

Review Article

Perception of Portuguese Consumers Regarding the Consumption of Cultured Meat

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Meat consumption is important to human diet due to its nutritional contents but the contents in saturated fatty acids, cholesterol and purines are harmful to human health. Furthermore, the population and urban growth expected in the coming decades and the consequent expected increase in the consumption of meat of animal origin is related to serious environmental, social and ethical problems that can jeopardize human food security and the future of the planet Earth. Cultured meat presents itself as a viable alternative, with no need to raise animals for slaughter, but consumer perception and acceptance are key factors for the implementation of this new product in the food sector. In the present study it was intent to observe the current pattern of consumption of conventional meat by Portuguese population, and the degree of concern regarding the problems with the food system. Data were collected through online anonymous questionnaire survey on social networks between the 30th October and 30th December 2021. Questionnaire was composed of 24 questions that addressed: i) sociodemographic data; ii) current social and environmental problems (related to meat consumption); iii) assessment of eating habits and food frequency consumption; and iv) perception of receptivity of the participants towards cultured meat. Results showed that 91.9% of the participants consume meat, while 8.0% of the sample reported not consuming any type of meat of animal origin. It was found that 55.2% of Portuguese participants were familiar with this new food, and 59.0% were willing to try cultured meat.

Keywords: Agriculture; Meat Consumption; Climate Change; Consumer Perception; Cultured Meat**Abbreviations**

DGS: Directorate-General for Health; GHG: Greenhouse Gases; LCA: Life Cycle Assessment; SPSS: *Statistical Package for the Social Sciences*

Introduction

After World War II, humanity witnessed a change in agri-food systems, becoming more hegemonic, that is, subject to certain diets, which gave rise to diets based on meat, wheat and milk (British hegemony) and diets based on meat, wheat and milk based on corn, soybeans and industrialized products (American hegemony), and these food systems led to the emergence of large consortia that began to control the value chains associated with food. Due to this organizational structure in the food sector, considerable environmental, social, economic and cultural impacts have arisen, and it is currently urgent to create new guiding principles, provide high quality diets, thus effecting a restructuring of the current agri-food system [1].

According to Lonnie et al., (2018), over time, meat has become an important part of the human diet, as it is considered an essential source of proteins, lipids and micronutrients [2]. Meat as a food product (from traditional livestock farming) is known in the literature as conventional meat, which can be defined as meat of animal origin for human consumption.

Although some popular myths address the probable vegetarian origin of the human being, according to Barrena (2020) evolutionary biology presents scientific evidence that homo-sapiens presents a series of adaptations, both anatomical and physiological oriented towards a more carnivorous diet [3], such as, for example, the characteristic mandible of the human being (it shows an omnivorous and not strictly vegetarian diet); short colon (greater difficulty in absorbing plant foods rich in fiber); the need for a diet with high protein quality (associated with the high cost of maintaining nervous tissue), and on the other hand, the human digestive system preferentially absorbs iron bound to hemoglobin and porphyrin compounds present in meat of animal origin. In contrast, herbivorous animals do not absorb iron from meat-associated compounds and rely on iron ions present in plants [3]. In this context, an exclusively vegetarian diet may not be natural to the human species, so the arguments in favour of a conventional meat-free diet continue to be of environmental, economic, ethical and personal health concerns.

The effects of the global agricultural industry are increasingly evident on our planet, with livestock alone accounting for 14.5% of human-induced Greenhouse Gas (GHG) emissions [4]. Considering the population and urban growth associated with the increase in food consumption, it is urgent to mitigate emissions from agricultural production, with this reformulation being a fundamental step towards achieving the goals of the Paris Agreement [5].

In this sense, alternative protein sources for human consumption,

such as meat grown in the laboratory, can be one of the solutions, providing a reduction in the environmental impact generated by traditional agriculture, animal welfare, better food security and increased efficiency in the production of meat. Meat? [6]. In this way, cellular agriculture is expected to be part of the fourth agricultural revolution, which can be defined as the controlled and sustainable manufacture of agricultural products through cells and tissues of plants or animals, without suppressing or slaughtering them. However, cultured meat is not yet commercially produced on a large scale, and estimates of its environmental impact are based on "Life Cycle Assessments" (LCA), which result in different conclusions related to the efficiency of the process [7], and according to Mattick (2018), the development of new renewable energy sources and the implementation of large-scale production processes could significantly reduce the selling price [8], since it currently costs six times more than conventional meat. According to several studies, compared to traditional agriculture, the production of cultured meat can use between 82 and 96% less water, 78 to 96% less GHG emissions, 99% less land and between 7 and 45% less energy, depending on the type of meat produced [8], and only in the case of the production of chicken meat, the energy used is higher than the value observed in the production of traditional poultry meat [8,9].

It should be noted that over the last decade, many consumers have changed their usual patterns of meat consumption, with an increase in alternative food products. In this context, cultured meat can represent a viable alternative to these products, strengthening the market by offering new categories of meat, for example, through the culture of cells from rare animals, endangered or extinct species (exotic meats).

In this way, since there is no need to slaughter animals, cultured meat can be well accepted among the vegetarian or vegan public gain [10]. In December 2020, cultured meat was regulatory approved by the Singapore Food Agency, being marketed to the public for the first time in a Singapore restaurant [11]. While most consumers admit willingness to try cultured meat [12,13], some consumers have concerns about food safety, sensory appeal and price [14,15], and, according to Slade [16], the perception of consumers about cultured meat changes quickly after receiving information about the advantages of this product and after trying cultured meat [16], as this product perfectly replicates the sensory appeal of conventional meat.

Literature Review

Eating Habits and Frequency of Meat Consumption

A food habit or diet can be defined by the way people use a certain food, being defined according to the culture and customs of each person, religion, influence of family members or acquaintances, but also by personal ideologies, through access to information or education, by income or food prices [17,18]. Currently, eating habits or diets such as the Mediterranean, carnivorous, omnivorous, flexitarian, vegetarian, vegan, lacto-vegetarian, ovo-lacto-vegetarian, frugivorous, raw, keto, ketogenic diet, among others, are common.

With regard to meat consumption by the portuguese, it was found in 2019, through the National Health Survey [19], that the frequency of meat consumption has been higher than recommended in the Food Wheel, with each portuguese having available for consumption,

in the period 2016-2020, on average, about 229.8 g/day of meat, with an increase of 8.7% in the average availability of meat of animal origin [19].

According to the report "*The Green Revolution Portugal*", carried out by Lantern (2020), there was a tendency for portuguese consumers to reduce their consumption of meat and sausages, with 45% of portuguese admit having reduced their consumption of red meat in the last year. Even so, the data indicate that 88.6% of portuguese consumers aged 18 years or over mention following an omnivorous diet, that is, they eat conventional meat in varying amounts and that 7.4% of the sample refers to having a flexitarian diet (reduced meat consumption), which, after all, 96.0% of the participants in this study consume meat of animal origin. In the Lantern study (2020) it was also found that 0.9% follow a vegetarian diet and 0.7% a vegan diet [20].

Structural and Biochemical Composition of Meat as a Food Product

Regarding the structural and biochemical composition of meat, according to Sarcinelli & Venturini (2007), the structural knowledge of meat, as well as its basic constituents and muscle biochemistry, are fundamental to understanding the functional properties of meat as food [21].

Generally, the epithelial tissue is presented by a smaller portion in the weight of the muscle, varying according to the location of the animal's body, the age, breed and species of the animal [22]. In the case of chicken meat, the characteristics of the epithelial tissue play a fundamental role in the formation of aroma, flavor and texture during the frying process [22]. As for the nervous tissue, it constitutes less than 1% of the meat, it is formed by highly specialized cells, being sensitive to stimuli of external origin, so when the nervous tissue is stimulated by nerve impulses, before or after the slaughter of the animal, can influence meat quality [22]. On the other hand, the adipose part of the connective tissue, which stores neutral fats and serves as an energy reservoir for the animal, has a high importance in the flavor, texture and juiciness of meat as food [22].

As for the chemical composition (g/100g) and energy content (kcal/100g), meat is mainly made up of proteins, lipids and water, in a proportion that can vary depending on factors such as age, breed or species and animal diet. Regarding the minerals present, meat has almost all the minerals necessary to meet the nutritional needs of human beings (phosphorus and potassium), as well as being an excellent source of trace elements (zinc and iron), and iron from meat has better bioavailability than the iron present in foods of plant origin. In terms of protein content, meat has proteins of high biological value, as it contains almost all the essential amino acids for human nutrition [22].

On the other hand, the lipids (fats) present in the meat are pointed out critically, since they are harmful to the human being when there is an excess of meat consumption. In this context, long-chain saturated fatty acids are responsible for some processes that are harmful to human health, and undesirable substances such as cholesterol and purines are still present [22].

World Meat Production

World meat production reached 337 million tons in 2019, an

increase of 44% (+103 million tons) compared to the year 2000. Despite the fact that there are several species of animals raised for slaughter and human consumption, only three represent 88% of global production (poultry, pork and beef). In this context, poultry meat has shown the highest growth in absolute and relative terms since 2000, covering 35% of world production in 2019, making it the most produced type of meat for consumption in the world. Among the main meat producers in the world, China, the United States of America and Brazil produce about 40% of the total production [23].

Social, Environmental, Economic and Ethical Problems Associated with the Consumption of Conventional Meat

The production and consumption of meat is associated with population and urban growth, with a clear and proven influence on problems related to food insecurity, global warming and consequent climate change, deforestation and loss of plant and animal biodiversity, pollution of natural resources (water, soils), generating problems such as hunger, unemployment and poverty, in addition to causing the suffering and exploitation of animals raised for slaughter, which are often treated in precarious conditions and using antibiotics used in the agricultural industry.

Use of natural resources and inefficient conversion of nutrients: Given the population growth and the strong demand for food of animal origin, the natural resources to sustain this growth are overloaded, and the planet can no longer sustain this increase in pressure [24].

Globally, 30% of the land surface is used for the production of animal feed to feed livestock [25], while the water used for growing animal feed represents 98% of the total water footprint of livestock production [26].

On the other hand, the feeding process of the animals may vary according to the species, especially between ruminant animals (cattle) and monogastric animals (poultry and swine). With regard to the feed conversion obtained by transforming animal feed into meat (as an end product), this process is measured according to the efficiency with which animals convert feed into body weight gain or usable product. Thus, raising cattle has a less efficient feed conversion compared to raising poultry or swine, and for each kilogram (kg) of edible meat (final product) 25 kilograms of feed obtained from feed and pasture are required [27]. Raising poultry or swine, as mentioned above, has more efficient values in the conversion of nutrients than cattle, and to obtain 1 kg of meat from a swine it is necessary to feed it with 6.4 kg of dry feed, while a bird only needs 3.3 kg of dry feed for every kilogram of edible meat. Other animal products, such as eggs and whole milk, have more efficient ratios than meat, 2.3 kg and 0.7 kg respectively [27].

Concept of Cultured Meat

Cultured meat is produced using animal cell culture (or culturing) technology, genuinely produced from specimen stem cells. The method of selecting the animal's genetic material can be performed from muscle, fat or connective tissue, using a biopsy, which is a painless process for the animal. Subsequently, from a single stem cell, successive multiplications and subsequent differentiation and maturation, there is an increase in the number of cells and cell density. This process is carried out in a sequence of progressive

scale bioreactors, until the appropriate amount of cells is reached, with or without the combination of other support materials. The cells obtained contain the same types of cells that are organized in the three-dimensional structures present in animals, forming the same tissues, so they can perfectly replicate the sensory and nutritional profile of beef, chicken, seafood or other meat products, conventionally produced [28].

Cultured Meat and Consumers

Concerns about animal welfare, sustainable meat production and awareness of GHG emissions associated with livestock are on the rise among consumers, which gives rise to interest in more sustainable meat alternatives, among which is cultured meat.

Several studies carried out in recent years have sought to understand public perception and consumer acceptance of cultured meat, analyzing issues such as the influence of environmental impacts, animal welfare, sustainability of the production process [28], between others.

According to Pakseresht et al. (2022), there is a link between consumer knowledge and attitude towards agri-food technologies, and consumer skepticism in new food production technologies (food neophobia) is associated with a lack of knowledge of the technology and its advantages. With regard to cultured meat, the literature points to evidence for the lack of knowledge of consumers in relation to the technology of cellular agriculture, having observed that individuals aware of the concept of cultured meat showed more predisposition to accept this product, and it should be noted that several studies indicate that prior knowledge can increase consumers' willingness to accept cultured meat [29].

Materials and Methods

Bearing in mind that cultured meat is not yet marketed in Portugal and it is not possible, as it would be convenient, to hold a sensory analysis event among Portuguese participants, in order to experience this new food product, we sought to assess the perception of Portuguese consumers in relation to certain environmental, social and ethical problems associated with the agricultural sector, as well as in relation to cultured meat.

An online questionnaire (*Google Forms*) was used as a research and information collection tool, which was distributed for 60 days through social networks. In addition to evaluating the eating habits of the Portuguese participants, we sought to observe their perception of the consumption of cultured meat and the possible availability to taste this new food.

The data collected from 1280 Portuguese participants were processed using the *Statistical Package for the Social Sciences* (SPSS) version 26.0.0 program, using basic exploratory data analysis techniques such as mean, standard deviation, percentage, absolute frequency or relative and the chi-square test of independence, as well as the respective contingency tables with significance tests ($p < 0.05$).

Results

Among the 1280 Portuguese participants, 72.2% were female and only 27.8% were male, with a minimum age of 18 years and a maximum of 74 years. With regard to the district of residence, there

Table 1: Eating habits and frequency of meat consumption (n = 1280).

Participants usual diet	n	%
Mediterranean diet	935	73,0
Carnivorous	160	12,5
Flexitarian	70	5,5
Vegetarian	31	2,4
Fish-vegetarian	28	2,2
Egg-lacto-vegetarian	23	1,8
Vegan	16	1,3
Others	16	1,3
Total	1280	100,0
Consumption of conventional meat by the participants	n	%
Yes	1176	91,9
No	102	8,0
Not specified	2	0,2
Total	1280	100,0
Frequency of consumption of red meats	n	%
2 a 4 times a week	403	31,5
1 vez por semana	362	28,3
1 a 3 times a month	245	19,1
Never or less than once a month	182	14,2
5 a 6 times a week	70	5,5
1 time a day	18	1,4
Total	1280	100,0
Frequency of consumption of white meats	n	%
2 a 4 times a week	624	48,8
1 vez por semana	212	16,6
5 a 6 times a week	182	14,2
1 a 3 times a month	137	10,7
Never or less than once a month	88	6,9
1 time a day	37	2,9
Total	1280	100,0
Frequency of consumption of processed meats	n	%
Never or less than once a month	422	33,0
1 a 3 times a month	389	30,4
1 time a week	310	24,2
2 a 4 times a week	128	10,0
5 a 6 times a week	22	1,7
1 time a day	9	0,7
Total	1280	100,0

of the participants consume this type of meat between 2 and 4 times a week and 28.3% at least once a week, with 19.1% of the sample mentioning they consume red meat between 1 to 3 times a month. Regarding the habit of consuming white meat, it was observed that 48.8% of the participants consume this type of meat between 2 and 4 times a week, that is, more often than red meat (+17.3%), verifying It is also noted that 16.6% of the participants consume white meat once a week, 14.2% have the habit of consuming it 5 to 6 times a week and 10.7% between 1 and 3 times a month. Regarding the consumption of processed meats such as sausages, ham, bacon, the data obtained indicate that the consumption of this type of meat is not as frequent as in the case of red or white meats, observing that 33.0% of participants admit that they consume processed meats “never or less than once a month”, while 30.4% report consuming this type of meat between 1 and 3 times a month and 24.2% of the sample consume processed meats once per week (Table 1).

After performing a statistical analysis ($p < 0.05$) on the frequency of meat consumption by participants (Table 2), it was found that male participants consume red meat “2 to 4 times a week” and that female participants admit to consuming meat “never or less than once a month” ($p = 0.001$).

As for the possibility of reducing or abstaining from meat consumption, taking into account certain reasons, 50.4% of the participants admit they are willing to make this sacrifice, with personal health (56.6%) being the main reason, followed by animal welfare (40.3%), environmental concerns (37.8%), alternative foods (32.3%) and the current price of meat (12.2%).

It should be noted that only 36.4% of the sample believes that it is not possible to maintain the sustainability of the current food system without reducing meat consumption. In this sense, it was observed that female participants admit that they are ready for this decision-making ($p = 0.001$) (Table 3).

Table 2: Frequency of consumption of red meat according to the gender of the participants (n = 1280).

Frequency of consumption of red meat	Gender				χ^2 / p
	Male		Female		
	n	%	n	%	
Never -1 time/ month	22	6,2	160	17,3	$\chi^2 = 34,327$ $p = 0,001$
1-3 times/ month	68	19,1	177	19,2	
1 time/ week	97	27,2	265	28,7	
2-4 vezes/ week	136	38,2	267	28,9	
5-6 times/ week	25	7,0	45	4,9	
1 time/ day	8	2,2	10	1,1	
Total	356	100,0	924	100,0	

was a more active participation by residents of the Autonomous Region of Madeira (23.0%), Lisbon (18.8%) and Porto (10.2%). It should be noted that 69.2% of the participants reported having a higher education course.

Regarding the type of diet, it was observed that 73.0% of the participants follow a Mediterranean diet, 12.5% follow a strictly carnivorous diet, 2.4% are vegetarians and 1.3% claim to be vegans. Overall, 91.9% of the sample admitted to consuming conventional meat, while 8.0% mentioned that they do not eat any type of meat of animal origin.

As for the consumption of red meat, it was observed that 31.5%

On the other hand, taking into account the concern for the environment (Table 4), it was found ($p < 0.05$) that participants aged 44 years and over have no intention of reducing meat consumption for this reason, as well as male participants. It was also observed that, regarding the price of meat, female participants do not consider the price as a relevant reason, following the reasoning of participants in general over 44 years old (Table 5).

With regard to prior knowledge of cultured meat, it was observed that 55.2% of the sample had already heard about this food product, with 59.0% agreeing partially or totally that cultured meat can contribute to the well-being of the population (Table 6).

On the other hand, we sought to assess the perception of portuguese consumers in relation to cultured meat, having observed

Table 3: Willingness of participants to reduce or abstain from meat consumption according to gender (n = 1280).

Willingness to reduce or abstain from meat consumption	Gender				χ^2 / p
	Male		Female		
	n	%	n	%	
Yes	129	36,2	516	55,8	$\chi^2 = 64,754$ $p = 0,001$
No	120	33,7	145	15,7	
I'm not sure	96	27,0	212	22,9	
I don't eat meat	11	3,1	51	5,5	
Total	356	100,0	924	100,0	

Table 4: Concern for the environment as a reason to reduce meat consumption (n = 1280).

Concern for the environment	Age in classes								χ^2 / p
	18-34		35-43		44-49		50-74		
	n	%	n	%	n	%	n	%	
No	165	51,1	226	65,3	203	67,2	202	65,4	$\chi^2 = 22,962$ p = 0,001
Yes	158	48,9	120	34,7	99	32,8	107	34,6	
Total	323	100,0	346	100,0	302	100,0	309	100,0	

Concern for the environment	Gender				χ^2 / p
	Male		Female		
	n	%	n	%	
No	249		69,9		$\chi^2 = 12,617$ p = 0,001
Yes	107		30,1		
Total	356		100,0		

Table 5: Conventional meat price as a reason to reduce meat consumption (n = 1280).

Conventional meat price	Age in classes								χ^2 / p
	18-34		35-43		44-49		50-74		
	n	%	n	%	n	%	n	%	
No	263	81,4	304	87,9	274	90,7	283	91,6	$\chi^2 = 18,828$ p = 0,001
Yes	60	18,6	42	12,1	28	9,3	26	8,4	
Total	323	100,0	346	100,0	302	100,0	309	100,0	

Conventional meat price	Gender				χ^2 / p
	Male		Female		
	n	%	n	%	
No	298		83,7		$\chi^2 = 7,764$ p = 0,005
Yes	58		16,3		
Total	356		100,0		

Table 6: Distribution of the sample in relation to prior knowledge about cultured meat (n = 1280).

Prior knowledge about cultured meat	n	%
Yes	706	55,2
No	491	38,4
I'm not sure	83	6,5
Total	1280	100,0

that only 14.6% of the sample disagreed that the production of cultured meat is a viable technology, with 52.7% considering a reduction in GHG associated with the production process of cellular agriculture compared to the production of meat in traditional agriculture, while 50.1% of the sample would support research and development of this product if they were in the position of rulers. Regarding the sensory appeal of cultured meat, only 22.8% disagreed that this product may have better taste, texture and aroma than conventional meat.

Regarding the negative impact that the production of cultured meat could have on the traditional agriculture sector, 50.2% partially or totally agree that the commercialization of cultured meat will have a consequent impact on this traditional sector. In the field of zoonoses, 49.3% admit that cultured meat is safer than meat production in agriculture, while only 17.2% say that cultured meat would not be advantageous in times of pandemics such as COVID-19.

In terms of animal welfare, 59.0% agree that the production of cultured meat is more ethical than the production of cultured meat, and 32.8% do not believe that cultured meat can solve the problem of hunger in the world. It should also be noted that in the opinion of 50.2% of the participants, cellular agriculture will have a negative impact on the traditional agriculture sector.

One of the most relevant issues of this study is the potential availability for Portuguese consumers to accept and to try this new food. In this context, it was observed that 59.0% admit being available to taste cultured meat and that 51.2% would buy cultured meat if the price was similar to that of conventional meat, and 19.0% would only buy if the value was lower, and only 4.1% agreed to pay a higher premium.

As for the obstacles to the commercialization of meat grown in Portugal, the participants mentioned fear or apprehension in relation to new foods, known as food neophobia (59.6%), the selling price of the product (53.6%), the sensory appeal (51.2%), ethical concerns (27.9%), legislation and regulations (19.7%), religious motives (6.3%), Portuguese culture, tradition and gastronomy (2.7%), food security (1.8%), among others.

Discussion

Comparing the results obtained between the study “Perception of Portuguese consumers in relation to the consumption of cultured meat” and with data from the report “The Green Revolution Portugal 2021” [22], similar results can be seen in some fields, since the participants refer an intention to reduce the consumption of conventional meat, the proportion being 50.4% and 45.0% respectively in both studies. On the other hand, among the reasons that would lead the participants to reduce the consumption of conventional meat, it was observed that the priority areas present correspondences in the first three choices, being personal health (56.6% and 68.0% respectively), animal suffering (40.3% and 30.0% respectively) and concern for the environment (37.8% and 29.0% respectively) were the most voted categories in both studies.

These data may represent a positive sign for cultured meat, taking into account what was mentioned by Bhat et al., (2017), which mentions that cultured meat can bring benefits to health and the environment, as it is possible to safely manipulate the composition of meat, providing less saturated fat, purines and cholesterol, as well as higher protein content, creating a healthier meat prototype [10].

On the other hand, through the data from our sample (n = 1280), it was observed that gender has no influence on the availability to try cultured meat, with younger participants with a more advanced level of education being more likely to agree to consume cultured meat.

Regarding the current price of cultured meat, the large-scale production method, as mentioned by Mattick (2018), could significantly reduce the selling price of this new product [8], requiring more investment in research and development.

Conclusion

Food neophobia, sensory appeal and the price of cultured meat are the main determinants for the acceptance of this new food by Portuguese consumers, taking into account that the probability of acceptance of cultured meat by consumers is higher when information is provided on the advantages of cellular agriculture in relation to meat production in traditional agriculture, which can considerably reduce the degree of food neophobia.

As for the price of cultured meat (currently it costs about six times more than conventional meat), this can be one of the main challenges of this new product, given that a less expensive manufacturing process is dependent on large-scale production, but it is a challenge with a solution in sight. However, taking into account that 4.1% of the sample mentioned that they would buy cultured meat, even if the price were higher, we can conclude that the consumption of conventional meat in Portugal could see a reduction of 4.1%, if the commercialization of cultivated meat becomes a real thing at the moment, which, despite being a paltry amount, would at least contribute to reducing the environmental footprint on the planet.

Regarding the sensory appeal, according to experts in the cellular agriculture industry and according to reports from consumers who have already tasted this food, they say that cultured meat exceeds in quality the characteristics of conventional meat, exceeding all expectations. In this way, conducting sensory analysis tests on meat grown in strategic locations can reach new fans and contribute to the mitigation of problems associated with traditional farming.

References

- Torrens JCS. Sistemas Agroalimentares. *P2P E INOVAÇÃO*. 2020; 7: 192–211.
- Lonnie M, Hooker E, Brunstrom JM, Corfe BM, Green MA, et al. Protein for life: Review of optimal protein intake, sustainable dietary sources and the effect on appetite in ageing adults. In *Nutrients*. 2018; 10: MDPI AG.
- Palmqvist Barrena P. *Vegetarianismo: é natural que os seres humanos incluam carne em sua dieta?* BBC News Brasil. 2020.
- Gerber PJ. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome. In *Most*. 2013; 14: 2.
- Baum CM, Bröring S, Lagerkvist CJ. Information, attitudes, and consumer evaluations of cultivated meat. *Food Quality and Preference*. 2021; 92: 104226.
- Reis GG, Heidemann MS, Borini FM, Molento CFM. Livestock value chain in transition: Cultivated (cell-based) meat and the need for breakthrough capabilities. *Technology in Society*. 2020; 62.
- GFI. Growing Meat Sustainably: the Cultivated Meat Revolution. *The Good Food Institute*. 2018; 1–4.
- Mattick CS. Cellular agriculture: The coming revolution in food production. *Bulletin of the Atomic Scientists*. 2018; 74.: 32–35.
- Tuomisto HL, Teixeira De Mattos MJ. Environmental impacts of cultured meat production. *Environmental Science and Technology*. 2011a; 45: 6117–6123.
- Stephens N, di Silvio L, Dunsford I, Ellis M, Glencross A, et al. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. In *Trends in Food Science and Technology*. 2018; 78: 155–166.
- Bhat ZF, Kumar S, Bhat HF. In vitro meat: A future animal-free harvest. *Critical Reviews in Food Science and Nutrition*. 2017; 57: 782–789.
- Bryant C, Sanctorem H. Alternative proteins, evolving attitudes: Comparing consumer attitudes to plant-based and cultured meat in Belgium in two consecutive years. *Appetite*. 2021; 161: 105161.
- Bryant C, van Nek L, Rolland NCM. European markets for cultured meat: A comparison of Germany and France. *Foods*. 2020; 9.
- Wilks M, Phillips CJC. *Attitudes to in vitro meat: A survey of potential consumers in the United States*. 2017.
- PS Valente J, Fiedler RA, Heidemann MS, Maiolino Molento CF. First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil. *PLoS ONE*. 2019; 14.
- Lupton D, Turner B. Food of the future? Consumer Responses to the Idea of 3D-Printed Meat and Insect-Based Foods. *Food and Foodways*. 2018; 26: 269–289.
- Slade P. If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. *Appetite*. 2018; 125: 428–437.
- Blein SI. O padrão alimentar ocidental: considerações sobre a mudança de hábitos no Brasil. 1998.
- Lody R. *Brasil bom de boca: temas de antropologia da alimentação*. 2008.
- DGS. *PROGRAMA NACIONAL PARA A PROMOÇÃO DA ALIMENTAÇÃO SAUDÁVEL*. 2020.
- Lantern. *The Green Revolution Portugal*. 2020.
- Freire Sarcinelli M, Silva Venturini K. *Estrutura da Carne*. 2007. www.agais.com.
- de Oliveira Roça R. *COMPOSIÇÃO QUÍMICA DA CARNE*. 2011.
- FAO. World Food and Agriculture – Statistical Yearbook 2021. In *World Food and Agriculture – Statistical Yearbook 2021*. FAO. 2021.
- Fox JL. Test tube meat on the menu? *Nature Biotechnology*. 2009; 27: 873–873.
- FAO. Livestock's Long Shadow: Environmental Issues and Options. In *FAO*. 2006.
- Godfray HCJ, Aveyard P, Garnett T, Hall J W, Key TJ, et al. Meat consumption, health, and the environment. In *Science (New York, N.Y.)*. 2018; 361.
- Alexander P, Brown C, Arneith A, Finnigan J, Rounsevell MDA. Human appropriation of land for food: The role of diet. *Global Environmental Change*. 2016a; 41: 88–98.
- Porto LM, Berti FV. *Carne cultivada: perspectivas e oportunidades para o Brasil*. Good Food Institute BR. 2022. www.gfi.org.br/gfibr@gfi.org.
- Paksereshat A, Ahmadi Kaliji S, Canavari M. Review of factors affecting consumer acceptance of cultured meat. *Appetite*. 2022; 170: 105829.