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ARTICLE INFO

ABSTRACT

The impact of the meat sector on the environment is critical and meat alternatives have been suggested as solutions to mitigate it. This study aimed to understand the attitudes, motives, and attributes shaping consumer willingness to try (WTT), eat regularly (WTE), and pay (WTP) for cultured meat having, as a case study, a sample of 838 Greek residents. The results primarily reflected the views of younger and well-educated consumers. Although this demographic was not the initial target, it was considered the anticipated primary market for cultured meat upon its launch. A total of 58% of the respondents expressed WTT cultured meat, with primarily Gen Z showing a higher positive attitude toward it. However, the WTT was primarily driven by curiosity and it was not reflected in WTE or in WTP. Greek consumers prioritized a set of characteristics they would expect from cultured meat, giving emphasis to factors such as taste, safety, and nutritional value. The importance of clear and non-misleading naming to preserve consumers' right to know what they are purchasing was also underlined. In conclusion, the potential acceptance of cultured meat in Greece is influenced by many factors, including generational shifts, product characteristics, naming and promotion.

1. Introduction

The role of the meat sector and its impact on the environment are crucial in the discussions on climate change and future policies may have important consequences for its production and trade (Leip et al., 2015; OECD-FAO, 2021). In 2021, 328.4 million tons of meat (beef, veal, pork, sheep, goat, and poultry) were consumed worldwide (Shahbandeh, 2024) while in Greece, meat consumption is expected to reach 733.2 million kg by 2029 (statista, 2024). Concerns have been raised, with some authors arguing that dietary greenhouse gas emissions are higher for meat-eaters compared to vegans (Raphaely and Marinova, 2014; Scarborough et al., 2014) while it has been reported that the meat-based food system demands more energy, land, and water resources even than a lacto-ovo-vegetarian diet (Pimentel and Pimentel, 2003). This ongoing debate, in the authors' opinion, appears to be

occupying the scientific community currently and will likely continue to do so in the coming years.

Various solutions to improve our agro-food systems have been proposed. Some of them focus on the livestock system itself, such as the development of agroecological practices or sustainable intensification (i. e. increasing or maintaining agriculture on existing lands with a high productivity but with lower environmental impacts) (Pulina et al., 2022). Others suggest various alternatives to meat, such as plant-based meat, cultured meat, insect-based products, or hybrids meat products (those containing both animal- and plant-based protein) (Choudhury et al., 2020; Gravel and Doyen, 2020; Ismail et al., 2020; Melios and Grasso, 2024). It is suggested that biotechnology can support the sustainable development of bio-based industries along their value chain, reducing adverse environmental impacts (Lokko et al., 2018). Thus, some authors argue that also the biotechnology of cultured meat could

offer a sustainable solution for meat consumption. Since the 1990s, small quantities of muscle tissue have been produced using cultured stem cells from animals (Kadim et al., 2015; van der Weele and Driessen, 2013).

However, there is an ongoing debate about whether cultured meat could serve as a solution to climate change. It was asserted that cultured meat aligns with and contributes to various United Nations Sustainable Development Goals (SDGs) and Social Determinants of Health (SDHs). It is presented as a solution to reinforce Environmental-oriented SDGs (2, 6, 7, 11, 12, 13, 14, and 15), Health-oriented SDG 3, Social-oriented SDGs (1, 5, and 10), Economic-oriented SDGs (4, 8, and 9), and Law-oriented SDGs (16 and 17) (Nobre, 2022). However, although less land will be used compared to livestock, in particular ruminants, there is still a controversy regarding the environmental impact of cultured meat on greenhouse gas emissions (Chriki and Hocquette, 2020; Sinke et al., 2023). While cultured meat requires fewer agricultural inputs and less land than livestock, it demands more intensive energy (Mattick et al., 2015). Moreover, cultured meat will have to compete with all the other meat alternatives (Chriki and Hocquette, 2020). Concerning protein content-based comparisons, the range from the most to the least impactful solution as shaped by the resource demands and the environmental footprints is the following: beef, microalgae, cultured meat, poultry, insects, and plants (Smetana et al., 2023).

Achieving a meat-like product from alternative protein sources with optimised sensory characteristics, such as texture, colour, and flavour, poses the biggest challenge (Melios et al., 2024b, 2024a). In order to achieve a conventional-meat-like product, the production of cultured meat involves four stages: cell isolation, cell culture, differentiation, and tissue development (Lee et al., 2021). However, while instrumental analysis of cultured meat has indicated comparable textural characteristics to conventional meat (Paredes et al., 2022), umami and bitter tastes may be less pronounced, as reported for cell-cultured meat derived from chicken and cattle muscles (Joo et al., 2022).

There are many factors, such as economic, social, and psychological, that could influence the long-term success of cultured meat in the market. Numerous techno-social, economic, and other challenges remain unresolved, playing a significant role in the survivability and viability of this technology (Jairath et al., 2021; Mattick 2015). Production cost is a critical concern, along with the substantial funds required for further research in the field (Bhat et al., 2015; Choudhury et al., 2020). Moreover, it has been emphasized that emotions, feeling of unnaturalness, critical thinking, and imagination all play crucial roles in the public debate on cultured meat (van der Weele and Driessen, 2013). Additionally, some consumers have reported concerns that certain components of cultured meat could be harmful to their health (Tsvakirai, 2024). Beyond addressing these challenges, producers and advocates must also consider their relationship to various social and cultural phenomena and institutions (Bryant, 2020). Another aspect to be considered is that the complete replacement of conventional meat with cultured meat may lead to adverse long-term impacts on the agriculture-based economies of developing countries (Jairath et al., 2021).

Several strategies have been suggested to achieve a smoother introduction of cultured meat to consumers. Proponents of cultured meat are developing, for example, strategies to enhance the acceptability of cultured meat by leveraging science and technology to improve its production processes and sensory characteristics; by advancing public knowledge through research in behavioural sciences; by communicating scientific information; and by implementing policy changes (Tomiyama et al., 2020). It was reported that previous awareness of cultured meat is one of the best predictors of its acceptance (Bryant et al., 2019; Rolland et al., 2020). Consequently, increasing acceptance can be achieved through positive information and framing that invokes more positive associations (Bryant and Barnett, 2020), such as labelling that emphasizes the health or environmental benefits of the product. Consumer acceptance of cultured meat also relies on the benefits that marketers

choose to emphasize, media coverage of the concept, and the features of the product itself (Bryant and Barnett, 2019a). Regarding neophobia, as cultured meat will be a new product on the consumer table, it has been suggested that the closer its similarity to conventional meat in terms of sensory and nutritional characteristics, the easier it will be to overcome food neophobia, and even meet social norms and rituals (Jahn et al., 2021). Moreover, a crucial consideration for further research is the nomenclature of cultured meat in different languages. Direct translations of English names may not convey the intended meaning in various languages, potentially leading to different levels of consumer acceptance across different linguistic and cultural contexts (Bryant and Barnett, 2019a). Recently FAO introduced the term "cell-based food" to refer to cultured meat (FAO & WHO, 2023). It should be highlighted, that it is very important that the chosen name helps potential consumers understand what they purchase or consume (Hallman et al., 2023).

Food choices are highly fragmented due to consumers' ideological attitudes and eating habits. Consequently, expecting to introduce new food products that are desirable across all consumer segments is unrealistic (Faccio and Lucrezia, 2019). For instance, the frequency of meat consumption or adherence to vegetarian diets are crucial factors when studying consumer attitudes toward cultured meat (Hopkins, 2015). Literature suggests that flexitarians appear to be the ideal target group for meat alternatives since, although they still have meat cravings, they are open to alternative diets (Jahn et al., 2021). Benefits related to environmental, budget, and health considerations drive this shift toward reduced meat consumption (Melios and Grasso, 2024; Shilling, 2023). However, it is essential to note, that this is not always the case, as flexitarians not only differ from meat lovers but also vary among themselves (Dagevos, 2021).

There is a need to increase our understanding of consumer attitudes toward cultured meat across different cultures and sociodemographic profiles before public and private research invest significant funds in it. Despite many consumer surveys mainly conducted in Western countries (e.g. Cornelissen and Piqueras-Fiszman, 2023; Verbeke et al., 2015), information on consumer perception of cultured meat in the South of Europe and in particular in Greece is limited. To the authors' knowledge, consumer attitudes toward cultured meat in Greece have been studied only once. In that study, conventional meat consumption was used to create consumer segments and compare consumers across Spain, Croatia, and Greece (Francekovi and Sakoulogeorga, 2021). A limitation of that study was that some respondents did not fully understand the concept of cultured meat. Additionally, it has been observed that because most surveys differ in their question wording, response options, and terminology, their outcomes are often not directly comparable between countries. Therefore, it has been suggested that future studies aiming to compare the acceptance of cultured meat should consider using the same survey instruments as previous studies (Bryant et al., 2019). The distinct cultural and dietary context in Greece—characterized by the Mediterranean diet with relevant low meat and a high plant-based foods consumption (Simopoulos, 2001)—provides a unique case study for understanding consumer acceptance of cultured meat. Additionally, the position of Greece at the crossroads of Europe, Asia, and Africa, along with its significant international tourism industry, further enhances the relevance of that region. The introduction of cultured meat in Greece, especially in high-profile tourist destinations like Mykonos, Santorini, and Athens, even if the local population drives it, is likely to have broader implications for the international food market.

This study is the first investigation involving consumers in Greece, where the concept of cultured meat was initially introduced through both pictorial and textual content. The results primarily reflect the views of younger, well-educated consumers, while most of them belonged to generation Z encompassing those born between mid-1990s and 2010s (NieŻurawska et al., 2023). Market research on cultured meat predict significant market growth by 2034 (Marketandmarkets 2023). However, as Mohorčich and Reese, (2019) suggested, this transition could take

longer than expected, as its adoption will be more time-consuming and complex than current predictions by proponents of cultured meat. Thus, as the launch and adequate market growth of cultured meat may take more than 10 to 15 years, the demographic profile obtained in this survey was not considered a limitation when interpreting the results. The largest age group (18 to 30 years of age) was considered anticipated to be the primary consumers of cultured meat upon its market launch, and their perceptions have already gained attention by other researchers as well (Bogueva and Marinova, 2020; Pilavora et al. 2023). The study extensively explored the attitudes, motives, and factors influencing consumers' willingness to try (WTT), to eat (WTE), and to pay (WTP) for cultured meat using a questionnaire that has been employed and tested in numerous other countries (Chriki et al., 2021; Kombolo Ngah et al., 2023; Liu et al., 2021, 2023 etc.). In addition, this research delves into the product characteristics sought by consumers, considering ethical, environmental, and production-related factors that influence consumer perceptions and acceptance of cultured meat (Pakseresht et al., 2022). Thus, this study seeks to examine the attitudes, motives, and attributes influencing consumer WTT, WTE, and WTP for cultured meat in the Greek context, considering diverse socio-demographic segments. Last, the most suitable name and context for this product in the Greek market are discussed. The results are thoroughly discussed in a separate discussion section to determine whether cultured meat could find a place in the Greek and Mediterranean diet and beyond.

2. Materials & methods

2.1. Questionnaire design

A total of 32 questions were carefully crafted to ensure the execution of an unbiased and impartial survey as described in Hocquette et al., (2022) and it was translated into Greek by native speakers, proficient in both Greek and English. The objective was to create questions that were both straightforward and easily understandable for all participants. To introduce participants to the concept of cultured meat, a brief explanation was provided, along with a visual illustration in Greek, with the intention of minimizing any potential confusion or misunderstanding with other meat substitutes. Both the pictorial and the text provided were created based on a similar study by Liu et al., (2021).

The text provided was the following:

"Artificial meat, also known as cultured meat, in vitro meat, cultivated meat, lab meat, clean meat and synthetic meat, is a novel food produced in laboratories using animal muscle stem cells, but does not come directly from a living animal and which proliferates in culture. The production of artificial meat is the subject of media enthusiasm to feed the growing human population. In order to address the increasing concerns about environment (global warming) and ethic (animal welfare) but also the weakness of the conventional meat production (limited farming resources and low efficiency to feed the ever increasing population), scientific research is devoted to introduce and develop on a large scale artificial meat as a novel food in the future". The Greek version of the text is available in appendix A and the pictorial used in appendix B. During the questionnaire translation, cultured meat was chosen to be referred to as the Greek translation of "artificial meat" ("τεχνητό κρέας") making more sense in the Greek language. The survey was structured into the following nine sections.

1. Introduction
2. Survey Context: A brief introduction and illustration about the context of "cultured meat".
3. Socio-demographic Information: This section comprised seven questions covering gender, age, education level, occupation, monthly income, meat consumption habits, and familiarity with "cultured meat".

4. General Questions: Two questions aimed at understanding respondents' food purchasing criteria and whether they were aware of the product.
5. Societal Challenges: Seven questions addressed societal concerns related to ethical and environmental issues, with respondents providing their responses on a scale of 1 (I strongly disagree) to 5 (I strongly agree).
6. Product Characteristics: Two questions focused on respondents' expectations and perceptions regarding the healthiness and quality of "cultured meat", also rated on a scale of 1 (very low) to 5 (very high).
7. Potential Interest: Four questions investigated the consumer acceptance of "cultured meat".
8. Public Opinion: Six questions aimed to capture personal perceptions of this new food compared to conventionally produced meat. It also included a question regarding what this product should be named.
9. Development Strategies: Four questions delved into the development strategies for "cultured meat".

2.2. Data collection

An online survey titled "Consumer Opinion on Artificial Meat in Greece" was developed using the Google Forms platform and conducted between early September and end of November 2023.

Initially, a pilot-scale dissemination was carried out sharing the survey with 10 individuals, whose responses were subsequently excluded from the dataset. This allowed for obtaining preliminary external feedback and making minor adjustments to the questionnaire. Subsequently, the survey was widely distributed through social media. Based on previous research, convenience sampling and snowball sampling were employed (Aminizadeh et al, 2024; Merlino, 2024; Hverstock, 2012). Daily Facebook posts and Instagram stories were shared on the personal accounts of one of the authors (SM), inviting consumers to participate in the survey via a link to the Google Forms document. A snowball sampling technique was also utilized, where respondents were encouraged to share and promote the survey among their networks (Goodman, 1961). So, as part of the posts, participants were asked to share the survey with their friends and contacts. Given that most social media users are younger and many of the author's contacts hold a BSc degree, these demographics became the primary target.

This study adhered to local guidelines aligned with the laws and regulations of the countries where it was conducted, including obtaining ethical approval from ethics committees (CAAE number: 37924620.5.0000.5404). The entire process adhered to the ethical guidelines for online research set forth by the European Society for Opinion and Market Research (ESOMAR, 2015).

In total, 838 responses were collected, which with a confidence level of 95% provides a maximum confidence interval of 3.3% based on the Greek population size (10,482,487 in 2021) and the varying proportions of responses to different survey questions (ELSTAT 2022; surveysystems 2024).

2.3. Statistical analysis

Data from Google Forms were extracted as an Excel file and all the statistical analyses were performed using XLSTAT Premium (Annual version 2023.1.6 1410). All the analyses were made with the Greek version of the questions and then they were translated into English. Unless otherwise indicated, a value of $p < 0.05$ was defined as the criterion for statistical significance.

In order to explore the attitudes and attributes influencing willingness to try, eat, and buy cultured meat, several statistical analyses, such as descriptive, inferential, and predictive, were employed to combine data from different questions and find associations among variables. Sociodemographic characteristics, consumers' meat consumption frequency, and familiarity with cultured meat were presented as percentages. To analyse significant differences among means, one-way ANOVA

followed by Tukey post-hoc test was used to compare subgroups within each of these categories. Additionally, the same statistical methods were applied to compare mean values of "emotional resistance" for subgroups based on frequency of meat consumption, presented in a bar chart. Similarly, mean values of opinions on whether "private research (by start-ups)" and "public scientific research" should invest in cultured meat development were compared among subgroups within the "age range" category. Moreover, within the age groups, the same method was used to compare the mean values between the consumers' opinions on the extent to which "private research (by start-ups)" and "public scientific research" should invest time and funding in developing cultured meat.

A linear regression model was used to estimate the influence of consumers' attitudes, regarding environmental sustainability, ethical production, impact on farming, and taste of cultured meat, as well as to identify predictors of WTT. WTT was used as a scale from 1 to 5 (1: I would definitely not try and 5: I would definitely try). The consumers' gender, age, level of education, activity area, monthly net income, meat consumption frequency, and familiarity with cultured meat were analysed as qualitative variables and one-way ANOVA followed by post-hoc Tukey test used to calculate the significant difference among the groups of each category and their WTT cultured meat.

Percentages regarding the consumers' motives, expectations, and product attributes influences on WTT cultured meat, as well as attitudes about the most relevant names, were directly extracted by Google forms.

3. Results

3.1. Sociodemographic characteristics

The sociodemographic characteristics of the sample can be found in Table 1. The proportion of women participants (62.2%) exceeded that of men (37.0%), with a small percentage identified as non-binary (0.8%). Moreover, the predominant age range was between 18 and 30 years of age. Based on these demographics, the sample is not representative of the Greek population at large but is more reflective of the potential consumer base for cultured meat. This is further discussed in the discussion section.

While 85.2% of the sample had completed tertiary education, 46.5% were identified as scientists, and 13.7% were employed in the meat sector. Nearly half of the participants reported an income below 1000 euro per month. Concerning meat consumption habits, the majority either consumed meat several times a week (68.1%) or less frequently. Only 6.9% of the population reported daily meat consumption, while 4.3% followed a vegetarian diet. Lastly, a significant majority (66.9%) of the population declared to have prior knowledge of cultured meat before participating in this survey. Regarding the most important criteria Greek consumers follow during their food purchases, the top criterion was "price" (71.5%), followed by internal food characteristics such as "nutritional value", "sensory quality", and "safety" (Fig. 1a). Ethics played a notable role, whereas the environmental impact was less influential on shopping habits. Appearance was found to be the least important factor, potentially due to the inclusion of the attribute "sensory quality" (which includes the appearance), which ranked high among consumer considerations.

3.2. Participants' willingness to try and general opinion towards cultured meat

Regarding WTT, most of the participants expressed a positive attitude towards cultured meat. Indeed, 58% of them indicated that they would probably or definitely try it, whereas only 23% stated that they would probably or definitely not try (Fig. 2a). However, despite this willingness, 95% of the sample would pay either the same or less for cultured meat compared to conventional meat (categories "same price as for conventional meat", "less than for conventional meat" and "much

Table 1
Sociodemographic data, meat consumption habits and product familiarity.

Variables	Groups	Percentage of the total sample
Gender identity	Woman	62.2
	Man	37.0
	Non-binary	0.8
Continent or country of origin	Greece	98.0
	Other countries within the European Union	1.2
	European countries outside the European Union	0.5
	Countries outside Europe	0.3
Age range	18 - 30 years	63.0
	31 - 50 years	31.4
	> 50 years	5.6
Level of education	Secondary school	12.5
	Third level, non-degree education	0.9
	Bachelor's degree	52.3
	Master's degree or higher	32.9
	Does not wish to answer	1.3
Activity area	Scientist outside the meat sector	37.8
	Scientist within the meat sector	8.6
	Not scientist but within the meat sector	5.1
	Not scientist and outside the meat sector	48.4
Monthly net income	€650 or less	27.0
	€651 - €950	27.2
	€951 - €1250	20.6
	€1251 - €1850	14.8
	€1851 - €2450	4.4
	more than €2451	6.0
	Does not wish to answer	0
Meat consumption frequency	Daily or within each meal	6.9
	Regularly: several times a week	68.1
	Rarely: weekly or less	20.6
	Never: vegetarian or vegan diet	4.3
Have you ever heard about artificial meat before?	No	33.1
	Yes	66.9

less than for conventional meat" in Fig. 2b).

As shown in Fig. 2c, consumers had a controversial opinion towards cultured meat. A total of 26% of them found it "absurd and/or disgusting" while the 74% either found it "fun and/or intriguing" (42%) or "promising and/or acceptable" (32%), suggesting a society potentially open to experimenting with it. However, the fact that 42% of the consumers found cultured meat "fun and/or intriguing" rather than "promising and/or acceptable" raises concerns about its long-term acceptance in the market. Moreover, although participants were open to try cultured meat, when asked about the context(s) in which they would like to regularly consume it, 51% preferred "not to eat it regularly" (Fig. 3). Furthermore, the consumers' frequency of conventional meat consumption was also recorded to explore how current familiarity with meat consumption might affect emotional resistance (e.g. disgust, nervousness) to cultured meat. While participants with daily meat consumption had higher emotional resistance towards it than the rest of the sample, this was not significantly higher (Fig. 4).

A significant portion of the sample (82%) reported that they currently do not consume meat substitutes (Fig. 5a). When asked about accepting cultured meat as a viable alternative compared to other meat substitutes (such as soy proteins) or other solutions (such as reducing food waste or developing farming practices), the entire sample was evenly divided into two. Interestingly, the vast majority of the sample (85%) thought that cultured meat will become a realistic scenario in the short (1 to 5 years) to medium (6 to 15 years) term while only a 7% answer that it could "never" be a realistic scenario (Fig. 5b).
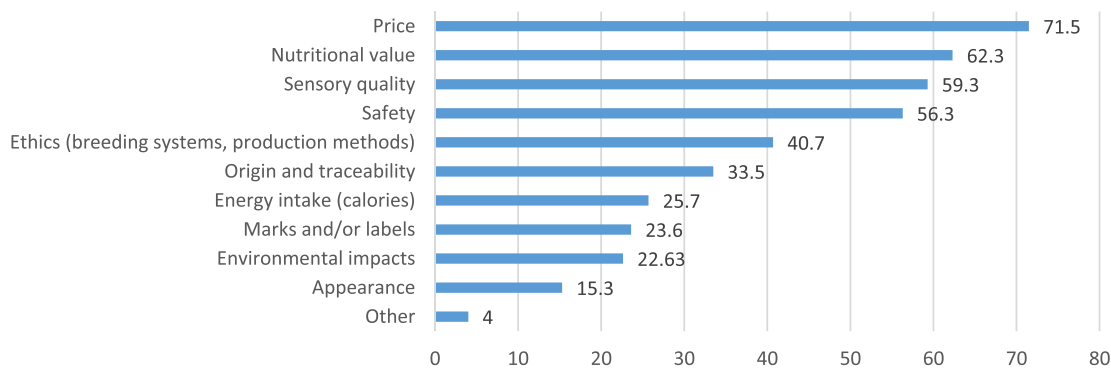
Fig. 1. Consumers' responses (%) to the question "What are the most important criteria during your food purchase?" (multiple answers were allowed).
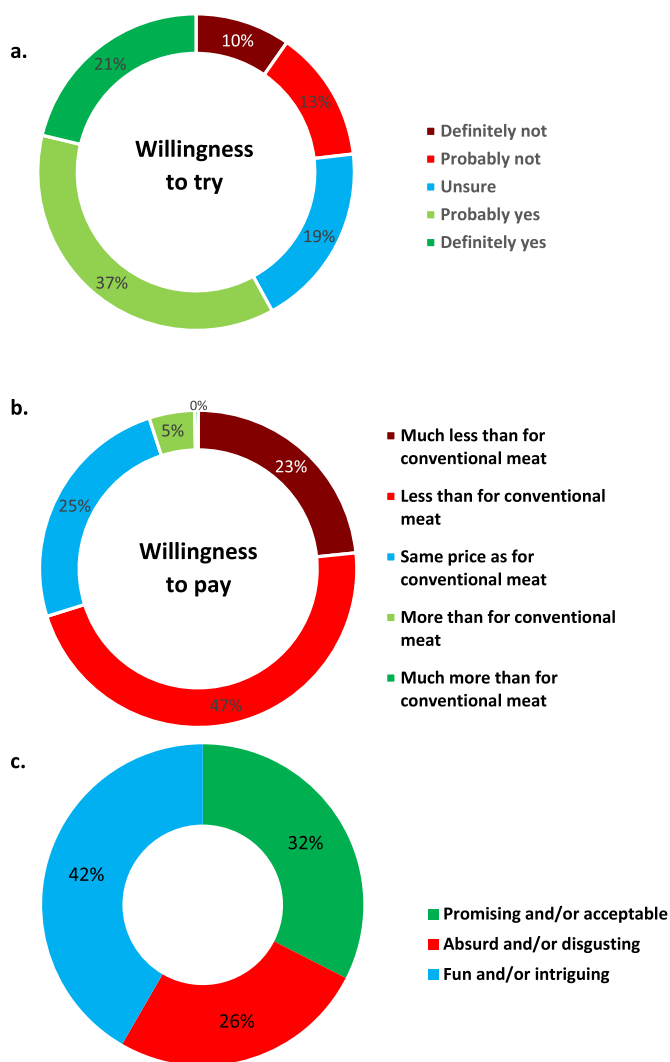

Fig. 2. Consumers' opinions (%) about a) "willingness to try", b) "willingness to pay", and c) "general feeling" regarding cultured meat (one answer among the proposed options was allowed for each question).

3.3. Participants' attitudes, expectations, and product characteristics that drive willingness to try cultured meat

In Fig. 6 are presented the consumers' attitudes driving their WTT cultured meat. The attitudes that notably influenced consumers' WTT it were those comparing it with conventional meat. For instance, while the notion that "on-farm breeding and the meat industry cause important ethical problems" did not significantly impact the WTT cultured meat, the idea that "the consumption of cultured meat would be more ethical compared to that of conventional meat" had a high positive significance (p<0.001).

Similarly, attitudes comparing cultured meat to conventional meat in terms of being "similar in taste", "healthy, safe, and nutritionally rich", and "eco-friendly" significantly influenced positively WTT it. Among the non-comparative attitudes, only the notion that "on-farm breeding and the meat industry cause important environmental problems" had a significant positive impact (p<0.05).

Going deeper into what would drive participants to try cultured meat, over 50% of the sample expressed WTT it out of "curiosity" (Fig. 7a). This information can be linked with the participants' reluctance to consume this product regularly, even if they are highly willing to try it, as discussed in the previous section. Following closely behind, motives such as "ethics", "clean label product", and "environmental sustainability" were found with 45.0%, 41.3%, and 38.7% respectively. On the other hand, regarding the reasons for not trying cultured meat, consumers expressed concerns about its "unnatural" nature and "safety" issues as primary reasons. They were also expecting it to be "more expensive" and "less tasty" (Fig. 7b). The impact on "local farmers" and "territories and rural life" was noted by only 22.8% and 21.7% of respondents, respectively.

Surprisingly, only 9.7% were "attracted" by the novelty of its technology in order to be willing to try it (Fig. 7a). In addition, lack of trust in the "laboratories and the start-ups developing it" was a prominent determinant (40.7%) to the consumers' reluctance (Fig. 7b).

Regarding their expectations, more than 50% of the sample anticipated that cultured meat would possess attributes directly linked to the product itself, such as being "adequately nutritious" (54.9%), "safe" (52.7%), and having a "taste similar to conventional meat" (50.2%) (Fig. 7c). These attributes underscore the crucial role of the product quality in the final purchasing decision.

Slightly less than half of the sample highlighted that they would expect cultured meat to address issues usually associated with conventional meat consumption, such as its potential contribution to reducing either "animal pain/suffering" (49.3%) or the "environmental footprint" (47.1%). Consistent with the above-mentioned results, only less than a quarter of the participants expressed concerns regarding the reduction or elimination of farming.

3.4. Willingness to try cultured meat per socio-demographic category

Table 2 displays the average scores provided by different socio-demographic categories, meat consumption frequency, and product familiarity concerning their WTT cultured meat. Results indicated that
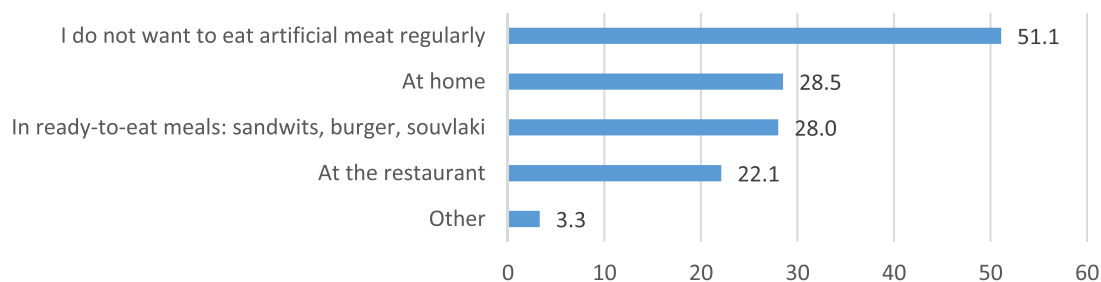
Fig. 3. Consumers' responses (%) to the question "In what context(s), would you eat artificial meat regularly?" (multiple answers were allowed).
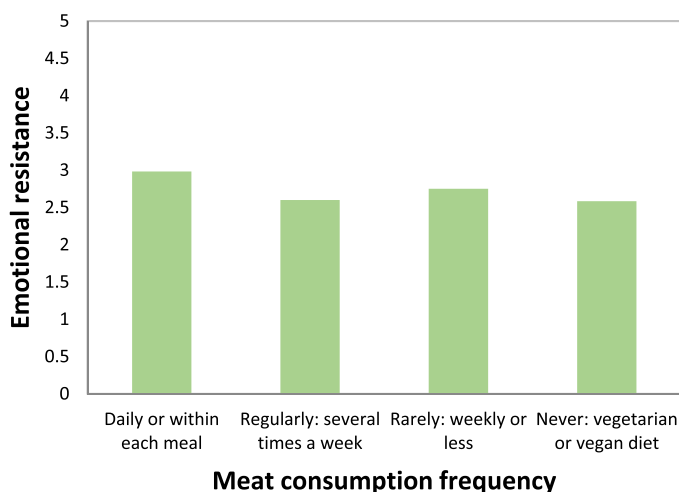

Fig. 4. Emotional resistance (e.g., disgust, nervousness) to trying cultured meat across different categories of meat consumption frequency. No significant differences between categories (p<0.05).

there were no significant differences (p<0.05) in WTT cultured meat among different groups based on "gender", "frequency of meat consumption", or "previous knowledge about cultured meat".

The youngest participant group, between 18 and 30 years of age, exhibited significantly higher WTT scores compared to older individuals, which was expected as it confirms previous studies (Table 2). In terms of education level, the highest WTT scores were observed among consumers holding a "master's degree or higher" or those who had attended "third-level non-degree education". However, no significant difference was noted among them and the other education levels, except for those who chose not to disclose their education level. However, these represented only 1.3% of the sample. Thus, no specific pattern emerged regarding education levels. Concerning income, participants with the lowest income range, together with those having an income between €950 and €1250 per month, had the lowest WTT. Individuals with incomes ranging from €651 to €950, or above €1251, indicated higher WTT scores with no significant differences among them.

A very interesting observation emerged regarding the WTT in relation to respondents' activity areas. Participants who defined themselves as "scientists within the meat sector" had the highest WTT value whereas the lowest value was associated with "non-scientists within the meat sector".

Two questions were used to assess participants' beliefs regarding the contributions of private research models (start-ups) and public scientific research to the cultured meat era, as presented in Table 3, divided into age range subgroups. The youngest group, which exhibited the highest WTT, also provided the highest values for the perceived necessity of both start-ups and public scientific research to invest in this biotechnology. However, this was significantly higher, than the other age
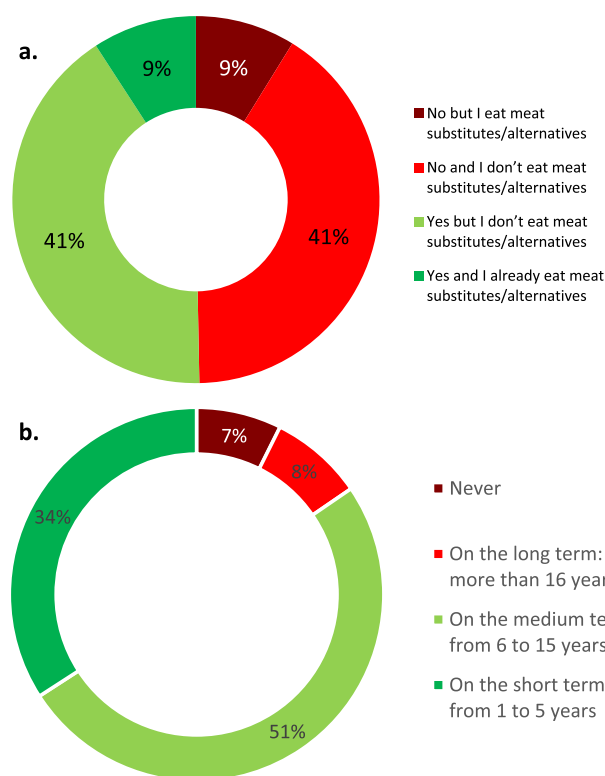

Fig. 5. Consumers' responses (%) to the questions: a) "Compared to other meat substitutes (such as soy proteins) or other solutions (such as reducing food waste or developing our farming practices), would you accept artificial meat as a viable alternative to conventional meat in the future?" and b) "On what term do you think artificial meat is realistic?" (one answer was allowed).

groups, only for the public scientific research. However, notably, all age groups assigned higher values to the potential contributions of start-ups.

3.5. The most appropriate name

The participants in this study found that the most relevant names to cultured meat were those emphasizing its artificial nature, such as meat that someone artificially created (38.3%), or this that is cultured (28.4%) or synthesized (25.1%) (Fig. 7d). The questionnaire, though, employing the name "artificial meat", potentially influenced respondents' preference for this term. More scientific names such as "*in vitro*", "lab-grown", "cellular", or those directly comparing it to conventional meat (e.g., the one without slaughter or without animal, or cleaner –considering the question of whether conventional meat is clean) did not gain much popularity among the participants. Interestingly, despite the prevalence of these terms, the questionnaire intentionally used names containing the word "meat". Later on, in a separate question, 58% of the participants reported that they would not agree to
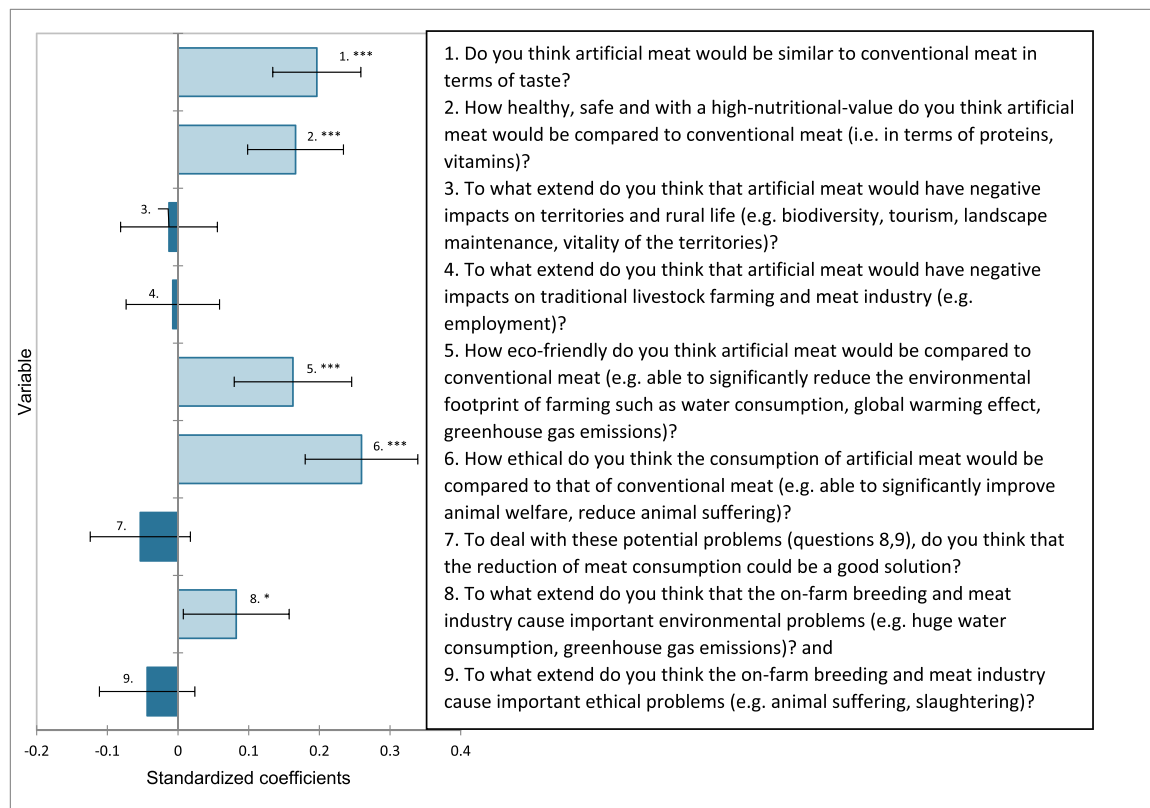
Fig. 6. Linear regression explaining the consumer attitudes driving willingness to try cultured meat in Greece. The scale used ranged from 1 (I disagree/very low) to 5 (I agree/very high). *Signification codes: *** p< 0.001, *p< 0.05.*

categorize this product as "meat" (Fig. 8).

4. Discussion

4.1. Sociodemographic characteristics

The demographic profile of the participants, although not intentionally targeted, primarily included younger and well-educated consumers, which, as it has been discussed in the introduction, is anticipated to be the primary consumers of cultured meat upon its market launch. Notably, the youngest group in this study, with a high proportion belonging to generation Z (NieŻurawska et al., 2023), exhibited a significantly higher WTT compared to older consumers. Similarly, in a study from China, more than 70% of the participants were willing to try cultured meat (Zhang et al., 2020) whereas a study from Australia reported that 72% of Generation Z was not ready to accept it (Bogueva and Marinova, 2020). Interestingly, unlike previous reported results (Verbeke et al., 2021), gender did not serve as an identifier of WTT in this study. This trend aligns with the evolving shift away from strict gender norms that were established in earlier generations (The Irregular Lab, 2019).

Regarding the education level of the sample, a high percentage of consumers reported having finished third level education. However, there is, sometimes, a misunderstanding in Greece, suggesting that completing a BSc degree and acquiring scientific knowledge could make someone a scientist. This could explain why many consumers identified themselves as scientists, despite not fitting the traditional definition of the term. Neither the level of education significantly influenced the WTT though. This could be attributed to the changing sources of information, due to the postmodern condition and the rise of social media dominance (Gare, 1995; Rennie et al., 2019). Another notable characteristic of the study's demographic profile is the relatively high percentage of participants working in the meat sector, which could have influenced the

results as discussed in Section 4.7.

4.2. Expected product characteristics at market launch

It has been reported that consumers seeking a healthier meat product are unwilling to compromise on sensory quality (Di Vita et al., 2019; Melios et al., 2024c). Consequently, stakeholders such as product manufacturers, distributors, and the scientific community need to carefully consider this before new product developments attempts. The findings presented here, strongly emphasize that WTT cultured meat greatly relies on the product itself and its intrinsic and extrinsic attributes. However, it seems that these expectations are not yet being met, and as other studies also refer to the significant impact of taste and sustainability on product acceptance (Cornelissen and Piqueras-Fiszman, 2023), it is raising the question of whether it is worth the substantial funds and effort necessary for developing a product of high sensory quality but still of questionable acceptance in the market.

4.3. Product familiarity and willingness to try

Cultured meat is perceived as unnatural by many consumers, triggering feelings of neophobia. It has been reported that attitudes and intentions toward cultured meat are primarily predicted by food neophobia and political conservatism, while complete opposition is again associated with neophobia but together with hygiene, disgust, sensitivity, etc. (Wilks et al., 2019). This can explain why today, among alternative proteins, insects and cultured meat face the lowest consumer acceptance (Onwezen et al., 2021). Similarly, in the present study, the unnatural nature of cultured meat was reported as an important factor to reduce the consumers' WTT. In general, evidence exists that the perceived naturalness of meat (traditional or cultured) significantly influences how consumers evaluate the risk of diseases associated with it (Siegrist and Sütterlin, 2017). Thus, as already mentioned by other
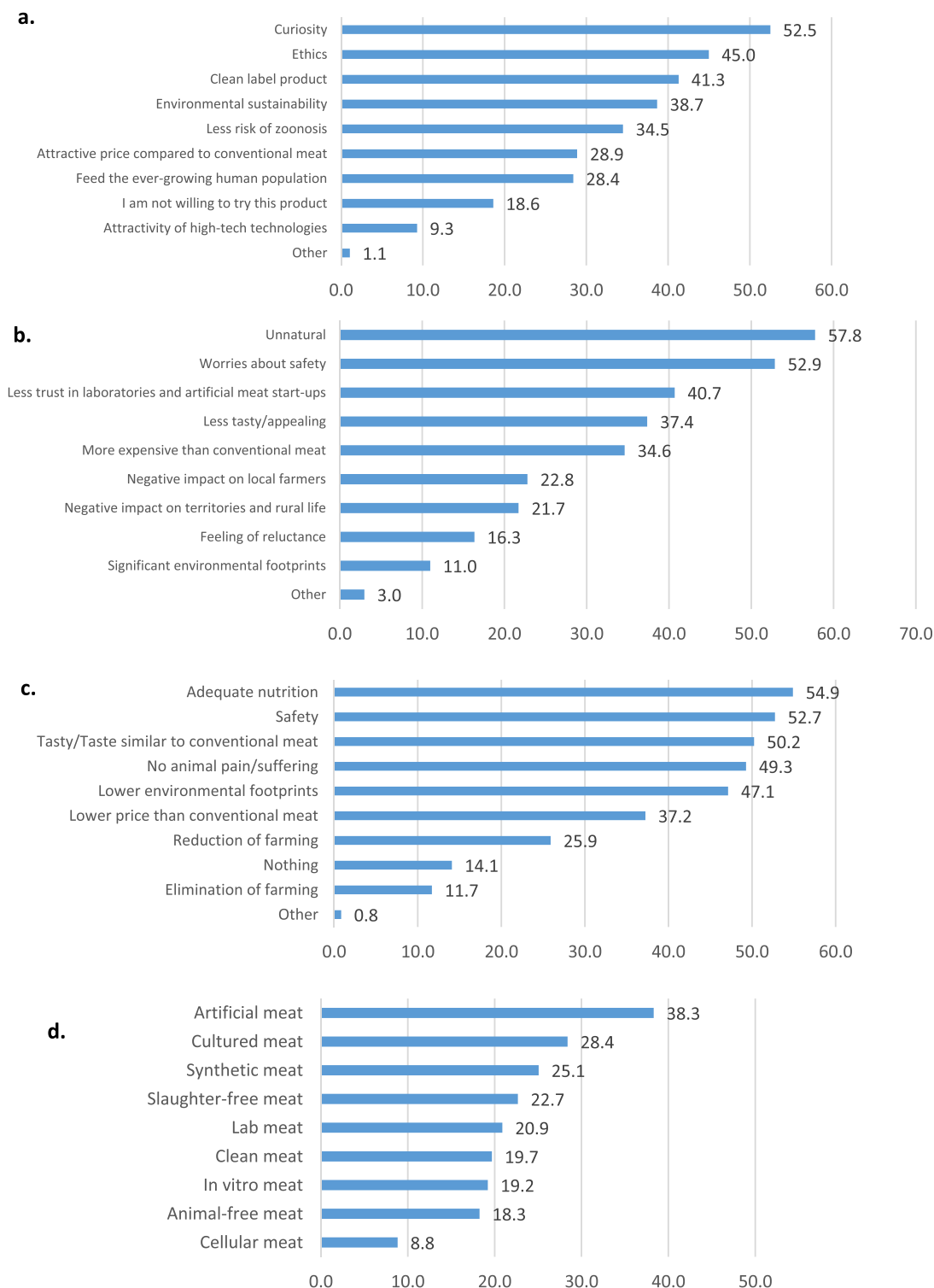
Fig. 7. Consumers' responses (%) to the questions: a) "what would be the reasons to try artificial meat?", b) "what would be the reasons NOT to try artificial meat?", c) "what would you expect from artificial meat", and d) "what do you consider as the most relevant names to be used for cultured meat (among those most commonly used by companies in the sector)" (multiple answers were allowed).

authors (Rolland et al., 2020), acceptance of cultured meat by consumers also hinges on consumer information levels that increase familiarity with it. However, product familiarity could also yield opposite results by familiarizing consumers with the idea of high-tech meat and resulting in its rejection. In this study, no differences in WTT were observed between consumers who declared familiarity with cultured meat and those who did not. This could be attributed to the perception of cultured meat as high-tech, which may have made familiar consumers more sceptical towards it.

4.4. Consumer perception of the high-tech concept

It has been reported that three critical factors emerge when analysing the case of cultured meat: the transferability of technologies from the

Table 2

Willingness to try cultured meat per sociodemographic category, meat consumption frequency, and product familiarity (1: "would never try" to 5: "would definitely try").

Variable	Categories	Mean ±SE
Gender identity	Woman	3.4±0.1
	Man	3.5±0.1
	Non-binary	3.3±0.5
Age range	18 - 30 years	3.6 ±0.1[a*]
	31 - 50 years	3.1±0.1[b]
	> 50 years	3.2±0.2[b]
Level of education	Secondary school	3.3 ±0.1[a,b]
	Third level, non-degree education	3.7±0.5[a]
	Bachelor's degree	3.4 ±0.1[a,b]
	Master's degree or higher	3.6±0.1[a]
	Does not wish to answer	2.5±0.4[b]
Activity area	Scientist outside the meat sector	3.5 ±0.1[a,b]
	Scientist within the meat sector	3.9±0.1[a]
	Not scientist but within the meat sector	2.9±0.2[c]
	Not scientist and outside the meat sector	3.4 ±0.1[b,c]
Monthly net income	€650 or less	3.3±0.1[b]
	€651 - €950	3.7±0.1[a]
	€951 - €1250	3.3±0.1[b]
	€1251 - €1850	3.5 ±0.1[a,b]
	€1851 - €2450	3.4 ±0.2[a,b]
	more than €2451	3.4 ±0.2[a,b]
	Does not wish to answer	N/A
Meat consumption frequency	Daily or within each meal	3.2±0.2
	Regularly: several times a week	3.5±0.1
	Rarely: weekly or less	3.4±0.1
	Never: vegetarian or vegan diet	3.3±0.2
Have you ever heard about artificial meat before?	No	3.5±0.1
	Yes	3.4±0.1

*Different letters signify significant differences within each category (p<0.05).

Table 3

The extent (mean±SE) to which consumers in Greece believe that the private research model (by start-ups) is relevant for potentially developing research on cultured meat and that public scientific research should invest time and funding to develop this biotechnology.

Age group	Start-ups	Public research
18–30	3.6±0.0	3.2±0.1[a]
31–50	3.3±0.1[A*]	2.8±0.2[bB]
>50	3.4±0.2[A]	3.0±0.4[bB]

*Lower case letters signify significant differences within columns while capital letters signify significant differences within rows (p<0.05).

medical sector, potential environmental benefits, and overcoming consumer resistance to its "unnatural" nature (Burton, 2019). In this study, except its unnatural characteristic already discussed, it was emphasized that high-tech technologies were not a pivotal factor influencing positively WTT cultured meat. Hence, it is suggested that it could not be reintroduced to the consumers based on its technology but rather on superior characteristics that it might possess.
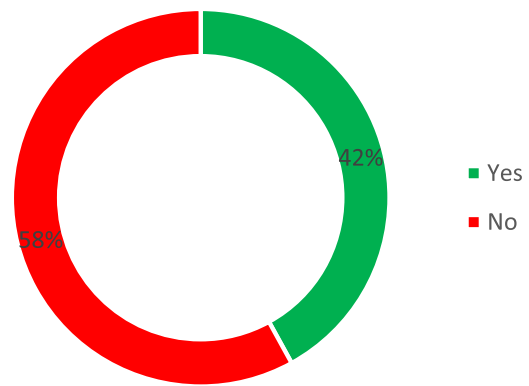

Fig. 8. Consumers' opinion (%) on whether cultured meat should be named "meat" or not if it is commercialized (one answer was allowed).

4.5. Consumer perception of the role of private and public research

There is still an ongoing discussion about whether start-ups or public scientific research institutions should lead the research in the area of cultured meat. Even if we observed a lack of trust in the "start-ups developing it", consumers pointed out the potential technical ability of start-ups to develop this product. A potential concern is the dominance of a few high-tech companies from the Global North in the future global food system, raising issues of equitable access for different income groups or different countries, and the role of governments in facilitating a smooth transition to cultured meat production and consumption (Painter et al., 2020). The growing number of patent applications related to cultured meat is noteworthy (Ng et al., 2021). Younger generations, though, were found to be positive about both private and public scientific research investing in this technology, and a decentralized model of development.

4.6. Naming of cultured meat in the Greek context

Whether cultured meat should include the word "meat" in its name, and how it should be framed is still a subject of debate. In this study, consumers in majority would not prefer it to be labelled as "meat", as in Brazil (Chriki et al., 2021), and the most popular name suggested by the consumers ("artificial meat") refers to its unnaturalness. As already discussed, "artificial meat" was the term used in the questionnaire, which may have influenced consumers' responses. However, this was followed by "cultured" and "synthetic", which still support the argument. If cultured meat is launched as "meat", consumers will inevitably compare it with conventional meat. At the same time, terms like "synthetic" categorize cultured meat as the "fake" version of the *real* meat (Mouat and Prince, 2018). Siegrist et al., (2018) suggested that cultured meat should be given a name that doesn't emphasize its production process, such as "in vitro meat" or "cultured meat", but rather a name that describes the product and its properties, highlighting its potential similarity to conventional meat (Siegrist et al., 2018). However, observations of this study suggest that consumers demand a name that allows them to understand what they consume and purchase. Thus, the name should be informative enough for the final consumer to make a critical choice. Therefore, we agree with the term "cell-based food", introduced by FAO and WHO, as a fair solution that does not mislead the consumer by presenting it as another version of conventional meat (FAO & WHO, 2023).

4.7. Consumer perception of the effect of cultured meat on livestock

Rather than a complete replacement of traditional meat production by cultured meat, a diversified protein market is likely to emerge, challenging industrial livestock production with cost-effective synthetic

alternatives like cultured meat (Burton, 2019). However, in this study, while there was a high WTT cultured meat among consumers, it was not observed that they had a negative attitude toward conventional meat. Overall, the perception that cultured meat could have negative impact "on territories and rural life" or "traditional farming", as well as concerns about "ethical problems" within the meat industry, did not significantly influence WTT. Probably this was because curiosity was a main driver of WTT cultured meat suggesting that responders would not intend to replace conventional meat with it. Another possible explanation is that most participants in the study were not connected to the livestock sector, and therefore, may not be as affected by such a transition. On the other hand, unlike previous studies (Bryant et al., 2020), this study found the lowest WTT cultured meat among workers within the meat sector, who are not scientists. Those were likely individuals involved in meat production and related activities where the potential market launch of cultured meat might pose a risk to their income.

4.8. Consumer willingness to pay for cultured meat

Research suggests that cultured meat retail cost could exceed $50/kg, necessitating capital cost reductions (Humbird, 2021). However, as an emerging technology, its production efficiency and emissions footprint can be improved, especially if energy generation becomes more environmentally friendly (Lynch and Pierrehumbert, 2019). As highlighted, the cost of cultured meat on the shelf will play a crucial role in its adoption as noted by 71.4% of consumers in this study. A significant percentage (47%) of consumers expected cultured meat to have a price lower than conventional meat. Therefore, the industry requires an influx of experts from interdisciplinary fields to solve technical issues and optimise the production leading to lower costs (Choudhury et al., 2020). Moreover, a great body of research has to be performed with respect to the cost-effectiveness of the technology and ethical and societal issues before effective large-scale production can be achieved (Bhat et al., 2015).

4.9. The effect of meat consumption level and patterns

Intersecting with eating habits in Greece, general meat consumption patterns are particularly relevant. Many vegetarians and vegans might exhibit reluctance toward products looking and tasting like meat as they have deliberately excluded meat from their diet and might not seek its alternatives (Cliceri et al., 2018; Gousset et al., 2022). Conversely, flexitarians might be open to try cultured meat as an "ethical" alternative to meat taste, while others might reject it as "unnatural" as already discussed. Simpler dietary and consumer behaviour changes, such as replacing beef with chicken, reducing food waste, and incorporating insects into diets, could significantly reduce food environmental impacts such as agricultural land use (Alexander et al., 2017). Thus, flexitarians may prefer this strategy to reduce their environmental footprint. Therefore, the frequency of meat consumption alone cannot reliably predict WTT or WTE cultured meat in the Greek context, nor the other way around.

Determining the target group for cultured meat consumption in Greece based on the frequency of meat consumption poses a challenge. Frequency of meat consumption here was much lower than that reported in similar studies in other countries (Bogueva and Marinova, 2020; Dijk et al., 2023; Li et al., 2023) and this must be taken into consideration if cultured meat is launched in Greece. This trend may be associated to the Mediterranean diet, where meat, though a part of it, is typically consumed less frequently than in other diets, especially "Western" diets (Simopoulos, 2001).

5. Conclusion

This study revealed several insights into consumer perceptions of cultured meat in Greece, as reflected by a predominantly young and well-educated sample. The findings underscored a high WTT among young consumers. However, the willingness to eat it regularly, as well as the willingness to pay for it, remained low. The acceptance of cultured meat in Greece seems to hinge on the product characteristics, with consumers demanding it to surpass conventional meat in taste, health benefits, environmental friendliness, and ethical production methods. Moreover, how cultured meat can be part of the Mediterranean diet is expected to play an important role during its launch in the Greek market.

Regarding its promotion and naming strategy, while it has been previously suggested to focus on its sensory profile, safety standards during production, as well as its ethical and pro-environmental "superiority", this should not overshadow consumer rights to know what they purchase and not to be misled. Thus, the name used by FAO ("cell-based food") seems like the most suitable one.

The landscape for cultured meat in Greece presents a complex scenario where WTT is influenced by numerous factors, including generational shifts, product characteristics, naming, and the context of promoting it while it does not always reflect the willingness to eat it regularly.

Ethical statement

This study adhered to local guidelines aligned with the laws and regulations of the countries where it was conducted, including obtaining ethical approval from ethics committees (CAAE number: 37924620.5.0000.5404). The entire process followed the ethical guidelines for online research established by the European Society for Opinion and Market Research (ESOMAR, 2015). This included obtaining informed and explicit consent from all respondents before their participation and ensuring the protection of their personal data. All respondents were fully informed about the survey's objectives and the use of their provided information. Their informed consent was obtained both before and after their participation in the study. Respondent information was collected anonymously, with the option to choose "do not wish to answer", and without collecting any personally identifiable information. Demographic details of respondents, including gender, age, education level, occupation, monthly net income, meat consumption habits, and familiarity with cultured meat, were collected anonymously.

CRediT authorship contribution statement

Stergios Melios: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Konstantinos Gkatzionis:** Writing – review & editing, Supervision, Methodology. **Jingjing Liu:** Writing – review & editing, Methodology, Conceptualization. **Marie-Pierre Ellies-Oury:** Writing – review & editing, Methodology, Conceptualization. **Sghaier Chriki:** Methodology, Conceptualization, Writing – review & editing. **Jean-Francois Hocquette:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.fufo.2025.100538.

Appendix A

Greek version of the text was provided to the consumers in the beginning of the survey:

"Το τεχνητό κρέας, γνωστό με τα ονόματα in vitro κρέας, κρέας καλλιέργειας, κρέας εργαστηρίου, καθαρό κρέας και συνθετικό κρέας, είναι ένα καινοτόμο τρόφιμο που παράγεται σε εργαστήρια χρησιμοποιώντας βλαστοκύτταρα. Αυτά τα βλαστοκύτταρα δεν προέρχονται κατευθείαν από ζώντα ζώα αλλά πολλαπλασιάζονται σε καλλιέργειες εργαστηρίου.

Η παραγωγή του τεχνικού κρέατος, έρχεται να απαντήσει στην ανάγκη διάθεσης τροφίμου στον αυξανόμενο παγκόσμιο πληθυσμό. Η επιστημονική έρευνα έχει στραφεί στην ανάπτυξη, σε μεγάλη κλίμακα, τεχνητών μορφών κρέατος ως μία εναλλακτική στο συμβατικό κρέας με σκοπό να μειωθούν οι ανησυχίες σχετικά με την επιβάρυνση του περιβάλλοντος λόγω της κτηνοτροφίας, ζητήματα ηθικής (κακομεταχείριση των ζώων) αλλά και την αδυναμία της συμβατικής κτηνοτροφίας να αυξήσει την παραγωγή."

Appendix B

Introduction of cultured meat provided to consumers to a survey adapted from Liu et al., (2021). Text in Greek: 1: Muscle biopsy, 2: Proliferation in culture, cell culture, 3: Muscle fibres, 4: Artificial meat food.

Data availability

Data will be made available on request.

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