves pigs' mothering and reproductive ability; reduces piglet mortality, the number of pigs with poor leg conditions (GOURDINE et al., 2010), as well as increases in social-play and decreased conflict behavior and stereotypies (NAKAMURA et al., 2011). However, it will still require improvements in pig growth rates (PARK et al., 2017), if it needs to compete with confined systems as a low cost production method. Thus, if traditional pork achieves higher prices as a consequence of cell-based pork availability, the pressure to reduce costs may decline. Likewise, free-range broiler chickens raised in open fields can enjoy improvements in their physical activities and behavioral diversity (EL-DEEK; EL-SABROUT, 2019). Also, animal welfare assessment in free-range systems demonstrates better health and ambience, behavior and psychologic states, less pododermatitis and lameness, an absence of panting, increasing wing-flapping and prevalence of positive emotional states (SANS et al., 2014). Chickens have been genetically selected for outdoor systems using the so-called 'slow growth'

lines, which automatically confer higher production costs for the fundamental characteristic of these animals: they grow slower. Using slow growth lines takes roughly double the time and other resources per kg of meat produced.

The most significant influence in terms of global animal welfare is, by far, the major reduction in the total number of individual animals involved in food production (FIGURE 8). This global decrease is in the order of hundreds of millions fewer cattle and pigs and of tens of billions fewer chickens per year. At this point it is again important to consider the low precision of these calculations, but their robustness in order of effects. In other words, even if future reality is 20 or 30% different than the assumptions accepted for our estimations, changes will be highly significant.

For the conventional animal food production that remains, further consideration is needed to understand which systems, either high, low or intermediate welfare, will be retained and thus define the impact of the innovation on the average welfare of the remaining farm animals. It is likely that further development in farm animal welfare regulations and animal protection laws will remain important. In addition, a stronger focus on welfare regulations for wild animals is likely required in many jurisdictions, to ensure that the outcome of substitution of farm animals by wild animals is associated with less overall suffering and that no increase in human activities that cause wild animal suffering will be allowed. Additionally, it seems possible to foresee potential changes in the human-animal relationship when meat production is uncoupled from animal raising and slaughter, with the mitigation of relevant barriers to animal protection and a recognition of animals as subjects by legislation.

3.3.3 Impact on the human-animal relationship

Eating animal meat sets inconsistencies in the human-animal relationship, as most people consider themselves animal lovers but, at the same time, they are causing suffering in non-human animals (JOY, 2005). In addition, meat eating tends to lead people to withdraw moral concern (LOUGHNAN et al., 2010). It has further been postulated that the institution of animal slaughter constitutes the basis of an implicit right to be violent, which may even be linked to a culture where violence has a valued place (BURGAT, 2017). If these views have validity, the development of

meat which is uncoupled from slaughter will change human-animal relationships in a profound way.

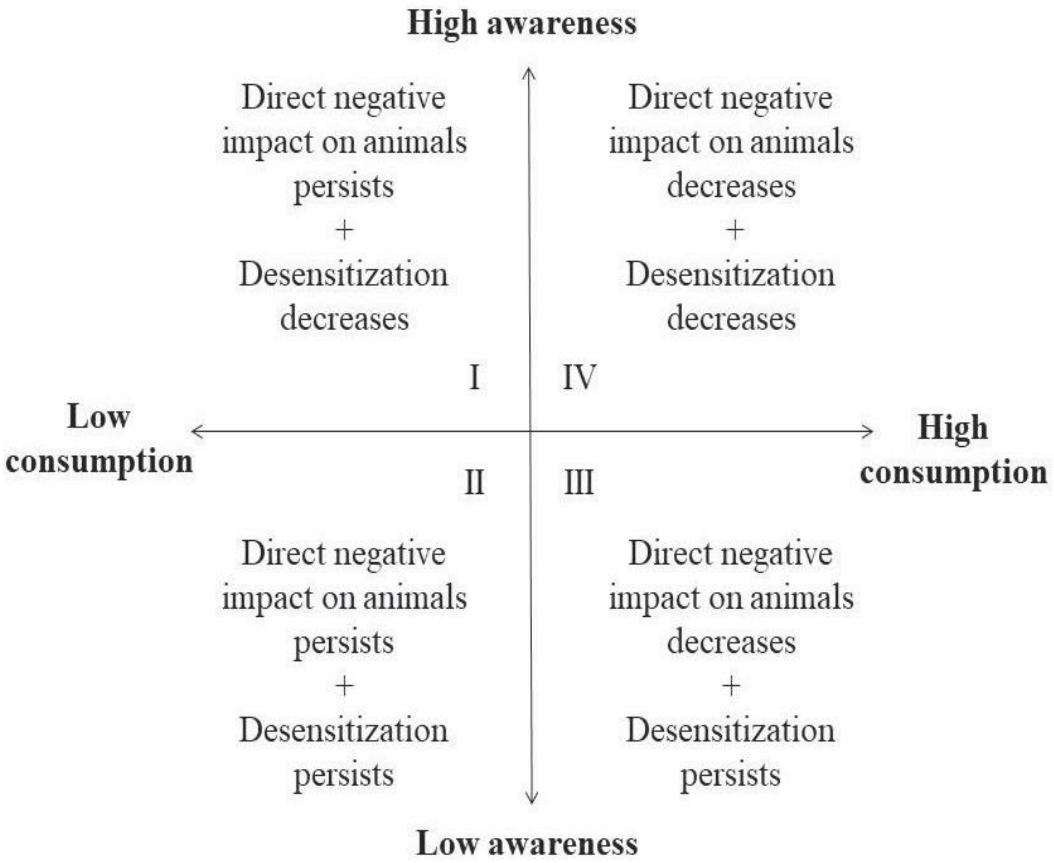
Animal-based products often have had their names changed to create distance from their animal origin (e.g. beef and pork as opposed to cattle and pigs). Historically, the division between words for animals and their meat emerged because of the French-speaking nobility eating the meat of the animals raised by English-speaking workers (QUINLEY; MÜHLENBERND, 2012). This cultural dissociation of conventional meat products from the animals from which they originate has increased recently, separating killing an animal to produce food from the stages of purchasing, distribution, preparation and consumption (BUSCEMI, 2014). The divergent nomenclature is related to the concept of the absent referent, which is anything whose original meaning is undercut as it is absorbed into a different hierarchy of meaning; in this case the original meaning of animals' fates is absorbed into a human-centered hierarchy (ADAMS, 2000). Even though references to the connection between animal and meat were reduced, many people still experience cognitive dissonance whenever something reminds them of the animal origin of meat (HARMON-JONES et al., 2009), which then evokes the meat paradox. To reduce the moral burden, people often minimize harm, deny responsibilities and diffuse the identity implications of their acts (BASTIAN; LOUGHNAN, 2017). Thus, as meat is detached from being raised under low welfare conditions and the killing of animals, this moral discomfort should disappear, allowing for unrestricted defense of animal welfare and animal life. This new freedom, in turn, may allow for the recognition that animals are morally relevant individuals, in other words, that they are subjects of a valuable life. Although a simple solution for these moral ambiguities is to follow a plant-based diet, meat consumption is strongly established into most global societies. Carnism is the ideology of meat consumption, where people, as omnivores, choose to eat meat even without the necessity of doing so (JOY, 2011). In this context, Monteiro et al. (2017) discuss two types of carnism: carnistic defense and domination. The first one relates to the meat paradox, supporting eating meat and denying animal suffering in the context of meat production. The carnistic domination is based on the hierarchy between humans and animals, justifying killing animals for human purposes and endorsing human superiority.

Independently of carnism type, the justification of killing animals to produce meat, which is a highly valued human food, may impair improvement of many areas of animal protection. The industrial meat production in typical western urban societies is associated with normalization of animals as having only instrumental value, and with killing animals. Thus, against this background, difficulties arise in recognizing the intrinsic value of individual animals and their rights to integrity and dignity. A right to integrity may be challenged by cell-based meat, confronting virtue ethics, which strives for excellence in character (HURSTHOUSE, 2011) and deontological theory. In modern society it becomes natural and somewhat necessary to treat animals as resources. This may relate to a generalization, which resides in the banalization of evil (ARENDT, 1963). For instance, Giedion (1948) described as follows the serial killing of animals in slaughterhouses: “What is truly startling in this mass transition from life to death is the complete neutrality of the act. One does not experience, one does not feel; one merely observes”. Indeed, meat is, perhaps most of all, a relationship with animals that is essentially about killing (BURGAT, 2017). Therefore, the processes related to meat production may be characterized as a type of desensitization in people (SCHACTER et al., 2011), because the exposure to dreadful experiences routinely may reduce emotional responsiveness.

If the expectations of price, taste and appearance of meat can be achieved by cell-based meat, consumers may accept it as a regular food (BRYANT; BARNETT, 2018). Also, there is strong evidence of cell-based meat consumer acceptance because of its welfare benefits (LAESTADIUS; CALDWELL, 2015; WILKS; PHILLIPS, 2017; MANCINI; ANTONIOLI, 2019; VALENTE et al., 2019). In addition, when potential consumers are further informed about environmental or animal welfare benefits – which improves their awareness about those benefits – their willingness to consume increases (BEKKER et al., 2017; VERBEKE et al., 2015; WEINRICH et al., 2019). Thus, since willingness-to-pay regarding animal welfare is related to a social consensus that it has moral value (BENNETT; BLANEY, 2002) knowledge about the positive impacts on animals provided by alternative meat production may result in an important contribution to the establishment of this product in the market. Therefore, besides the positive implications of cell-based meat for animals, there may be indirect animal ethics gains in terms of freedom to consider animals as an end in themselves.

In FIGURE 9, we represent a possible relationship between the consumption of cell-based meat and the awareness of its consequences in improving animal ethics issues. We projected four different contexts, which are represented anticlockwise from left to right: first, low consumption of cell-based meat and high awareness (quadrant I) may maintain a direct negative impact on animals but may decrease the desensitization; second, low consumption and low awareness (quadrant II) may also have a persistent direct negative impact on animals and continued desensitization; quadrant III, with high consumption and low awareness, shows the direct negative impact on animals that may decrease but the desensitization may persist; finally, quadrant IV presents high consumption of cell-based meat and high awareness, which may decrease both the direct impact on animals and desensitization.

FIGURE 9 – DIRECT CONSEQUENCES TO ANIMALS AND INDIRECT EFFECTS ON ANIMAL ETHICS OF DIFFERENT LEVELS OF CELL-BASED MEAT CONSUMPTION AND AWARENESS OF ITS ANIMAL ETHICS CONSEQUENCES.



As meat has traditionally required major animal inputs, resulting in significant impacts on their lives, from being selectively bred to being killed (MOUAT et al., 2019), in addition to being closely confined, the consumption of cell-based meat may be a new determinant of animals' interests and the quality of their lives. Growing awareness, despite urbanization, of the practices of animal production has had an important impact on the ethics of what we eat (MOUAT et al., 2019). Phillips (2015) has argued that it is not relative welfare that matters to animals, and therefore to us, but the absolute number of animals that are suffering worldwide. This is further argued by Phillips (2015) to be increasing, because more animal production uses small animals, so more are eaten; more are grown in developing countries without welfare standards, and in intensive production systems (REIS; MOLENTO, 2019); and demand for meat is increasing worldwide. While the major switch from slaughter-based to cell-based and plant-based meat consumption will directly reduce farm animal suffering (quadrants III and IV), the animal ethics improvements will likely depend on decreasing the banalization of animal suffering (SINGER, 1995), i.e., decreasing the present levels of desensitization regarding animals (quadrants I and IV). The important direct gains to animals from the decision to buy alternative meats, even when based on non-animal related reasons such as price or human health issues (quadrant III), deserve proper recognition, since from an animal point of view, what matters is not what we think or feel, but what we actually do (WEBSTER, 1995). This recognition does not exclude the importance of striving for decreased desensitization, since this is essential if broader and more permanent gains for animal welfare are to be achieved. In other words, the improvement of the relationship between human and non-human animals in a broad sense seems to be dependent on increasing both the consumption of alternatives to conventional meat and the levels of awareness regarding the role of alternative meats in uncoupling meat from animal suffering and slaughter (quadrant IV).

Our hypothesis is that alternative meats may diminish desensitization towards animals, since people will not have to tolerate the necessary animal suffering and killing for the sake of meat consumption. From a broader perspective, the concepts of animal rights and animals as subjects-of-a-life (REGAN, 2004) may find more overall support when meat production is uncoupled from the need to kill animals. However, this may require specific actions to increase awareness of animal

ethics issues, since other factors may lead the transition to alternative meats. Thus, even though the transition from traditional meat to cell-based meat will have an intrinsic direct positive impact on farm animals, the promotion of awareness may increase the human-animal relationship in a more generalized sense.

3.4 CONCLUSIONS

The development of a slaughter-free meat chain will have significant practical and animal ethics impacts on our relationship with non-human animals, which are wider than the prima facie benefits to farm animals. This is supported by utilitarian, deontological and virtue ethical principles applied to animals. Considering the many uncertainties involved, especially those regarding the rate of substitution, which is dependent on acceptance levels of alternative meats by different societies, the resolution of technological challenges and the need for transparency to avoid significant drawbacks, it is highly likely that a major disruptive change is on the horizon. Gains in environmental resources such as land, water and biomass are likely to be very significant, while energy costs per kg may remain high for cell-based meat. More research is needed to understand the consequences of new meat alternatives for the welfare of the remaining farm animals, since it will depend on economic pressures and the strategies that will be adopted by the conventional meat chain. Finally, alternative meats may diminish desensitization towards animals, since people will not have to allow for some kind of necessary animal suffering for the sake of meat consumption. Thus, there may be indirect animal ethics gains in terms of freedom to consider animals as an end in themselves. Our relationships with non-human animals may be about to change to a more respectful, mutualistic relationship, for the benefits of all concerned.

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4 FINAL CONSIDERATIONS

The upcoming disruption of cell-based meat technology to the conventional animal production systems will most likely change many aspects of the global meat chain, including the traditional roles different specialist have played and the relationship society maintains with non-human animals. The choice different players seem to have is not whether this change will come or not, but whether and how they will benefit from it. This work contributes to the understanding of the positioning of Brazilian specialists in meat production and of the potential influence of cell-based meat in remodelling the relationship between humans and animals. Considering the general context and the results of the research here presented, it seems essential for Brazil to invest in cell-based meat technology and to expand local knowledge about the subject, thus reducing resistance to this novel chain by all national players. In particular, the initiative from universities to both generate knowledge and teaching regarding cell-based meat technology may allow more people to get involved, since start-ups are private and have policies to protect information. Also, government support and commitment is crucial for the access, the motivation and the organization of the Brazilian implementation of this technology.

Moreover, the increased awareness of consumers regarding animal welfare has been transforming the food market and it seems that cell-based meat has the potential to encompass both sensory aspects of meat and ethical concerns, since it is a slaughter-free method. Brazil as a leading country in animal production has to get involved in the foundation and further establishment of this technology nationally. Otherwise, it is likely to lose meat market shares and be dependent on foreign technology.

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APPENDIX 1 – SURVEY ABOUT PROFESSIONAL PERCEPTION OF MEAT PRODUCTION SYSTEMS

1. Do you agree to participate voluntarily in this study?
   - ◯ Yes, I agree to participate in this study
   - ◯ No, I do not agree to participate in this study

2. What is your occupancy?
   - ◯ Veterinary
   - ◯ Animal scientist
   - ◯ Bioprocess engineer
   - ◯ Others: (description)

3. What is your area of expertise?
   - ◯ Academy
   - ◯ Small animals (pets)
   - ◯ Production animals
   - ◯ Wild animals
   - ◯ Laboratory area
   - ◯ Industrial area
   - ◯ Others: (description)

4. What is your speciality?
   Examples: general clinical, surgery, nutrition, industrial biotechnology, etc.

5. How old are you?

6. How long have you been graduated?
7. Gender:
   - ◯ Female
   - ◯ Male

8. Which University have you graduated?

9. Which group do you fit?
   - ◯ Meat consumer (Question 10)
   - ◯ Vegetarian
   - ◯ Vegan

10. How many times a week do you eat meat?
   - ◯ 1 day per week
   - ◯ 2 days per week
   - ◯ 3 days per week
   - ◯ 4 days per week
   - ◯ 5 days per week
   - ◯ 6 days per week
   - ◯ Every day

11. Do you know another way to produce meat that does not involve raising animals?
   - ◯ Yes (Question 12)
   - ◯ No
   - ◯ Do not know

12. Which one(s)?

13. Do you know what is cell-based meat, also known as lab-grown meat, artificial meat, in vitro meat, synthetic meat, clean meat or slaughter-free meat?
   - ◯ Yes
   - ◯ No

14. How did you get in touch with information about cell-based meat? (Multiple response)
   - ◯ Books
   - ◯ Scientific articles
   - ◯ Participation in seminars, lectures and courses
   - ◯ Reports on TV

◯ Reports in printed newspapers or magazines
◯ Reports in online newspapers or magazines
◯ Social media
◯ Others: (description)

Cell-based meat is produced by cell multiplication, using cells extracted once from the live animal, later grown in the laboratory.

15. What comes to your mind when you think of cell-based meat? Cite the first three words you think:

16. In your opinion, is there any benefit in the production of conventional meat, through the raising and slaughtering of animals?
◯ Yes (Question 17)
◯ No
◯ Do not know

17. Which one (s)?

18. In your opinion, is there any problem in conventional meat production?
◯ Yes (Question 19)
◯ No
◯ Do not know

19. Which one (s)?

20. In your opinion, is there any benefit in the production of cell-based meat?
◯ Yes (Question 21)
◯ No
◯ Do not know

21. Which one(s)?
22. In your opinion, is there any harm in the production of cell-based meat?

◯ Yes (Question 23)
◯ No
◯ Do not know

23. Which one (s)?

24. In relation to the environment, conventional meat is:
◯ Very unfavorable
◯ Unfavorable
◯ Neutral
◯ Favorable
◯ Very favorable
◯ Do not know

25. In relation to the environment, cell based-meat is:
◯ Very unfavorable
◯ Unfavorable
◯ Neutral
◯ Favorable
◯ Very favorable
◯ Do not know

26. In relation to human health, conventional meat is:
◯ Very harmful
◯ Harmful
◯ Neutral
◯ Beneficial
◯ Very beneficial
◯ Do not know

27. In relation to human health, cell-based meat is:
◯ Very harmful
◯ Harmful

- ◯ Neutral
- ◯ Beneficial
- ◯ Very beneficial
- ◯ Do not know

28. In relation to animal welfare, conventional meat is:
    - ◯ Very negative
    - ◯ Negative
    - ◯ Neutral
    - ◯ Positive
    - ◯ Very positive
    - ◯ Do not know

29. In relation to animal welfare, cell-based meat is:
    - ◯ Very negative
    - ◯ Negative
    - ◯ Neutral
    - ◯ Positive
    - ◯ Very positive
    - ◯ Do not know

30. In relation to meat production efficiency, conventional meat is:
    - ◯ Very inefficient
    - ◯ Inefficient
    - ◯ Neutral
    - ◯ Efficient
    - ◯ Very efficient
    - ◯ Do not know

31. In relation to meat production efficiency, cell-based meat is:
    - ◯ Very inefficient
    - ◯ Inefficient
    - ◯ Neutral

◯ Efficient
◯ Very efficient
◯ Do not know

32. In relation to consumer acceptance, cell meat will be:
◯ Very rejected
◯ Rejected
◯ Neutral
◯ Accepted
◯ Very accepted
◯ Do not know

33. Cell-based meat will be available to consumers in:
◯ 5 years
◯ 10 years
◯ 15 years
◯ 30 years or more

34. Regarding the number of jobs related to the production of meat, cell-based meat will:
◯ Reduce much
◯ Reduce
◯ Indifferent
◯ Increase
◯ Increase much
◯ Do not know

35. Why? (Optional)
36. Regarding the participation of Brazil in the global meat market, cell-based meat will:
◯ Reduce much
◯ Reduce
◯ Indifferent

- ◯ Increase
- ◯ Increase much
- ◯ Do not know

37. Why? (Optional)

38. The veterinary class, regarding cell-based meat, will stand:
    - ◯ Very unfavorable
    - ◯ Unfavorable
    - ◯ Neutral
    - ◯ Favorable
    - ◯ Very favorable
    - ◯ Do not know

39. Why? (Optional)

40. The animal scientist class, regarding cell-based meat, will stand:
    - ◯ Very unfavorable
    - ◯ Unfavorable
    - ◯ Neutral
    - ◯ Favorable
    - ◯ Very favorable
    - ◯ Do not know

41. Why? (Optional)

42. The bioprocess engineer class, regarding cell meat, will stand:
    - ◯ Very unfavorable
    - ◯ Unfavorable
    - ◯ Neutral
    - ◯ Favorable
    - ◯ Very favorable
    - ◯ Do not know

43. Why? (Optional)

44. Should Brazil invest in cell-based meat production?

◯ Yes

◯ No

45. The investment in cell-based technology meat should be the responsibility of: (Check all that feel appropriate.) (Multiple response)

◯ Universities

◯ Non-Governmental Organizations (NGOs)

◯ Government

◯ Private sector (business and industry)

◯ Others

46. What is your vision of the future with respect to meat production? (Optional)

47. Suggestions and comments:(Optional)

ANNEX 1 – PUBLISHED ARTICLE INTITLED "CRITICAL PERSPECTIVE OF ANIMAL PRODUCTION SPECIALISTS ON CELL-BASED MEAT IN BRAZIL: FROM BOTTLENECK TO BEST SCENARIOS"

animals

MDPI

Article

Critical Perspective of Animal Production Specialists on Cell-Based Meat in Brazil: From Bottleneck to Best Scenarios

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Simple Summary: The opinion of professionals involved in animal production is very important to the development of the emerging cell-based meat chain. This paper aims to analyse the perspective of Brazilian veterinarians and animal scientists regarding cell-based meat—women, veterinarians, vegetarians and vegans were more supportive of cell-based meat. The resistance expressed by the professionals seems related to a lack of knowledge and the association of cultivated meat with artificiality, which has a negative connotation. Therefore, higher education and motivation of veterinarians and animal scientists may mitigate the resistance and help these professionals to engage in this new chain for the benefit of the professionals themselves, society, the animals involved and the environment.

Abstract: Recently, many studies regarding consumer perception of cell-based meat have been published. However, the opinion of the professionals involved in animal production also seems relevant. In particular, veterinarians and animal scientists may be important players in the new cell-based meat production, acting as proponents or barriers to this major improvement for farm animal welfare. Therefore, our aim is to analyse the knowledge and perspective of Brazilian veterinarians and animal scientists regarding cell-based meat. Veterinarians (76.8%; 209/272) and animal scientists (23.2%; 63/272) responded to an online survey. Logistic regression, latent class and logit models were used to evaluate objective answers, and the Discourse of the Collective Subject method was used to interpret open-ended answers. Specialists who were women (62.5%; 170/272), veterinarians (76.8%; 209/272), vegetarians (7.0%; 19/272) and vegans (1.1%; 3/272) were more supportive of cell-based meat. Lack of knowledge and the connection with artificiality, the most frequent spontaneous word associated with cell-based meat by all respondents, were the main negative points highlighted. Thus, it seems fundamental to offer higher education to veterinarians and animal scientists regarding cell-based meat, since engaging them with this novel technology may mitigate both the resistance and its negative consequences for the professionals, society, the animals involved and the environment.

Keywords: animal protection; animal welfare; animal production; cultivated meat; cultured meat; slaughter-free meat

ANNEX 2 – PUBLISHED ARTICLE INTITLED "UNCOUPLING MEAT FROM ANIMAL SLAUGHTER AND ITS IMPACTS ON HUMAN-ANIMAL RELATIONSHIPS"

frontiers in Psychology

REVIEW
published: 04 August 2020
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Uncoupling Meat From Animal Slaughter and Its Impacts on Human-Animal Relationships

Marina Sucha Haldemann[1], Carla Forte Maiolino Molento[1], Germano Glufke Reis[2] and Clive Julian Christie Phillips[3]*

[1]Animal Welfare Laboratory, Federal University of Paraná, Curitiba, Brazil, [2]School of Business Administration, Federal University of Paraná, Curitiba, Brazil, [3]Centre for Animal Welfare and Ethics, Faculty of Science, The University of Queensland – Gatton Campus, Gatton, QLD, Australia

Slaughter sets the debate about what is acceptable to do to animals at an extremely low bar. Recently, there has been considerable investment in developing cell-based meat, an alternative meat production process that does not require the raising and slaughtering of animals, instead using muscle cells cultivated in a bioreactor. We discuss the animal ethics impacts of cell-based and plant-based meat on human-animal interactions from animal welfare and rights perspectives, focusing on industrial meat production scenarios. Our hypothesis is that the insertion of cell-based meat in the global meat market may alleviate farm animal suffering and potentially restore resources for wild fauna. We employed a conservative estimation of the cell-based meat contribution to the global meat market in the year 2040 to analyze the consequences for human-animal relationships for both wild animals and farmed domesticated animals. We discuss possible effects of an animal cell domestication process, previously described as the second domestication, on human-animal relationships. We consider its potential to reduce the impact of human demographic changes and land use on animal life, in particular whether there would be increased biomass availability and free land for wild animals. We anticipate a major reduction in animal suffering due to the decrease in the number of individual animals involved in food production, which justifies the adoption of cell-based meat from a utilitarian perspective. For the conventional animal food production that remains, further consideration is needed to understand which systems, either high or low welfare, will be retained and the impact of the innovation on the average farm animal welfare. Additionally, it seems likely that there will be less acceptance of the necessity of animal suffering in farming systems when meat production is uncoupled from animal raising and slaughter, supported by a deontological perspective of animal ethics. Consequent to this is anticipated the mitigation of relevant barriers to animal protection and to the recognition of animals as subjects by legislation. Thus, the development of the alternative meats may be related to a significant change in our relationship with non-human animals, with greater benefits than the *prima facie* effects on farm animals.

Keywords: animal protection, animal suffering, cell-based meat, second domestication, human-animal relationship

OPEN ACCESS

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ANNEX 3 – PUBLISHED ARTICLE INTITLED “THE (CELL-BASED) MEAT OF THE FUTURE: PROSPECTS FOR ENVIRONMENTAL STRATEGIES OF FIRMS”

Technology in Society 62 (2020) 101286

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Livestock value chain in transition: Cultivated (cell-based) meat and the need for breakthrough capabilities

Germano Glufke Reis [a,*], Marina Sucha Heidemann [b], Felipe Mendes Borini [c], Carla Forte Maiolino Molento [b]

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ARTICLE INFO

Keywords:
Clean meat
Slaughter-free meat
Global value chain
Environment
Animal welfare

ABSTRACT

Alternative protein sources such as cell-based meat are potentially associated with improvements in important issues related to intensive industrial livestock production: animal welfare, environmental impact, food safety and the low efficiency of conventional meat production. However, little is known about the potential implications of the new cultivated meat technology for emerging countries. Thus, drawing on the Global Value Chain literature and on the blossoming literature on cell-based meat, we have first discussed how this new chain may be structured. Then, based on the analysis of a set of companies that operate in the fast-developing cultivated meat industry, core enabling capabilities that are required in order to enter the new meat value chain were identified; they encompass technological, business structuring, market positioning and relationship with stakeholder capabilities. It is likely that all listed capabilities are relevant for any country to access the livestock chain in transition. We propose reflections that may contribute to decisions which, in turn, may define aspects of the cultivated meat chain, for the sake of relieving animal suffering and taking care of our home planet, while providing all humans with quality food that meet their nutritional requirements and consumption desires.

1. Introduction

Livestock production in emerging economies represents relevant resources not only for local consumption but also for economic income, job generation and technological upgrading. According to the World Economic Forum [1], over half a billion people are involved in animal production in those countries. Brazil, for instance, is one of the major meat producers in the world and is highly engaged with the meat Global Value Chain (GVC). However, we are witnessing the birth of alternative forms of protein sources, as for example the cell-based meat, which is meat cultured from animal cells, through specific processes and equipment [2,3]. This cultured meat, therefore, does not depend on on-farm animal production and may potentially lead to significant transformations in the conventional meat chain. Major meat processing multinationals from developed countries, such as Tyson Foods, are investing in the technology [4] and startups are appearing worldwide. As investments increase in a fast pace, cell-based meat products are expected to gradually reach the markets within the next few years [3]. Moreover, cell-based meat products are forecasted to be niche and relatively expensive items at first; however, they are likely to become more affordable over time [3,5]. In response to this accelerated trend, the United States Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) engaged in conversations regarding cell-based meat labeling and regulation, essentially to align on a joint regulatory framework between the two agencies [6,7]. The fact that such institutional alignment was necessary may epitomize the relevance of this new industry.

In spite of the relevance of the subject, little is known about the potential implications of the cell-based technology for emerging countries, especially for those who are important players in the meat industry, as is the case of Brazil. Thus, drawing on the GVC framework [8, 9] and based on the emerging literature on cultivated meat, we have first analyzed how the cultivated meat chain may be structured. Following, we identified a set of core enabling capabilities that are needed for emerging countries to have access to the cultivated meat value chain. Capabilities are defined here as “(…) the ability of an organization to

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Received 16 December 2019; Received in revised form 20 March 2020; Accepted 3 June 2020
Available online 12 June 2020

ANNEX 4 – PUBLISHED ARTICLE INTITLED “FIRST GLIMPSE ON ATTITUDES OF HIGHLY EDUCATED CONSUMERS TOWARDS CELL-BASED MEAT AND RELATED ISSUES IN BRAZIL”

PLOS ONE

RESEARCH ARTICLE

First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil

Júlia de Paula Soares Valente[¶], Rodrigo Alonso Fiedler[‡], Marina Sucha Heidemann[‡], Carla Forte Maiolino Molento[*¶]

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OPEN ACCESS

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Competing interests: The authors have declared that no competing interests exist.

Abstract

Our aim was to study Brazilian consumer attitudes towards cell-based meat and related issues. From 408 respondents from Curitiba and 218 from Joinville, the majority was women with higher level of education; 65.2% and 70.2% frequently consumed meat and 50.7% and 50.9% would not stop eating meat; 81.6% and 82.6% had little or no knowledge about cell-based meat. After watching an explanatory video, 41.9% and 34.4% stated they would eat cell-based meat without restrictions; 24.5% and 23.9% stated they would try depending on conditionals. Overall, 63.6% declared they would eat cell-based meat; among vegetarians and vegans, 24% and 8% stated they would eat cell-based meat, with additional 25.0% and 27.0% stating "it depends"; thus, the major public for cell-based meat seems to be meat eaters. Animal welfare was the principal reason for considering not eating meat and a major benefit of cell-based meat. In conclusion, the majority of respondents would not stop eating meat; additionally, they would eat cell-based meat.

Introduction

In comparison to the last decades, global population growth up to 2050 is expected to be slower. Despite this fact, the Food and Agriculture Organization of the United Nations published a report showing that meat consumption tends to double midway through the century [1]. Higher consumption necessarily implies increases in meat production, with associated increases in environmental and animal ethics issues. Therefore, new substitutes for traditional animal protein are being researched [2]. Among the options is cellular agriculture, a new technology in food production that in the future may supply large amounts of high-quality protein [3]. Cell-based meat, also known by the names of clean, cultivated, synthetic, artificial, *in vitro*, lab-grown, cell-based and slaughter-free meat, is a novel and disruptive technology. The very name to this new meat is still undecided and a major issue, since it is known that the name influences how positive behavioral intentions towards the product will be [4].

ANNEX 5 – PUBLISHED ABSTRACT INTITLED "NEW ALTERNATIVES FOR ANIMAL-DERIVED PRODUCTS: FROM GLOBAL START-UPS ECOSYSTEMS TO THE FARM OF FUTURE"

NOVAS ALTERNATIVAS PARA PRODUTOS DE ORIGEM ANIMAL: DO ECOSSISTEMA DE STARTUPS GLOBAIS À FAZENDA DO FUTURO

Atualmente, o consumo de proteína animal vem aumentando mundialmente e esta demanda tende a crescer, estimulando o desenvolvimento de tecnologias alternativas às formas convencionais de produção animal, como a carne celular.

Além de possibilitar o atendimento dessa demanda, a carne celular pode contribuir para a redução de problemas relacionados à produção industrial intensiva de animais e de sofrimento animal, bem como reduzir determinados impactos ambientais.

Em função desses aspectos, um número crescente de startups tem germinado em todo o mundo, focadas no desenvolvimento de tecnologias e produtos à base de carne celular, atraindo recursos de investidores internacionais.

Contudo, ainda pouco se sabe sobre como a introdução da carne celular transformará a cadeia tradicional da carne, gerando novas oportunidades e formas de interação entre os atores da cadeia.

Assim, o objetivo deste trabalho é explorar como serão as "fazendas do futuro" na era da carne celular, identificando a estrutura geral da cadeia de valor da carne celular e a sua interação com a cadeia convencional da carne, com base na análise da literatura existente e do ecossistema de empresas que já atuam nessa nova indústria.

Desta forma, projetamos que a estrutura da cadeia envolverá: fornecedores de sistemas de cultivo e processamento; cultura e processamento de carne celular; processamento complementar e composição (blending) de produtos utilizando também carne convencional; desenvolvimento de produtos e marcas; distribuição; marketing e vendas.

Palavras-chave: Carne celular; Cadeia de valor; Bem-estar Animal.

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ANNEX 6 – CERTIFICATE OF LECTURE INTITLED “CELL-BASED MEAT: THE FUTURE OF THE INDUSTRY OF MEAT”

CERTIFICADO

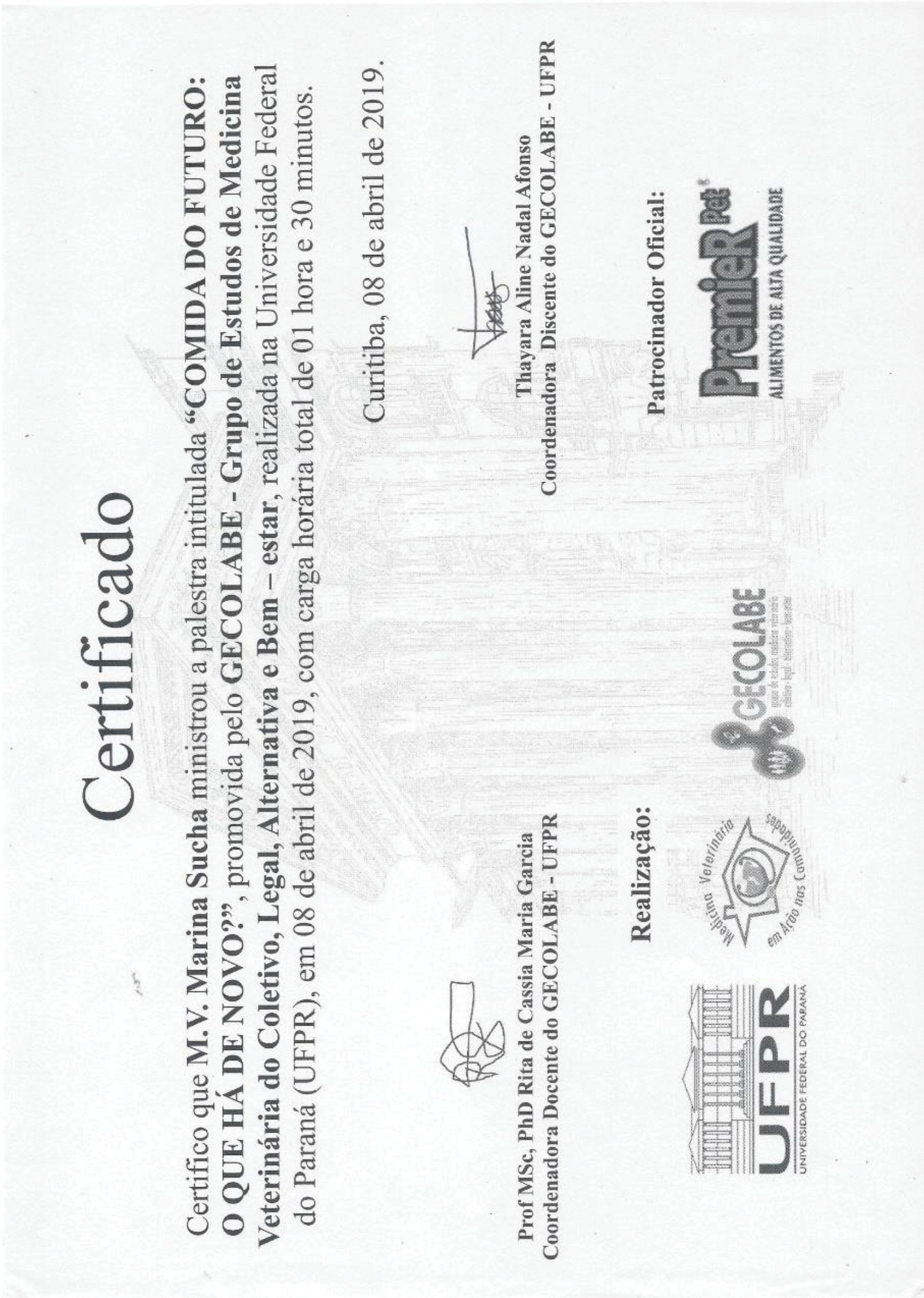
Certificamos que Marina Sucha Heidemann, portadora do CPF 081.633.589-59, ministrou a palestra "Carne de Base celular: o futuro da indústria da carne" na Semana ECOS 2018, promovida pela ECOS – Empresa Júnior de Biologia UFPR, no dia 17 de Outubro de 2018, às 16:00, no Setor de Ciências Biológicas, totalizando 01 (uma) hora.

Joice Laskoski
Diretora Presidente

Fernanda Cuminesi
Diretora do Projeto

ECOS
EMPRESA JÚNIOR BIOLOGIA UFPR

ANNEX 7 – CERTIFICATE OF LECTURE INTITLED "FOOD OF THE FUTURE: WHAT IS NEW?"



Certificado

Certifico que **M.V. Marina Sucha** ministrou a palestra intitulada **"COMIDA DO FUTURO: O QUE HÁ DE NOVO?"**, promovida pelo **GECOLABE - Grupo de Estudos de Medicina Veterinária do Coletivo, Legal, Alternativa e Bem – estar**, realizada na Universidade Federal do Paraná (UFPR), em 08 de abril de 2019, com carga horária total de 01 hora e 30 minutos.

Curitiba, 08 de abril de 2019.

Prof MSc, PhD Rita de Cassia Maria Garcia
Coordenadora Docente do GECOLABE - UFPR

Thayara Aline Nadal Afonso
Coordenadora Discente do GECOLABE - UFPR

Realização:

Patrocinador Oficial:

ANNEX 8 – CERTIFICATE OF CLASS INTITLED “CELL-BASED MEAT: A NEW TECHNOLOGY OF ANIMAL-DERIVED PRODUCTS”

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DO PARANÁ
SETOR DE CIÊNCIAS AGRÁRIAS
DEPARTAMENTO DE MEDICINA VETERINÁRIA

DECLARAÇÃO

Declaro, para os devidos fins, que a Médica Veterinária ***Marina Sucha Heidemann*** ministrou palestra sobre ***“Carne celular: uma nova tecnologia de produtos de origem animal”*** aos alunos do curso de Medicina Veterinária, da Universidade Federal do Paraná, na disciplina de **Tecnologia de Produtos de Origem Animal, código AV418**, no dia 11 de abril de 2019, totalizando 04 horas.

Curitiba, 11 de abril de 2019.

Caroline Constantino

Profª Caroline Constantino
Matrícula UFPR 206204 / SIAPE 1288871
Departamento de Medicina Veterinária
Universidade Federal do Paraná

ANNEX 9 – CERTIFICATE OF LECTURE INTITLED “CELL-BASED MEAT: A NEW TECHNOLOGY OF ANIMAL-DERIVED PRODUCTS”

UFPR

UNIVERSIDADE FEDERAL DO PARANÁ
CENTRO ACADÊMICO DE MEDICINA VETERINÁRIA

CENTRO ACADÊMICO DE MEDICINA VETERINÁRIA

CERTIFICADO

Certificamos que **Marina Sucha Heidemann** ministrou palestra intitulada **“CARNE CELULAR: Uma nova tecnologia de produtos de origem animal”** pertencente ao Módulo Tecnologia de Produtos de Origem Animal e Sanidade Animal da XXXVI Semana Acadêmica de Medicina Veterinária da Universidade Federal do Paraná, realizada entre os dias 6 de maio e 10 de maio de 2019, sob organização do Centro Acadêmico de Medicina Veterinária – campus Curitiba, nas dependências do Setor de Ciências Agrárias, com duração de 50 minutos.

Curitiba, 06 de maio de 2019

Lucas Augusto do Santos Flores
Presidente do CAMV-UFPR

Nicole Muniz Ferreira Gonçalves
Coordenadora do Módulo TPOA e Sanidade Animal

CENTRO ACADÊMICO DE MEDICINA VETERINÁRIA

Universidade Federal do Paraná
Centro Acadêmico de Medicina Veterinária – Gestão Canivet (2018-2019)
XXXIII Semana Acadêmica de Medicina Veterinária – UFPR
Programação do Módulo Tecnologia de Produtos de Origem Animal e Sanidade Animal

	SEGUNDA- FEIRA	TERÇA-FEIRA	QUARTA-FEIRA	QUINTA-FEIRA	SEXTA-FEIRA
	Avicultura	**Bovinocultura de Leite**	**Bovinocultura de Corte**	**Suinocultura**	**Prática**
08h00 às 9h20	PANORAMA NACIONAL E MERCADO DE TRABALHO Lucas Bassi	BUBALINOCULTURA LEITEIRA José Martinez - IAPAR	HIGIENE E CONTROLE DE QUALIDADE DA CARNE MV. Rafael Martins Felicio - MAPA	BEM-ESTAR ANIMAL NA SUINOCULTURA Prof.Dr. Kelly Mazutti Monteiro	MINICURSO DE TIPOS DE CORTE DE CARNE SUÍNA Chefs Bernardo Fadel e Jhow Butcher
09:20 às 09h40	*Coffee-break*				
09h40 às 11h00	AVICULTURA: Abate, corte e exportação Prof. Dr. José Mauricio França - UTP	LEITE: DO CAMPO À MESA MV. Pedro I. Teider	ENCEFALOPATIA ESPONGIFORME BOVINA MV. Ellen E. Laurindo - MAPA	MANEJO E PRÉ-ABATE DE SUÍNOS MV. Camila Demarco Maito	
11h00 às 13h30	**Almoço**				
13h30 às 14h30	FINALMENTE MÉDICO VETERINÁRIO... E agora? MV. Ton Kramer	A INFLUÊNCIA DA NUTRIÇÃO NA COMPOSIÇÃO E QUALIDADE DO LEITE MV. Giancarlo Negro	INSENSIBILIZAÇÃO DE BOVINOS NO ABATE Guilherme Martins - Frigorífico Argus	PSC: panorama atual e previsões MV. Aglaci Tomporoski - ADAPAR	LIVRE
14h30 às 15h20	**CARNE CELULAR: Uma nova tecnologia de produtos de origem animal** MV. Marina Sucha	CADEIA DE PRODUÇÃO PECUÁRIA Prof. Dr. Paulo Rossi - UFPR	FEBRE AFTOSA, PANORAMA ATUAL NO PR MV. Walter C. Ribeirete - ADAPAR.	BIOSSEGURIDADE NA SUINOCULTURA MV. João H. Teotonio - ADAPAR.	
15h20 às 15h40	*Coffee-break*				
15h40 - 17h00	PNSA E PANORAMA EPIDEMIOLÓGICO MV. Cassiano Kahlow - ADAPAR	A confirmar	DESAFIOS DA CARNE BRASILEIRA NO MERCADO MUNDIAL MV. Evilásio P. Melo	REDUÇÃO DO USO DE ANTIMICROBIANOS NA SUINOCULTURA MV. Lucas Piroca	

ANNEX 10 – CERTIFICATE OF LECTURE INTITLED "CELL-BASED MEAT: THREATS OR OPPORTUNITIES?"

UFPR

UNIVERSIDADE FEDERAL DO PARANÁ
CENTRO ACADÊMICO DE MEDICINA VETERINÁRIA

CERTIFICADO

Certificamos que **Marina Sucha Heidemann** ministrou palestra intitulada **"Carne celular: ameaças ou oportunidades?"** pertencente ao Módulo Bem-estar, Comportamento e Ética Animal da XXXVI Semana Acadêmica de Medicina Veterinária da Universidade Federal do Paraná, realizada entre os dias 6 de maio e 10 de maio de 2019, sob organização do Centro Acadêmico de Medicina Veterinária – campus Curitiba, nas dependências do Setor de Ciências Agrárias, com duração de 2 horas.

Curitiba, 08 de maio de 2019

Lucas Augusto do Santos Flores
Presidente do CAMV-UFPR

Thayara Aline Nadal Afonso
Coordenadora do Módulo Bem-estar,
Comportamento e Ética Animal

CENTRO ACADÊMICO DE MEDICINA VETERINÁRIA

Universidade Federal do Paraná
Centro Acadêmico de Medicina Veterinária – Gestão Chapa do CAMV (2018-2019)
XXXVI Semana Acadêmica de Medicina Veterinária – UFPR
Programação do Módulo Bem-estar, Comportamento e Ética Animal

PROGRAMA DO MÓDULO BEM-ESTAR, COMPORTAMENTO E ÉTICA ANIMAL

SEGUNDA 06/05

8H - 8H30
Boas vindas e introdução
Prof. Dra. Carla Molento
LABEA/UFPR

8H30 - 10H
Comportamento canino
Prof. Dra. Ceres Faraco
INSPA

10H - 10h30
COFFEE

10h30 - 12H
Bem-estar do paciente felino no ambiente clínico
Me. Marúcia de Andrade Cruz
Clínica Mania de Gato

12H - 14H
ALMOÇO

14h - 16H
Diagnóstico de maus-tratos
Dra. Janaina Hammerschmidt
Prefeitura de Pinhais

16H - 16h30
COFFEE

16h30 - 18h30
Direito animal
Prof. Dr. Vicente de Paula Ataide Junior
Juiz Federal

TERÇA 07/05

8h - 9h
O que aprendemos a partir das avaliações de bem-estar de frangos de corte no Brasil?
Dra. Ana Paula de Oliveira
LABEA/UFPR

9h - 10h
Bem-estar de peixes
Pós-doutorando Ciargi dal Pont
UFPR

10H - 10h30
COFFEE

10h30 - 12h
Bem-estar e manejo de animais silvestres em zoológicos
M.V. Rafael S. Pagani
Zoológico de Pomerode

12H - 14H
ALMOÇO

14h - 16H
Manejo etológico de animais de produção
Dra. Monique Valéria de Lima Carvalhal
UNESP

16H - 16h30
COFFEE

16h30 - 18h30
Bem-estar de ovinos: uma experiência na Escócia
Doutoranda Vanessa Soriano
LABEA/UFPR

QUARTA 08/05

8h - 9h
Seleção artificial em cães e gatos: posicionamentos de órgãos oficiais internacionais da Medicina Veterinária
M.V. Rosangela Ribeiro Cobera
WAP

9h - 10h
Desafios e avanços na legislação brasileira sobre proteção animal
Vereadora Fabiane Rosa

10H - 10h30
COFFEE

10h30 - 12h
Avanços Globais no Bem-estar Animal: Bases Científicas para a Eliminação do Confinamento Intensivo
Me. Maria Fernanda Martin
HSI

12H - 14H
ALMOÇO

14h- 16h
Carne celular: ameaças ou oportunidades?
Mestranda Marina Sucha
LABEA/UFPR

16H - 16h30
COFFEE

16h30 - 18h30
Carne Sem Abate: cadeia global de valor
Prof. Dr. Germano Glufke Reis
UFPR

QUINTA 09/05

8h - 8h30
Cerimônia de Lançamento dos livros: "Animal Experimentation: Working Towards a Paradigm Change" e "Animal Welfare: From Science to Law"
Prof. Dr. Felipe Wouk
UFPR

8h30 - 10h
Pronunciamento das autoras de capítulos dos livros
Prof. Dra. Rita Garcia
Prof. Dra. Carla Molento
UFPR

10H - 10h30
COFFEE

10h30 - 12h
Princípios Éticos Norteadores da Experimentação Animal
Prof. Dra. Marta Fischer
PUC/PR

12H - 14H
ALMOÇO

14h - 16h
Eutanásia
M.V. Vânia Plaza Nunes
ENPDA

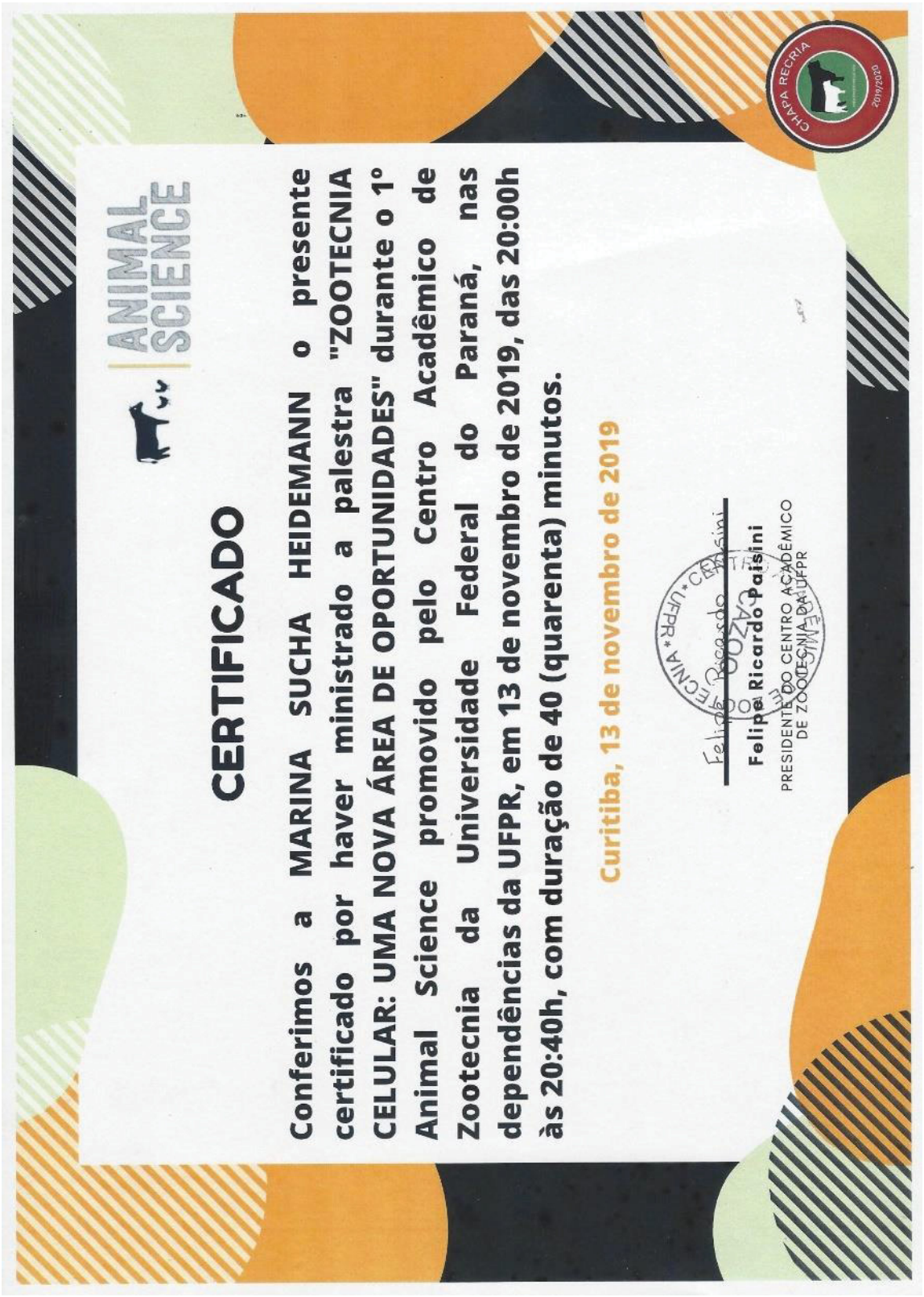
16H - 16h30
COFFEE

16h30 - 17h30
Dinâmica em grupo

SEXTA 10/05

Viagem para Foz do Iguaçu
Visita técnica no Parque das Aves

ANNEX 11 – CERTIFICATE OF LECTURE INTITLED “CELLULAR ANIMAL SCIENCE: A NEW AREA OF OPPORTUNITIES”



ANIMAL SCIENCE

CERTIFICADO

Conferimos a MARINA SUCHA HEIDEMANN o presente certificado por haver ministrado a palestra "ZOOTECNIA CELULAR: UMA NOVA ÁREA DE OPORTUNIDADES" durante o 1° Animal Science promovido pelo Centro Acadêmico de Zootecnia da Universidade Federal do Paraná, nas dependências da UFPR, em 13 de novembro de 2019, das 20:00h às 20:40h, com duração de 40 (quarenta) minutos.

Curitiba, 13 de novembro de 2019

Felipe Ricardo Paisini

PRESIDENTE DO CENTRO ACADÊMICO DE ZOOTECNIA DA UFPR

CHAPA RECRIA 2019/2020

ANNEX 12 – CERTIFICATE OF AWARDED ABSTRACT INTITLED “QUALITY OF THE ANIMAL WELFARE APPROACH IN OFFICIAL DOCUMENTS AND TECHNICAL REPORTS”

FORUM NACIONAL DE PROTEÇÃO E DEFESA ANIMAL

Escola de Veterinária UFMG

CERTIFICADO DE APRESENTAÇÃO DE TRABALHO E PREMIAÇÃO

Certificamos que Marina Sucha Heidemann apresentou pôster do trabalho *Qualidade da abordagem do bem-estar animal em documentos oficiais e relatórios técnicos*, premiado como um dos três melhores, no V Seminário de Defesa Animal: Desafios da Sociedade Civil e do Poder Público, ocorrido nos dias 25 e 26 de maio de 2018 na Universidade Federal de Minas Gerais, perfazendo um total de 20 horas.

Sônia Peralli Fonseca
Presidente do Fórum Animal

Vania Plaza Nunes
Diretora Técnica do Fórum Animal
CRMV/SP 4119

Danielle Ferreira de Magalhães Soares
Professora Adjunta
Escola de Veterinária - UFMG

Sexta-feira 25/05/2018

9:00	**Abertura - Sônia Peralli Fonseca – Presidente FNPDA** • **Mestre de Cerimônia – Vania Plaza Nunes – Diretora Técnica FNPDA** • **Elizabeth MacGregor – apresentação FNPDA** • **Dra. Danielle Ferreira- vídeo + projetos Escola de Veterinária - UFMG**
9:30	**Painel Bases da Defesa Animal** **(1) Senciência Animal -** Dra. Karynn Capilé (FNPDA) **(2) Ordenamento Jurídico Brasileiro -** Dra Luciana Imacula de Paula (CEDEF) **Moderadora**: Dra. Edna Cardoso (OAB-MG)
10:50	***Coffee Break***
11:05	**Painel Animais de Companhia – Situação da Leishmaniose visceral - novas estratégias de enfrentamento** **Palestrantes:** - Dra. Maria Helena Franco Morais (PBH) - Dr.Vitor Ribeiro (PUC-MG) **Moderador**: Dr. David Soeiro (UFMG)
12:30	**Almoço**
14:00	**Painel Animais de Companhia – Como detectar e enfrentar aumento de casos de Esporotricose zoonótica** **Palestrantes**: - Dra. Kelly Moura Keller (UFMG) - Dra. Myrian Iser (ANCLIVEPA) - Dra.Mércia Alves (PBH) e Dra. Livian Otávio Lecca (UFMG) **Moderadora**: Dra. Camila Valgas
15:50	***Coffee Break***
16:05	**Painel Animais de Companhia – Estratégias de Manejo Populacional de Cães e Gatos: Qualidade dos procedimentos e resultados obtidos** **Palestrantes**: (1) Marcos Legais - Dra. Ana Liz Ferreira Bastos (GEDEF) (2) Experiência de Belo Horizonte - Eduardo Viana Vieira Gusmão (PBH) (3) Castração a baixo custo – Helenice (ABG) (4) Manejo de gatos nas ruas - Paloma Carla Fonte Carvalho (UFMG) **Moderadora**: Dra. Christina Malm (UFMG)
17:45	**Painel Desastres ambientais –papel das OSCs e do Serviço Público** (1) Situação dos animais vítimas do rompimento da barragem de Samarco em Mariana (evento midiático) – Dra. Ana Liz Ferreira Bastos (2) Situação de Rio Casca (evento não midiático) – Dra. Carla Sassi **Moderadora:** Dra. Flávia Quadros (UFMG)
18:30	**Avanços do Movimento Mineiro pelo Direito dos Animais e situação de capivaras em BH** - Adriana Araújo (MMDA) - Dr. Leonardo Maciel **Moderadora** – Dra. Danielle Ferreira
20:00	***Encerrramento***

Sábado 26/05/2018

08:00	**Painel Entretenimento** **(1) Rodeios e Vaquejadas -** Dra.Vania Nunes (FNPDA) **(2) Panorama dos zoológicos brasileiros -** Dr. Daniel Ambrozio Vilela **Moderador**: Dr. Bruno Divino Rocha (CRMV-MG)
09:30	***Coffee-break***
09:45	**Painel Animais Usados para Consumo** **(1) Gaiolas – Suínos e Aves -** Dra. Patrycia Sato (FNPDA) **(2) Exportação Gado Vivo -** Dra. Lynn Simpson (Austrália) **Moderadora:** Dra.Ingrid Eder
11:30	**Painel Equídeos** **(1) Cenário nacional (consumo, transporte)** – Dra. Lisiê Buss (Ministério da Agricultura – MAPA) **(2) Problemas decorrentes da tração e transporte** - Ciryl Alexandre de Marval (PUC Minas) **(3) Experiência Relatório Gedef** - Dra. Barbara Goloubeff (Polícia Militar MG) 20 minutos **Moderadora:** Andressa Silveira (UFMG)
13:00	***Almoço***
14:15	**Painel Animais Silvestres** **(1) Gestão Nacional da Fauna** – Roberto Cabral Borges (IBAMA) **(2) Caça -** Dra. Juliana Sarrena (DEPAVE-SP) **Moderadora:** Dra. Samilla Moll
15:45	***Coffee-break***
16:00	**Painel Políticas Públicas** **(1) Nível Municipal -** Vereadora Carla Sassi e Áurea Carolina **(2) Nível Estadual –** Comissão ALMG - Dep. Estadual Noraldino Jr. **(3) Nível Federal –** CPI de Maus Tratos no Congresso Nacional– Anastasia **Moderadora**: Dra. Lilian Marotta (Promotora MPMG)
17:40	**Premiação: (1) Posters de trabalhos acadêmicos (2) Projetos Afiliadas FNPDA**
19:00	**Encerramento**

ANNEX 13 – PUBLISHED ABSTRACT INTITLED "SHEEP FARMERS' PERCEPTION OF SHEEP WELFARE IN SOUTHERN BRAZIL: PRELIMINARY RESULTS"

SHEEP FARMERS' PERCEPTION OF SHEEP WELFARE IN SOUTHERN BRAZIL: PRELIMINARY RESULTS

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The aim of this study was to describe the perception of sheep farmers regarding sheep welfare, through a survey in Southern Brazil. Fifty-nine farmers answered a questionnaire either online or on paper, from September to November 2017. There were three open and three multiple-choice questions. Some questions were not answered by all farmers since respondents could choose to skip part of the questionnaire or quit participation at any point. Most respondents considered sheep and beef cattle systems (63%, 22/35) as the best in terms of animal welfare, followed by dairy cattle (29%, 10/35). When asked what are the conditions in their farms which improve sheep welfare, 71% (42/59) answered that sheep had free access to pasture and 69% (41/59) free access to a source of water, followed by calm management (54%, 32/59), access to shadow (51%, 30/59), experienced shepherd (47%, 28/59), good forage quality and quantity (46%, 27/59) and immediate veterinary care (32%, 19/59). Concerning on-farm welfare challenges, 40% (23/59) mentioned untrained dogs stressing sheep during handling, lamb mortality (36%, 21/59), inexperienced shepherds (32%, 19/59), forage scarcity at certain times of the year (25%, 15/59) and the absence of shadow (14%, 8/59). The top answer regarding welfare problems which farmers feel no autonomy to solve was the low value attributed to sheep meat chain (43%, 18/42), followed by predation (26%, 11/42) and stolen animals (14%, 6/42). As for suggestions and demands to improve sheep welfare, 35% (6/17) cited the need of support for the meat chain and profit from animal welfare as a value, 35% (6/17) requested help to mitigate predation and robbery problems and 29% (5/17) asked for more information and training regarding sheep welfare. In relation to animal abuse, answers listed first physical aggression (56%, 19/34) followed by not feeding the animals (32%, 11/34). Other answers were associated to fear (18%, 6/34), health problems (18%, 6/34), stress and suffering (12%, 4/34), animal isolation (9%, 3/34), thirst (9%, 3/34), low animal welfare (6%, 2/34), pain and injury (6%, 2/34), thermic stress by cold (3%, 1/34), restriction to natural behaviour (3%, 1/34) and killing the animal (3%, 1/34). Thus, farmers presented an interesting perception of animal welfare aspects of their activities and expressed relevant requests, mostly regarding more information on sheep welfare and the need for the attribution of higher value to sheep production.

Acknowledgment: CAPES Science Forensic Program

ANNEX 14 – PUBLISHED ABSTRACT INTITLED “MOTIVATION FOR CHASING BEHAVIOUR DISPLAYED BY COMMUNITY DOGS”

MOTIVATION FOR CHASING BEHAVIOR DISPLAYED BY COMMUNITY DOGS

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Many dogs are living as stray animals due to the difficulties in dog population management. Some of these dogs are recognized by the community and receive care from local residents and may be called community dogs. Some Brazilian cities are maintaining a Community Dog Program to improve both the welfare of the free-ranging dogs and their reproductive control, with positive public health benefits. One challenge of this strategy is the occurrence of chasing behaviour. Dogs that exhibit chasing behaviour are in greater risk of suffering mistreatment, such as being kicked, stoned or beaten. Furthermore, the behaviour may be harmful to other animals, including humans. The purpose of this research was to study the behaviour of chasing objects or individuals by community dogs, to understand its motivation. Six mixed breed dogs were observed and recorded for three chasing events. Four male dogs, three of them neutered, and two spayed females were studied. Dogs were aged between three and ten years old and have been living in the study area from three to eight years. Three videos of each dog, obtained during 6-h daily field observations per animal, were analysed by descriptive statistics considering body language, aspects of the context and other behaviours relevant to the identification of the motivation. The dogs exhibited chasing behaviour motivated mostly by territorialism in all studied events. In 72% of the events, the dogs presented offensive body language, and in 28% of the events their behaviour suggested that they may have experienced fear and discomfort in addition to territorialism, since there was defensive body language. The existence of fear as a motivation for chasing was evidenced by the hesitation during chasing, the exhibition of appeasement signals and the avoidance of contact with the target. In 56% of the events, the chasing started in front of the caretaker's house and none of the community dogs chased beyond the street where the caretaker lives. Therefore, the results suggest that the motivation for chasing behaviour in those occurrences was territorialism, which may be associated to fear. Our results on the territorialism aspect of the motivation coupled to further research detailing the reasons behind fear may shed light on the development of successful intervention strategies to mitigate chasing behaviour and its associated risks to the welfare of animals and humans.