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Review article
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ASSESSMENT OF THE CONSUMERS' ATTITUDE TO THE ALTERNATIVE MEAT. REVIEW

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Keywords: *meat substitutes (analogues), cultivated meat, alternative proteins, consumers' behavior, food neophobia*

Abstract
Cultivated meat technology is a new and pretty controversial food technology presented as a method of meat production without dependence on large-scale farming of industrial livestock. It is based on the principles of people's humanistic attitude to animals and environmental care. The article summarizes the results of the "life cycle" assessment of the cultivated meat and the possible environmental effect of its production technology on global warming. The presented review is aimed at assessing consumer perception of cultivated meat by analyzing and systematizing the results of previous studies that examined the consumers' attitudes to the risks and benefits of the alternative meat. Systematized research data allowed identifying key factors that influence onto the consumers' perception of the food products. For example, one of the main reasons for a negative attitude towards cultivated meat is food neophobia. In addition, differences in this product acceptance by various consumers groups were analyzed. Generalization of the results allowed systematizing the motivators and barriers that may affect the mass consumption of the cultivated meat in the future, taking into account the innovations in the new food technologies development. Acceptance rates of the cultivated meat vary in relevance with demographics, socio-cultural, religious, ethical perceptions and traditions. However, it should be noted that there is no consensus on the perceived advantages, disadvantages, threats and opportunities of the consumers' acceptance of the cultivated meat. This review notes that a number of studies show a relatively high level of consumer/population willingness to try the cultivated meat. However, the acceptance rates of the cultivated meat are generally lower than for other alternative proteins (e. g. legumes, plant-based meat). The main negative factor in the acceptance of the cultivated meat is that consumers perceive the cultivated meat as the unnatural one.
The study therefore examines various issues related to the formation of both positive and negative attitudes towards the cultivated meat. It also helps to better understanding the consumers' psychology and allows more accurate prediction of their behavior.

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Introduction

Diet and environmental sustainability are closely linked. Food choices, eating habits and consumption patterns affect climate change, biodiversity and the way of using the energy, water and land. Although consumers are generally unaware that their dietary patterns and eating behaviors are part of a broader concept of environmental sustainability, the scientists dispute that prevailing dietary principles are having a threatening effect on the planet's ecological environment. In this context, the livestock sector became the focus point of the heightened attention of the scientific community due to its impact on climate change, including methane emission from the decomposition of organic waste, as well as ethical issues and impacts on human health [1,2,3,4]. The livestock industry is estimated to account for 14.5% of anthropogenic greenhouse gas emissions [5].

In recent years meat processing plants, engaged in production of organic meat, have been exposed to increasing pressure due to heightened attention to the role of corporate actors and their responsibility for the effect on climate change [6]. The meat industry has been criticized for its economic inefficiency, environmental costs, and its negative impact on human health [4,7].

More and more studies highlight the consumers' concerns about the environmental, human health and animal wellbeing impacts of meat consumption. Additionally, taking the COVID-19 pandemic into consideration, there is a growing awareness that meat production may cause the zoonotic diseases [8]. In addition, there is a concept known as the "meat paradox", which is the contradiction between love and respect for animal life on the one hand, and the pleasure experienced from eating meat, on the other hand [9]. These arguments are used by some market players to promote meat analogues or meat alternatives from various protein sources. All of the above, together with forecasts of global population growth and increasing demand for protein products, set the preconditions for development of the alternative proteins [1].

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Researchers have analyzed the various options of using the existing resources pursuing the target to improve the sustainability of food production. The attention is focused on minimizing the using additional agricultural land, water, and other natural resources in order to reduce the load on the environment. Key measures include changing diets to be healthier and more plant-based ones, improving manufacturing technologies and management practices, and reducing food loss and waste volume [10,11].

New food products like meat substitutes, including insect protein, plant proteins and the cultivated meat [12], are ultimately intended to replace traditional meat partially.

One of the available meat analogues, the cultivated meat, is considered as a promising solution to meet the consumers' demand for meat products. Its production is aimed at reducing the negative impact on the environment, solving problems of antibiotic resistance, and ensuring humanistic attitude to the animals. In recent years, there has been a surge of interest from investors and the media to the cultivated meat production technology. At the end of 2022, there were more than 156 publicly announced companies worldwide that produce the cultivated meat [13].

However, despite the potential benefits of *in vitro meat,* further research is needed into its environmental benefits, nutritional characteristics, production ethics and the safety of products made from it [14,15,16].

The cultivated meat (also known as cellular, the cultivated, clean, slaughter-free, *in vitro,* lab-grown, and nanopastured meat) has recently gained popularity. The cultivated meat does not require large-scale farming methods and is produced by culturing animal cells *in vitro* without raising animals [17]. Unlike plant-based meat, which imitates the taste and texture of traditional meat, the cultivated meat is derived from animal muscle tissue [1].

In addition, the results of a preliminary life cycle analysis of *in vitro* meat production by Tuomisto and de Mattos [18] showed that using, for example, cyanobacterial biomass as a nutrient source could reduce energy consumption and land use by 99%, water consumption by 90%, and energy consumption by 40%. If this reduction in resources using were implemented, it would lead to a significant reduction in greenhouse gas emissions and an improved environmental situation.

Currently, the above-specified calculations are contradictory and not comprehensive enough, given the following arguments: 1) the various life cycle assessments of the alternative meat, that are currently available, are based on hypothetical data, and do not provide an accurate assessment (since the cultivated meat is not yet produced in industrial volumes); 2) a comparison based solely on quantitative data (based on CO_2 equivalent only) is meaningless, since it is necessary to take into account, for example, the differences between methane CH_4 and carbon dioxide CO_2 [15].

For example, in their study, Lynch, J. and R. Pierrehumbert [19] compared the potential climate impacts of the cultivated meat and cattle production using a simple climate model that simulates the behavior of carbon dioxide ($CO_{2)}$, methane (CH_4) and nitrous oxide ($N2O)_,$ rather than relying solely on CO_2 equivalents. Cattle production systems cause the emissions of all three of these greenhouse gases, including significant emissions of CH_4, while emissions from the cultivated meat production are almost entirely limited to CO_2. However, emissions of short-life gases like methane behave very differently in comparison with CO_2. Lynch, J. and R. Pierrehumbert [19] concluded that, in the short term, global warming will be less associated with the cultivated meat production rather than with the cattle meat production. However, in the long term, the impact of the cultivated meat production will be more significant because short-life gases such as CH_4 build-up in the atmosphere in fewer quantities compared to CO_2. It can therefore be assumed that the warming impact of livestock farming will decrease and stabilize the environment over the years, while the warming due to the long-life CO_2 gas emitted by the production of the cultivated meat will remain. That is, the potential advantage of the cultivated meat over cattle meat in terms of global greenhouse gas emissions is not fully proven [19].

The recent life cycle assessment of the cultivated meat demonstrates that it will be the most environmentally friendly meat product if produced using sustainable energy [20]. Accordingly, the widespread introduction of the cultivated meat into human diets could improve the sustainability of the global food system [21].

For a new meat substitute to be widely adopted, it must imitate closely or, even better, recreate all the properties of traditional meat, including appearance, texture, flavor and taste. If successfully developed, it could be considered a meat equivalent without derogatory terms [17]. Proponents of alternative meat argue that its production would require significantly fewer or no farm animals, which in turn could help reducing the environmental concerns related to the high carbon and water footprint of the traditional livestock farming [18,22]. Since the cultivated meat is "real meat", it is expected to have the same or even improved properties compared to conventional meat. Given that the cultivated meat is nearly identical to conventional meat at a molecular level, it is likely to have similar organoleptic characteristics, including taste, flavor, texture and appearance, and could therefore be a viable substitute for traditional meat [23]. *In vitro* meat culturing could promote the development of new products with improved or specialized properties. For example, the biochemical composition of meat could be altered in a way to improve its nutritional quality by adding more polyunsaturated fatty acids or vitamins, which could be achieved by altering culturing conditions [17,24].

The technology of meat culturing is still under research, and different production methods (e. g. cyanobacterial-based culturing media and plant-based culturing media for tissue growing) are being studied to improve its characteristics and organoleptic properties [18].

Industrial production the cultivated meat is still in its early stages of development [25]. Companies developing the cultivated meat are looking for ways to improve their efficiency and reduce costs in order to bring their products to a competitive market, given that there are certain social and ethical limitations, and a number of technological issues (effective culturing conditions, etc.) still need to be addressed. However, the most important step towards commercialization of the cultivated meat is its acceptance by the consumers. Researchers have already established that consumers' attitudes play a key role in the acceptance of new food technologies [2,5,7,14,26–29].

Consumers' experience plays an important role in ensuring the sustainable competitive advantage of a product [30]. Consumers' experience is defined as the sum of customers' perceptions during consumption, purchase, use, and feelings from their interaction with a product or the goods [31]. Although there is no consensus on the definition and concept of consumers' experience, most scholars agree that this experience is formed during the decision-making process. It covers the entire consumption chain, which includes a series of interactions with the various objects. These interactions effect the cognitive, affective, sensory, and behavioral reactions. As a result, the total sum of feelings, perceptions and attitudes are formed, which constitute the consumers' experience [31].

Researches on food consumption show that food consumption experiences include sensory perceptions such as taste, flavor, smell and appearance. They play an important role in shaping consumers' hedonistic and emotional reactions of the consumers to the food. Moreover, the consumers look for the food products with some novel ingredients that contribute to the sustainability of food production systems and improve the health [32]. In other words, the perceived food attributes such as tenderness, juiciness, flavor and taste can enhance positive food experience [33] and contribute to consumers' behavioral intentions such as repeated purchase. For these reasons, food producers should take into account the changes in food preferences and choices to improve food quality and to understand better the consumers' behavior.

Materials and methods

The purpose of this article is to provide the review of interdisciplinary literature on the potential benefits and risks of the cultivated meat, considered from an environmental care and healthcare perspective.

This review is based on the scientific articles published in English and Russian from January, 2005 to July, 2024. The publications were selected from the databases of Scopus, Google Scholar, Science Direct and eLibrary. These articles examine data targeted to analyzing and summarizing the evidence base for the consumers' acceptance of the cultivated meat as an alternative for the natural meat. Particular attention is paid to the perception of these technologies by various population groups, and society as a whole.

The extensive literature search methodology, used to conduct the study, consisted of two stages. The first stage involved a literature search to collect the representative studies. The second stage involved selection of source based on the analysis of the title and abstract of each publication. The selection was conducted via using keywords and phrases such as: "meat substitutes", "alternative proteins", "the cultivated meat", "*in vitro meat*", "cellular agriculture", as well as terms related to "sustainability", "food system", "consumers' eating behavior", "consumers' acceptability", "willingness to reduce animal protein intake", "motivation to consume the cultivated meat" and "health". The documents related to the analysis tools of the consumers' perception for the cultivated meat were selected. Motivators and barriers that could influence its mass consumption in the future, including the acceptance of food innovations, were also examined. Key risks that prevent the population's mass acceptance of the cultivated meat were then defined. Among them are safety and nutrition issues, the feeling of unnaturalness of the product, mistrust, disgust and food neophobia. At the same time, economic and ethical issues are highlighted, as well as two uncertainties that will significantly influence consumers' perception in the long term: price and taste. The review concludes with a discussion of the main strategies aimed at defining the ways of increasing the acceptability of the cultivated meat.

Inclusion criteria:

- results of quantitative studies of the cultivated meat perception, conducted among the adult population in the various focus groups;
- results of studies on the consumers' willingness to reduce their consumption of animal protein and the study of the consumers' behavior in this context;
- research into the consumers' behavior and assessment of the level of public acceptance of the new protein sources introduced to replace animal protein from the meat;
- assessment of the factors that positively and/or negatively influence the consumers' perception of the cultivated meat;
- possible strategies for the introduction of the cultivated meat and meat products into the diet.

Exclusion criteria:

- research not related to the consumers' behavior;
- research in the vegetarianism and veganism field;
- scientific works limited to the meat consumption analysis without taking into account changes in the food consumption structure;
- publications focused on the physiological aspects of meat consumption;
- studies on the consumption of the organic meat compared to the conventional meat;
- scientific publications targeted to analyzing the consumers' perceptions of alternative proteins — plant-based, including algae and legumes, and insect proteins.

The initial selection by the terms presented 793 articles, with the largest number of publications (97.7%) taking place within the period 2015–2024. 670 articles were excluded

because they did not meet the inclusion criteria. In particular, these articles were not related to consumers' behavior or their perception of the cultivated meat. As a result, 123 full-text articles were selected, 36 of which were excluded. For the final selection and selection of articles, the "snowball" method was used — a non-probability (chain) sampling method and the inclusion and exclusion criteria were considered. Thus, the reference list of the analyzed articles was used to identify additional publications. Only those documents were taken into account that contained a detailed analysis aimed at studying the perception of the cultivated meat by consumers', as well as the factors that determine and influence consumers' attitudes towards it. The literature search and "snowball" build-up were conducted until new correlations and information ceased to be found. As a result, 87 articles were included into the systematic review. Duplicates of articles were screened out and were not considered.

Alternative meat substitutes (protein sources)

Meat is an essential source of protein, of fat, iron and many other nutrients crucially essential to humans. Meat is a food that has significant cultural and social significance, as its consumption is associated with hedonism, satiety and celebratory moments. However, environmental, nutritional, social and moral issues associated with its production, processing and consumption are gradually stimulating demand for alternative proteins [34].

Market trends contribute significantly to the high demand for meat, including poultry, as the alternative protein segment accounts for less than 4% of the total global protein share. At the same time, the accelerated growth of the alternative protein industry (its compound annual growth rate is 2–3 times higher than that of meat, including poultry) and its market penetration, especially among the fast-growing sector of the flexitarians [35,36], facilitate the search for new ways of protein producing. These methods should ensure food security for the growing global population, while promoting environmental protection and animal wellbeing. Since the industrial revolution and changing eating habits, people's need for meat has increased many times over. There is an interesting phenomenon related to economic stability and meat consumption. Meat consumption is higher in the developed countries of the world, and its consumption keeps gradually increasing as the number of middle-income people increases worldwide. Taking this trend into consideration, it is feasible to develop an efficient meat production system to satisfy the future meat demand [37].

Pathways to reducing natural meat production may include reducing meat consumption in favor of unprocessed plant-based sources, developing various "meat alternatives" based on plant proteins, fermentation proteins, invertebrate proteins, or lab-grown proteins, based on farm animal cells [7,38].

Alternative protein sources are used to substitute the protein-rich animal products, and are an integral part of sustainable food systems that satisfy human protein needs, which are predicted to nearly double by 2050. It was noted that there are two opposing trends in protein consumption: low-income populations are shifting from plant-based to animal-based protein sources, while high-income populations are seeking to substitute animal-based protein sources with alternatives [39].

The studies conducted have systematized groups of the products that are alternatives to animal/fish proteins [39,40]:

1) using the substitutes. This option provides for the using of readily available substitute of the target compound, like available vegetarian diet options;
2) modification of existing non-animal/non-fish protein sources. This option provides for the modifying the available non-animal/non-fish protein sources in order to replace the target compound with, for example, insects-derived protein;
3) creation of alternative sources of proteins. This option is innovative and offers the greatest potential for solving the most complex problems. It involves the use of new technological processes for the production of proteins, such as 3D bio-printing, cell culture products, precise fermentation, etc. in terms of product characteristics / in the context of creating a new product / in terms of product production;

The most important groups of alternative proteins are insect-derived proteins, as well as plant proteins including algae and legumes, and the cultivated meat [41,42]. However, the potential of the cultivated meat, algae and insects as an important part of the future diet is considered to depend on nutrient bioavailability and digestibility, food safety, production costs and the consumers' acceptance [43].

Meat substitutes made entirely from plant components are increasingly present on the market, and their share is gradually increasing. Most products are based on soy proteins, milk proteins, wheat proteins or on mycoprotein. Although texturing technologies of improving the sensory perception and taste of these products are constantly being improved, it is quite difficult to accurately imitate meat when using plant proteins, carbohydrates and fats. Therefore, plant-based meat substitutes are mainly used in processed meats such as hamburgers, sausages or other types of minced meat products [17].

Insects are another source of alternative proteins. As food the insects are generally considered a healthy, nutritious alternative to conventional meat products such as chicken, pork, and beef. At all stages of their life cycle, they contain significant amounts of protein (40% to 70% of dry matter), minerals such as calcium, iron, zinc, and vitamins. Their amino acid composition is similar to amino acid composition of beef and soy. The content of unsaturated fats is 10–30% of dry matter" [44,45].

In addition, insect proteins in average are digestible better (76–98%) than plant proteins, such plant proteins from peanuts and lentils (52%). The digestibility of insect proteins is only slightly lower compared to animal proteins in beef and egg whites (100%) [45,46].

However, it should be noted that persistent negative social attitudes towards insect consumption hinder the expansion of the global food market and limit the use of insects as a food option. This may be due to the fact that people are skeptical about new products due to neophobic tendencies, as they consider some products to be exotic, "disgusting" and alien to European food culture [45,47]. In studies of attitudes towards insect consumption among people with different dietary styles (omnivores, vegans and non-vegan vegetarians), it was found that vegans have the highest neophobia scores not because they express disgust towards insects, but because of their ethical objections to eating animals or animal products in general. Much more favorable attitudes were observed among non-vegan (non-strict) vegetarians, who are more concerned with environmental sustainability than animal rights and who believe that insects are not "proper" animals and that's why can be eaten [11].

One of the alternatives to animal proteins is the actively developing sphere of biotechnology — meat production by *in vitro* cell culture, or production of the cultivated meat, which will provide the population with a sufficient amount of meat by creating a complex structure of muscles of the farm animals without deteriorating the taste qualities. The introduction of this product will reduce dependence on traditional animal husbandry, but it should be noted that there are technical challenges in meat tissue reproducing [48,49].

In vitro meat production is a potential viable alternative to the natural meat that could provide consumers with a product that is indistinguishable from the original, with very similar nutritional and culinary value. That is, the cultivated meat should either be similar in taste, aroma, appearance (including color, texture, tenderness) and nutritional value, or should even be superior to "animal" meat. Given that currently available alternative products often do not have comparable properties to their animal-based analogues, still there is a long way to go before reaching the industrial production of the cultivated meat. Important issues to consider include scalability of the production process, quality control of mammalian cell/tissue cultures, maintaining sterility in culture, preventing contamination or diseases development, and controlled breeding of stem-cell-donor animals [17]. In addition, there is also the challenge of the product marketing, which arises due to the certain features of society's perception of the cultivated meat. According to research [50], it is impossible to predict precisely the attitudes towards a product since it has not yet been fully introduced to the market.

Growing meat in labs and factories will likely change the meat industry. It will take time, will take a lot of researches and developments, and a gradual change of the negative perception of alternative meat among the consumers [17].

No doubts the meat industry of the future will be more complex than the meat industry of today, with a greater number of meat products or meat substitutes on the market obtained from different sources or processes. For successful marketing of the new products, the new products should be a commercially viable alternative to conventional meat production. The success of the cultivated meat as an alternative option, as substitute or as supplement to conventional meat will play an important role, because the consumers will highly likely turn to the products with similar market positioning [26].

It should be noted that early studies suggested the cultivated meat's potential to reduce land use by 99%, water consumption by 96%, and energy consumption down to 45% [51]. Subsequent studies have shown that as the cultivated meat production has smaller ecological footprint than beef production and lower greenhouse gas emissions than poultry, pork, and beef production, it requires more energy than poultry and pork production and yet is comparable with beef production. A controlled production environment, in which the cultivated meat is produced, could provide conditions for improved public health and safety, reducing the risk of diseases [19,26]. However, a number of authors have noted that large-scale cell culture production cannot be perfectly controlled and that unexpected biological mechanisms, such as cancer cell proliferation, may arise during the production process, which is a health concern for the consumers [26].

Alternative protein sources such as legumes, algae, insects, plant-based meat alternatives and the cultivated meat [52,53] are generally considered to be healthier and more environmentally friendly than the traditional animal proteins. However, the advantages of producing alternative proteins to meat still have not been fully scientifically proven, especially with regard to benefits for the environment. For example, it is still not clear whether the cultivated meat will be produced in a more sustainable manner than conventional meat. For example, analysis shows that high-tech and potentially destructive innovations require high degree of societal coordination to make them viable. At the same time, the potential sustainability benefits of these technologies may be limited by necessity of intensive processing that includes significant energy consumption and significant losses during the conversion of the raw material into final products. Thus, the priority given to meat alternatives with limited environmental potential is not only an issue of technological optimization of the production systems, but are also the second-order problems related to formulating the necessary tasks, creating control networks, evaluating innovative solutions and economic-technological representation [41].

All of the above meat alternatives are being researched and implemented, but so far no specific strategy has proven to be perfect or a completely implementable solution [7,17]. Furthermore, the researchers acknowledge that meat alternatives are currently embedded in "very different socio-legal regimes." In practice, this means that regulatory ambiguities and barriers are relevant for more innovative types of alternative proteins [41,54,55].

Paradox of pantophagy and food neophobia

The food industry is constantly encountering the necessity of finding the new concepts in order to meet increasingly specific demands of the consumers. However, innovative food products, such as meat alternatives, do not always become part of consumers' habits nor create a market. One of the main sources of resistance to nutrition novelty is the consumers' attitude, who in some cases treats a new product with suspicion or hostility due to specific ideologies, excessive adherence to traditions or due to neophobia.

In addition to availability and economic factors, all other factors that determine food choice can be divided into biological (genetically determined), cultural, or individual (psychological) factors. These three categories can be applied to human universal food preferences, to differences between cultures, and to individual differences within one culture [56].

The paradox of pantophagy, first described by the psychologist Paul Rozin, is the tension and fear, that people experience when choosing food. These feelings arise from the conflict between the desire to vary the diet and try new foods, on the one hand, and the fear of unfamiliar foods or possible disgust to them due to safety concerns, on the other.

Thus, a person's attitude to food is characterized by duality, expressed in fluctuations between food neophobia (distrust to the new products) and food neophilia (curiosity and attraction to some food novelty). However, as scientific literature analysis shows, it is not always easy to understand when the consumers' resistance can be overridden by improving the product [57], and when it is explained by personal opinion and thus cannot be quickly eliminated.

Paul Rozin, who first described food neophobia, suggested that it has an adaptive and evolutionary function. As omnivores, humans must follow the strategy to avoid toxic foods and to prefer foods that are beneficial to their health and growth [56]. Evolutionarily, this is facilitated by neophobia from the moment a child begins to move independently of his/her parents. Aversion to bitterness, for example, due to innate hedonic neurobiological mechanisms, helps a child avoid eating potentially toxic plants and may last as long as adulthood [11].

A number of researchers have identified disgust as a major concern with the cultivated meat [27,58]. Wilks et al. [28] measured sensitivity of disgust, which is an individual's predisposition to experience disgust when stimulated by various stimuli, which is thought to be a predictor of food choice behavior and disgust reactions. The results of the study showed that food neophobia was the highest predictor of willingness to try the cultivated meat and perceiving the health benefits of the cultivated meat. Various factors are responsible for the development of food disgust, with cultural and social norms leading to deeply ingrained perceptions of disgust. Disgust sensitivity has been used to determine acceptability of novel foods, including novel animal products and novel food technologies [28].

The food neophobia scale reflects attitudes or emotions associated with food, so a better understanding of the values specific to a particular culture may be more efficient in collecting knowledge about whether such new products match the consumers' profile [58].

Consumers believe that food safety is an essential requirement for product quality [59], as consuming unsafe food can cause harm to human health. Indeed, studies have proven that fear of harmful effects is one of the main factors in the consumers' refusal to try new food products. It is suggested that consumers' perception of food safety risks contributes to the food neophobia development [5].

Since neophobia puts obstacles to the desire to try new foods, while neophilia promotes it, addressing both poles of the paradox of pantophagy is a promising approach to better understanding the consumers' perceptions of the cultivated meat [5].

Consumers' reactions to the cultivated meat

Researches of the consumers' acceptance of the cultivated meat have become numerous in recent years and have identified a consistent set of motivators and barriers to its future large-scale consumption. Although the consumers in general acknowledge the animal and environmental safety benefits of the cultivated meat, many of the yet have concerns about taste, price, and safety, as well as ethical, cultural, and religious issues.

Results from various studies show that the consumers' perceptions of the cultivated meat have mixed nature [2,29,60,61].

People's sensitivity to the sufferings of the farm animals has contributed to the rise of vegetarianism popularity. However, this has not reduced the desire to eat meat, especially among the consumers with higher incomes, who nevertheless also state that they do not want to contribute to animals' sufferings. From this perspective, the cultivated meat is an excellent compromise option for the animals' wellbeing and for addressing the ethical concerns of meat consumers [11].

Although the cultivated meat is unlikely to enter the market at the nearest future, potential producing companies are already studying the profiles of potentially interested consumers. Providing information, especially about the environmental benefits, is important to create a positive opinion among the potential consumers. Lack of awareness about the new technologies has been referred to as a cause of mistrust, uncertainty, and concerns about potential long-term negative impacts [27,50].

Many studies have shown that while most consumers were willing to try the cultivated meat, only few were willing to buy it, especially at a higher price [50,62]. Although many consumers supported the idea of the cultivated meat production, they chose not to consume it, considering the product beneficial to society but potentially dangerous to themselves in particular. This attitude covers the cultivated meat to a greater extent than any other alternative proteins [29].

It's interesting that the results of all surveys show that meat eaters are potentially more interested in the cultivated meat than the vegetarians and the vegans. However, the boundaries between these two groups of the consumers are not definitely clear, and the majority of the consumers, who are interested in meat alternatives, are mainly meat eaters, while the vegans/vegetarians still remain a minority [9]. Vegetarians and vegans, despite being in favor of any alternative to intensive animal farming, seem to have no desire to try and consume a product that in any case is derived from animal raw materials [25].

The similar results, where the vegans and vegetarians are more positive about the cultivated meat but are less interested in tasting it in comparison with the meat eaters, have also been found in the studies conducted in the United States [63]. The explanation for this apparently contradictory behavior is that these categories of the consumers do not object to the production of the cultivated meat, but at the same time are not interested in eating it. In this regard, it is necessary to conduct a research of the people's motives when they choose the food products, since these motives are likely to be driven by strong internal logic, even if at first glance these motives seem contradictory. Positive consumers' perception of new products should not be interpreted as a sign of commercial success [63].

Paradoxically, the vegetarians who were not interested in tasting the cultivated meat, had higher expectations of its taste than the meat eaters, who were actually interested in purchasing it. It has been noted that consumers with the greatest interest in purchasing are predominantly young, well-educated, and knowledgeable about the cultivated meat [11,14,63].

Another group of the consumers to consider are those who are not ready to refuse from eating meat but who have already reduced their consumption or are considering doing so. They are known as meat reducers or the flexitarians. Unlike the vegans and the vegetarians, who have been the subject of research for decades, meat reducers have received little attention, and few studies have analyzed their motivations for reducing meat consumption [1,64].

Willingness to buy and consume the cultivated meat depends on a number of demographic and sociocultural factors: men (compared to women), liberals (compared to conservatives), and low-income respondents (compared to high-income respondents) were significantly more ready to try the cultivated meat [65]. A number of studies show a strong correlation between the political orientation and attitudes toward the cultivated meat [13,66]. Liberals were seen as more tolerant than conservatives and linked the consumption of the cultivated meat to other agendas of the animals' wellbeing and environment protection [66]. Right-wing political parties were more likely to support the basics of loyalty, power, and purity, while left-wing politicians were more prone to focus on concepts of harm-minimizing and care-maximizing. This may indicate a link between the attitudes toward the cultivated meat and approval of certain moral principles [13].

Gomez-Luciano et al. found that although the cultivated meat is perceived as more delicious than insect-based or plant-based meat in some markets, across the countries it is generally considered the least healthy, least nutritious, and unsafe alternative to animal proteins. Ideas of perceived healthiness and nutritional value of the cultivated meat took place among the most important predictors of willingness to pay for the cultivated meat across all countries studied [12].

Zhang et al. [62] examined the consumers' awareness, acceptance, and their willingness to pay for the cultivated meat. Their approach is different because they examined the consumers' perceptions before and after being provided with information about the cultivated meat. Before learning about the cultivated meat, most consumers were either against the cultivated meat or were neutral towards it. After receiving the additional information, the percentage of consumers who were against the cultivated meat decreased from 22% down to 12%. Most respondents were willing to try (85%) or even buy (78%) the cultivated meat after receiving the information.

The summary assessment of the valence of the consumers' perception of the cultivated meat showed that social and cultural benefits (minimal risks) were identified as driving forces and turned to be stronger motivators than health and safety benefits (minimal risks), which were classified as relatively strong driving forces. On the other hand, the concerns of the cultivated meat quality (minimal benefits) were defined as those causing strong disgust [67–69].

Public opinion about the cultivated meat as an unnatural product and about the ethical aspects of its production

People who are concerned about the naturalness of food products are less likely to accept the cultivated meat. Here the term "naturalness" refers to the extent at which this product is perceived as the product of natural origin (e. g. produced by conventional agriculture), as opposed to a technological process by which the product is produced "artificially" [70].

The first important ethical and legal question concerns the nature of the product, since it must be determined whether it is meat or not. According to the definition of the American Meat Science Association, not only for biological or technological reasons, but also for semantic and commercial reasons, "the cultivated meat" is not meat actually [15]. Indeed, meat is defined as "edible tissues of an animal, consumed as food" and "to be considered meat, *in vitro meat* must be originally derived from an animal cell, tested and found safe for human consumption, and be comparable in composition and organoleptic characteristics to the meat, naturally obtained from the animals," according to Woerner and Boler [71]. Consequently, the authors of this article consider that the use of the term "meat" has created an ambiguity that is beneficial to the proponents of the cultivated meat. They strive for elimination

of the negative aspects related to natural meat (environmental degradation, animals' sufferings) while focusing on the positive properties of meat for the consumers, like strength, vitality and a healthy lifestyle. In this way, start-ups could successfully introduce the name "meat" for these cultivated muscle fibers into everyday language. Indeed, the main keywords used in media articles are "meat" and, to a lesser extent, "food" [15]. It is therefore necessary to ensure that meat substitute products are correctly labeled (so as not to mislead the consumers) and that their nutritional value is comparable to the products they are intended to substitute.

There are many issues related to the cultivated meat industry that need to be addressed through appropriate legislation and regulations. Food adulteration is a major concern in the regulation of the cultivated meat, where the cultivated meat may be marketed as conventional meat or vice versa [21].

Although the environmental benefits of the cultivated meat may play a key role in changing the potential consumers' attitude, yet there is a general distrust due to its "unnaturalness" and concerns about the possible health consequences caused by new technologies [72]. Recent research has shown that the perceived unnaturalness of pure meat and concerns about its safety are two key psychological barriers to the acceptance of pure meat. While some people are reluctant to accept the cultivated meat due to its assumed unnaturalness, the others believe that naturalness is unimportant to their eating decisions. Similarly, while some people experience strong discomfort and fear in relation with new food technologies, the others are confident that new technologies are generally safe and scientifically based [73]. In other words, people vary greatly in their assessment of the foods naturalness (i. e., the importance of foods naturalness, given the degree of fear of new food technologies) [74].

It is a common belief that everything natural is healthy, while everything unnatural (artificial) is harmful to eat. This is just an assumption that has nothing to do with reality. In ancient times, there was no intensive animal husbandry, meaning that animal breeding became itself an unnatural process. Thus, the terms "natural" and "unnatural" are very ambiguous, especially in relation to the cultivated meat production [75]. Even though the cultivated meat is grown artificially in a laboratory, the product is similar to the original (regular meat) and does not pose a health risk [37]. Since meat is grown in the controlled environment, the chance of generating the harmful by-products, excessive fat and pathogens is reduced [19].

The biggest challenge to the general acceptance of the cultivated meat still lies in the consumers' acceptance, while researches found the varying levels of acceptance and purchase intentions across the cultures [7,29,75]. Qualitative investigations of the reasons for this uneven acceptance assumes that it is related to unnaturalness as it is perceived by the consumers, lack of trust in the technology and companies producing it, public health risks, and taste/price issues. It has been declared that "natural" meat excites emotions, wakes up nostalgia for traditions at home, and the cultivated meat is associated with phrases such as "messing with nature" and "playing God" [58].

Idiomatic expressions such as "playing God" and "messing with nature" described the participants' ideas on the unnaturalness of the cultivated meat and were used to reject the technology or express doubts about its purported benefits, particularly in relation to nutritional value and health [27]. This reaction matches the findings of de Barcellos et al. [76], who found that consumers perceive new beef production technologies like shock wave processing as "messing with their food" and they prefer less invasive (and more familiar) technologies.

The researchers suggested that consumers' assessment of the cultivated meat as unnatural was, to some extent, an emotional reaction, as it was closely linked to feelings of disgust towards this new product. In the context of food, the term "natural" often possesses emotional appeal [77], and indeed, it can be argued that "natural" can evoke nostalgia and adherence to culinary traditions, identity, childhood memories or the home comfort.

Specific cultural and religious issues make the situation more challenging. There is disagreement among the religious communities, including Jews, Muslims, and Hindus, about the cultivated meat due to its uncertain status. In the consumers' survey on the cultivated meat among 3,030 participants, including Jews, Muslims, and Hindus, the majority of the participants responded that they would be willing to eat the cultivated meat [72]. However, both Muslim and Jewish authorities still debate whether the cultivated meat of any origin can be classified as halal or kosher, and in Hinduism there are also food restrictions on eating beef that require discussion [78].

It should be noted that some people ask question on the ethical status of the cultivated meat. The cultivated meat requires fetal bovine serum (FBS) as a nutrient medium, which is an animal product made from blood taken from cattle fetal through a closed blood collection system at a slaughterhouse. This raises serious ethical questions about the potential suffering of a living organism. The use of such a nutrient medium should be gradually abandoned, and therefore various alternative media are being sought. For example, a serum-free medium was developed that supported the propagation of satellite cells of turkey in nutrient culture [79,80]. Moreover, there are various serum substitutes that are a good alternative to fetal bovine serum. The example is Ultroser G, one of many commercially available substitutes that contains all the nutrients necessary for the growth of eukaryotic cells (growth factors, binding proteins, adhesin factors, vitamins, hormones, and mineral trace elements) [21]. A serum-free medium made from maitake mushroom extract was also successfully used, with the growth rate in it being higher than with fetal bovine serum [79].

In addition to the culture media, some scientists fear that widespread use of the cultivated meat will encourage cannibalism, because once this technology is developed,

any type of meat can be grown in the laboratory using a cell line. This is also a serious ethical issue that requires proper legislation regarding production of meat worldwide [37].

Role of information in the optimization and acceptability of the cultivated meat

Positive factors do not always increase consumers' acceptance. For example, Escribano et al. [81] found out that the aspects such as regional and local production, sustainability, environmental concerns, consumers' health, and product quality were not sufficient to increase the acceptance of the cultivated meat. Asioli et al. [82] reported that consumers, interested in new food products, would pay less for the cultivated meat labeled "no antibiotics ever" (i. e., with a human health claim) than for a product without such a label. Both studies were conducted online and provided the participants with technical information about the cultivated meat production. The availability of such technical information resulted in significantly lower preference for the cultivated meat. In comparison with the conventional meat [34,81].

And vice versa, the conventional meat labeled as the cultivated was preferred over the conventional meat labeled as the conventional before and after tasting, provided that the participants were adequately informed about the personal, social, or tasting benefits [83]. In this case the personal benefits gave rise to significantly higher positive expectations, followed by social and tasting benefits. Therefore, when promoting this new product, positive information, especially about its health benefits, may facilitate its acceptance by the society, in contrast to the technical or "anti-traditional" data [29,34,52].

Well-presented information can even override the sensory appeal of the product [52]. For example, when the consumers received positive information on the cultivated meat [83], their attitude towards a regular burger, presented as "the cultivated", remained unchanged after its tasting because it provided the same sensory experience as the conventional meat. This sensory similarity is critical to attracting meat eaters, who are more likely to choose the cultivated meat over the plant-based alternatives [52].

Moreover, the information about personal benefits leads to a significantly greater increase in acceptance of the cultivated meat than other information conditions, suggesting that messages aimed at persuading the consumers to eat the cultivated meat should focus primarily on the benefits for the consumers (rather than the benefits to the society, the environment, or the animals). Verbeke, W. et al. [27] noted that the latter is usually initially more obvious to the participants of the survey.

The researches assessing the impact of positive information on the perception of the cultivated meat have shown that information about the safety and nutritional properties of the product significantly influences the consumers' willingness to purchase it and to try. However, information about the taste of the cultivated meat, on the contrary, does not contribute to the formation of positive perceptions. The results also showed that providing positive information increases the willingness to buy the cultivated meat, but does not affect the willingness to try it. It is clear that willingness to try depends on additional incentives that involve a more in-depth analysis of the nutritional profile and food preferences of the particular consumers' group.

Research has shown that women showed a higher willingness to replace conventional meat with the cultivated meat if they were informed about its safety for human health. Young adults (under 30), who are likely to be potential consumers, showed a greater preference for the cultivated meat if they were provided with information related to animal wellbeing and human safety [84]. This information was less efficient among the older respondents, which may indicate their preference for established habits and, therefore, their more cautious attitude towards the cultivated meat. Other categories that were less affected by the information were those who do not eat meat, those who do not intend to reduce their meat consumption, and the people with lower levels of education [25]. The observation of the latter group is consistent with previous studies reporting that people with higher education are more likely to make decision on the basis of analytical rather than an emotional approach, which possibly makes them more open for new dietary scenarios than less educated consumers.

Nomenclature and terminology as an information factor are also important. Bryant et al. [85] found that different product names provide a significant impact on the rates of acceptance. For example, the use of the term "pure meat" led to significantly higher acceptance than "lab-grown meat," while "the cultivated meat" and "animal-free meat" fall somewhere in between. In addition, it was found that the difference between the groups perception was explained by the positivity of the associations that respondents made. This suggests that the nomenclature affects the acceptance is through mechanism of association with the concepts that are more or less attractive for the consumers.

Another condition that influences the acceptance of the cultivated meat is the form of information presentation (framing). Thus, the use of frames that emphasize the social advantages of the cultivated meat or its similarity to the conventional meat lead to significantly higher rates of acceptance in comparison with the frames that emphasized the advanced scientific aspect of its production technology [29].

Possible strategies for promoting the alternative meat

To increase the acceptability of the cultivated meat, it is important to inform and educate the consumers about new foods and methods of production.

Strategies to support the cultivated meat can use various approaches. Consumers' perception of the cultivated meat can be improved through different content strategies depending on specific consumers' preferences [66].

To cope with the criticism that the cultivated meat is unnatural, its proponents should focus on the benefits that the technology may bring [66,86]. Marketers can take advan-

tage of the moral ambiguity related to the conventional animal agriculture by drawing attention to an ethical issue that many meat eaters do not typically consider, and by presenting the cultivated meat as a transparent and credible option. However, the producers should be careful when moralizing this issue, as this approach may turn off not only the consumers but also the conventional meat producers whose investments may be vital to their success [86].

Another approach is to highlight the environmental benefits of the cultivated meat, although some evidence suggests that arguments based on self-interest (such as improved health and food safety) are likely to be the most persuasive [83]. In particular, the prevention of antibiotic resistance development and zoonotic pandemics favorably show up the cultivated meat in comparison with the conventional animal agriculture, which is often criticized for these disadvantages [87].

The long-term success of the cultivated meat will depend on its ability to compete with the conventional meat in terms of price and taste. Experts agree that the cultivated meat is unlikely to compete on price with the conventional meat in the near future. This is considered a significant obstacle to widespread acceptance, and some experts believe that the cultivated meat will either occupy a luxury niche or will be associated with health benefits for the consumers to justify its higher cost [29]. As with any technology, it is likely that the price of the cultivated meat will reduce over time as the producers compete and production methods become more efficient.

Recent researches show that most consumers find the cultivated meat to be less tasty, as well as inferior in texture and appearance. This pessimistic approach to the quality of the cultivated meat can be seen as an opportunity: the cultivated meat companies can convincingly imitate the taste and texture of hamburger patties in order to exceed the consumers' expectations. Indeed, the high possibility of testing the cultivated meat compared to other technological innovations allows consumers experiencing the key aspects by themselves without much effort. Experts in the sphere consider it a priority to create a product that imitates not only the taste but also the texture and smell of conventional meat [29].

Using structural equations modeling method, Lin-Hi et al. [20] investigated the role of so far ignored organizational factors of the producing company (trustworthiness, reliability, corporate social responsibility, and external motivations) as preconditions for the consumers' acceptance of the cultivated meat, given its status as a radical innovation. The authors find that a key characteristic of the radical innovations is a high level of uncertainty regarding the consequences of their use, for example in terms of the lack of reliable knowledge about the potential functional shortcomings and social disadvantages of the product. The results showed that organizational factors matter for the consumers' acceptance of the cultivated meat, as perceived organizational reliability of the producing company signals the benevolence, honesty, and competence of the product manufacturer or the seller, especially when the product's characteristics are perceived as ambiguous [20].

The authors note that the study has some limitations, taking into consideration that the acceptance of the cultivated meat is taken at an intentional rather than behavioral level. However, since the cultivated meat is currently not available to most consumers it is still not possible to measure the consumers' reactions to the cultivated meat in terms of actual purchasing behavior. While the cultivated meat is still in the process of its development, future studies should apply multiple methods to examine the consumers' perceptions from various angles. This will help set the foundation for analyzing actual purchasing behavior when such a product finally comes to the supermarket shelves [20].

Conclusion

In modern society, where the alternative food products are available, people develop their own food identity by defining their eating behavior (whether they consider themselves as health-conscious, environmentalists, animal rights activists, or traditional omnivores, etc.). Therefore, future research should experimentally assess how these factors and benefits affect the consumers' acceptance of new food products.

The issues outlined in this review may form the basis for efforts to formulate a standard description and set of measures that can be used in future studies to obtain more commensurate and comprehensive data on the perceptions of various consumers' groups towards the cultivated meat and on assessment the actual consumers' behavior. In particular, future research should examine the most effective ways to handle the concerns about the "naturalness" of food products, given the central role of naturalness in the perception of safety and acceptance of new food technologies in general. The consumers' concerns about the unnaturalness of the cultivated meat should be solved to encourage them to become more familiar with the product and change their attitudes towards it. One way to do this may be using less technical terminology and product labelling. Information about the production (benefits and risks) of the cultivated meat should be as accessible and transparent as possible.

Moreover, it should be taken into consideration that cross-cultural and ethical directions in the consumers' perception researches are directly related to researches of understanding the food identity profile of the members of the focus group being investigated, and may be important for the formation of future marketing or regulatory strategies.

The consumers' perceptions of the cultivated meat will continue changing in the coming years as the technology becomes commercialized. The better awareness of the new product, including legal regulation and commercial availability, media coverage, and opportunities to try the product samples, along with the development of strategies to build positive attitudes towards food innovation, are all factors that are likely to facilitate the consumers' acceptance of the cultivated meat.

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