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Approach of Gastronomy and Culinary Arts and Cookery Students towards In Vitro Meat

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HIGHLIGHTS

- In vitro meat presents a significant opportunity for environmental sustainability and food security.
- While most students perceive IVM as unnatural, they have a more neutral view on its ethical and environmental benefits
- Greater education and public awareness are needed for the acceptance of this technology.

Abstract

Today, environmental issues, ethical concerns, and population growth have led to the questioning of traditional animal protein production methods. In vitro meat technology, developed in this context, stands out as an innovative method that enables the production of meat from animal cells in a laboratory setting. However, despite its clearly established technological and environmental benefits, consumer acceptance and social perceptions remain uncertain. This study aimed to examine the perceptions and attitudes of Gastronomy and Culinary Arts and Cookery students towards in vitro meat (IVM) and to reveal the acceptability and potential of this innovative food technology. The study was conducted with the participation of a total of 403 students studying at the Gastronomy and Culinary Arts and Cookery departments of Sinop University and Karabuk University. A total 66.7% of the participants reported being unfamiliar with the concept of in vitro meat. In the analyses, gender (p=0.105) and university (p=0.123) variables did not have a significant effect on general attitudes towards IVM, but a statistically significant difference was found between Karabuk and Sinop University students in the tendencies of "trying, consuming and purchasing" (p=0.032). Although the participants think that IVM is unnatural ("IVM is unnatural" statement, Mean=4.02), their perceptions of its ethical and environmental benefits are more neutral. In conclusion, considering the potential of in vitro meat technology to effectively use limited natural resources, reduce environmental impacts and ensure food safety, the integration of this technology into the culinary field is of great importance. However, in order to realize this potential, it is necessary to create a wider awareness in the society, to include such innovative technologies more in educational programs and to develop strategies to ensure that food industry professionals adopt this innovation.

Keywords: In Vitro Meat; Gastronomy and Culinary; Arts and Cookery Students; Sustainable Food

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1. Introduction

Although conventional agricultural and livestock production methods have historically played a central role in global food supply chains, they have increasingly been criticized for their negative environmental impacts, ethical concerns regarding animal welfare, and inefficiencies in resource use. As the global demand for animal-derived products rises in parallel with population growth and changing consumption patterns, it becomes imperative to explore alternative and sustainable food production systems (Van Eenennaam and Werth 2021). One such emerging solution is cellular agriculture, a biotechnology-driven method that allows for the production of animal or plant-based products by cultivating cells in controlled laboratory environments, rather than relying on traditional animal farming (Treich 2021). This technology involves the production of animal products by culturing animal cells in bioreactors or using microorganisms in protein synthesis, rather than directly from animals (Mattick 2018). Two different methods are used in cellular agriculture applications: tissue-based and protein-based. In the tissue-based method, cells taken from animals are multiplied to obtain a form similar to animal meat, while in the protein-based method, proteins naturally found in animal products are copied and plant-based components such as vegetable oils are added to the final product (Waschulin and Specht 2018; Kırmacı and Akmanoğlu 2021).This approach aims to reduce environmental impacts and provide a more sustainable production process compared to traditional agriculture (Farhoomand et al. 2022).

Cellular agriculture is important to ensure the continuity of sustainable food production and to provide solutions to problems such as quality, hygiene and animal diseases in animal food production. Among consumers, interest in traditional methods is decreasing and demand for alternative methods is increasing due to ethical concerns and environmental impacts in animal production processes. The similarity of meat and other products produced through cellular farming to traditional products increases the likelihood of acceptance of these products by consumers (Waschulin and Specht 2018). At the same time, these methods contribute to the sustainability of the future food supply by ensuring the efficient use of natural resources and food security. In this context, by integrating scientific innovations such as biotechnology and nanotechnology, cellular agriculture forms the basis of solutions to future nutritional problems (Demirel 2020).

Cellular agriculture aims to meet the food needs of the growing population in the future by offering an innovative and sustainable approach to the production of animal products. In this process, stem cells or non-stem cells taken from animals are cultured in special devices called bioreactors. Bioreactors provide a three-dimensional scaffold material and an environment enriched with nutrients such as sugar, salt and amino acids for the cells to grow (Kadim et al. 2015). Since the scaffold has a biodegradable structure, it integrates with the product and becomes suitable for consumption. The transformation of cells into different structures such as muscle, connective and adipose tissue is guided by signaling proteins in the bioreactor. This innovative method minimizes hygiene risks in the production process, reducing the possibility of contamination with pathogens such as *E. coli* and *Salmonella* and making the use of drugs and hormones unnecessary (Specht et al. 2018).

Technological barriers need to be overcome for cellular agriculture to become widespread. In particular, work is ongoing on scaling up bioreactors developed for medical purposes to commercial production (Mattick 2018). While cellular agriculture has the potential to meet the needs of 10 billion people by 2050, the success of this technology depends on a realistic assessment of the opportunities and challenges it brings. In this context, cellular agriculture is considered as a smart solution for the future, both ethically and environmentally (Gasteratos 2019). In vitro meat requires fewer resources than traditional methods and makes efficient use of natural resources such as limited water and land (Bonny et al. 2015). Research shows that cellular meat production can reduce energy consumption by 45%, land use by 99%, water demand by 96% and greenhouse gas emissions by 78-96%. Cellular agriculture offers significant benefits in terms of environmental sustainability, human health and animal welfare. Since hormones and accelerators used in the livestock sector are not used in this method, it creates a healthier production model. In addition, the absence of the need for animal slaughter prevents the spread of zoonotic diseases such as avian and swine flu and reduces health risks by making antibiotic use unnecessary (Stephens et al. 2018).

In addition to its advantages in terms of environmental sustainability and animal welfare, cellular meat technology has the potential to meet nutritional needs. Meat produced by cellular methods attracts consumers as an excellent source of protein, omega-3 fatty acids, vitamin B12 and iron (Wilks and Phillips 2017). With the development of this technology, significant water savings are expected not only in meat production, but also in dairy, poultry and seafood. For example, 98% less water is expected to be consumed in beef production, 99.6% less in dairy and 86% less in seafood. In addition, it will contribute to ocean conservation by providing solutions to problems that threaten marine ecosystems such as overfishing (Tuomisto and Teixeira 2011).

Cellular seafood; cellular agriculture technologies offer great potential not only for land animals but also for seafood production. Cell-based seafood is produced by culturing a small muscle sample from creatures such as molluscs, fish and crustaceans in bioreactors (Rubio et al. 2019). The products obtained by this method are referred to as “farmed”, “cultured” or “laboratory-grown” seafood. This technology offers a solution to problems such as overfishing and environmental pollution that hinder sustainable fisheries, while enabling the production of healthy seafood free from ocean-borne pollution such as microplastics and mercury. Increasing demands, especially in the fishing industry, and uncertainty in the potential for sustainable catches make cell-based fish products a more attractive option (Halpern, et al. 2021). Overfishing over the last 40 years has caused some fish species to exceed their sustainable biological limits by 33%. This raises concerns about the future of fish, crustaceans and molluscs, which meet 20% of global protein needs (Potter et al. 2020). By 2050, the world's population is projected to increase by 2 billion and the demand for food is expected to rise substantially, indicating that the need for seafood will also increase. However, current fishing methods may be insufficient to meet this demand (Ahmed et al. 2019). In addition to meeting the growing demand, cell-based seafood offers a complementary solution to protect the ocean ecosystem and prevent overfishing. Despite the sustainability challenges faced by traditional fisheries, this new technology is expected to play an important role in conserving ocean resources and meeting protein needs (Harpern et al. 2021). Cell-based seafood production has also attracted the attention of commercial enterprises. However, the number of companies in this field is limited; while there are more than 30 entrepreneurial companies in cell-based meat production, only 6 companies are working on cell-based fish production (Potter et al. 2020). This shows that cellular agriculture in the seafood sector is still in its infancy. Furthermore, estimates suggest that 98% of existing fish stocks will only recover by 2050. However, with improved management and policies, fish production could increase by 20%. Cell-based seafood will not only support sustainable fisheries, but will also be an important alternative to meet the needs of the growing population in the future as an environmentally friendly protein source (Ahmed et al. 2020). Cellular meat responds to consumers' health and environmental demands, while eliminating the ethical problems of traditional meat production. The global cultured meat market is expected to reach a size of $319.8 million by 2028. This growth makes cellular meat an economic opportunity, not only in terms of environmental sustainability. In the future, this technology is expected to play a leading role in transforming agriculture and animal husbandry (Wilks and Phillips 2017).

However, despite the increasing relevance of this technology in academic and industrial domains, there remains a significant gap in understanding how future food professionals, particularly students in gastronomy and culinary arts and cookery perceive these innovations and how they might integrate them into their future careers. In response to this gap, the main purpose of this study is to analyze the perceptions and attitudes of gastronomy and culinary arts and cookery students towards innovative food production technologies such as cellular agriculture and in vitro meat. In this context, it was aimed to evaluate students' awareness levels of these technologies, their perceived advantages and disadvantages, their views on the potential of these products in culinary applications, and their attitudes in this context. The research also aims to determine students' perspectives on the relationship between traditional food production methods and cellular agricultural technologies, thereby providing data that will contribute to innovative food applications in the field of gastronomy and cookery in the future.

2. Materials and Methods

In this study, which was carried out to determine the approach of culinary students towards in vitro meat, quantitative research method was used and questionnaire technique was utilized in data collection. In this study, questionnaire technique was used as a data collection method. The questionnaire used in the study consists of two parts. In the first part, there are questions to determine the demographic characteristics of the participants such as gender, age, university, department, class, and two questions about their meat consumption (categorical rating and percentage of diet consisting of meat). Accordingly, participants were asked about their familiarity with in vitro meat (IVM). Regardless of their level of familiarity, all participants were presented with a short and informative text and picture about the product before participating in the study. The text was prepared with a neutral content and aimed only to inform the participants rather than direct them. In the second part, there are 25 statements measuring the attitude towards in vitro meat. Studies in the relevant literature were utilized in the preparation of the questionnaire. The scale developed by Wilks and Phillps, (2017) was used in the questionnaire. Within the framework of the study, a 5-point Likert-type scale (1- Strongly Disagree , 5- Strongly Agree) was used in the questionnaire.

The population of the study consists of the students of gastronomy and culinary arts and cookery departments at Sinop University and Karabuk University. The main reason for choosing Gastronomy and Culinary Arts and Cookery departments as the research population is that both departments focus on students studying in the culinary field. These students will be active in the food and beverage sector in the future and in vitro meat has the potential to be served in kitchens. In addition, it is to determine how the views on in vitro meat differ between undergraduate and associate degree students. The questionnaires were administered to individuals through online methods at January, 2025. The data were collected using Google Forms, and simple random sampling technique was preferred as the sampling method in the study. The determination of the sample size was based on the idea that a sample size of 384, which is frequently referenced in the literature, would be sufficient (Kurtuluş 2011). In this context, the sample was formed by collecting data from a total of 403 participants. In this way, the reliability and generalizability of statistical analyses were increased.

The data obtained in this study were analyzed using SPSS 16.0 (Statistical Package for Social Sciences) program and statistical results were obtained. In the analysis process, descriptive statistics (frequency, percentage distribution) were calculated for the participants' gender, age, university, department, class, food consumption habits and the percentage of meat in their diets. In addition, both bivariate and multivariate analysis methods, Levene's Test, and Indepented-Sample T-test were used to measure the participants' knowledge about in vitro meat, their tendency to try, consume and purchase in vitro meat, and their level of knowledge about in vitro meat. The data of the questionnaires were transferred to the statistical analysis and evaluation program and the analyses related to the research were completed through this program.

Additionally, within the scope of the study, ethical approval was obtained from the Social and Human Sciences Research Ethics Committee of Karabuk University, dated December 30, 2024, with the reference number E.399581.

3. Results and Discussion

In this study, attitudes towards in vitro meat, demographic characteristics, knowledge about in vitro meat, tendencies to try, consume and purchase in vitro meat, and in vitro meat knowledge levels of gastronomy and culinary arts and cookery department students at Sinop University and Karabuk University were statistically analyzed and given in tables. The reliability of the application and analysis processes of the program used in the study was determined as .831 with the "Cronbach's Alpha" value calculated as a result of the analysis. Data on the demographic characteristics of the participants who participated in the study are given in Table1.

Table 1. Demographic Variables of the Participants

Variables		No. of Responses	Percentage of Sample
Gender	Female	287	71.2
	Male	116	28.8
Age	17-19	162	40.2
	20-22	181	44.9
	23 years and older	60	14.9
University	Karabuk University	201	49.9
	Sinop University	202	50.1
Department	Cookery	203	50.4
	Gastronomy and Culinary Arts	200	49.6
Class	1st grade	166	41.2
	2nd grade	136	33.7
	3rd grade	58	14.4
	4th grade	43	10.7
Eating Habits	Red Meat	252	62.5
	Chicken Meat	115	28.5
	Fish Meat	3	0.7
	Vegetarian	32	7.9
	Vegan	1	0.2
Meat consumption rates in the Diet	%10	48	11.9
	%20	54	13.4
	%30	80	19.9
	%40	89	22.1
	%50	81	20.1
	%60	19	4.7
	%70	15	3.7
	%80	10	2.5
	%90	2	0.5
	%100	5	1.2
Have you heard of in vitro meat	Yes	134	33.3
	No	269	66.7
TOTAL		403	100

Participants' demographic characteristics, educational status, dietary habits and awareness levels of some concepts were evaluated. The results reveal several noteworthy trends that carry implications for both educational content and future professional orientation in the field.

A significant finding emerged regarding participants' awareness of the term in vitro meat. While 33.3% of the respondents stated that they had heard of the term, the majority 66.7% reported no prior familiarity. This indicates a considerable lack of awareness among students being trained for careers in food production and innovation. Considering the growing relevance of alternative protein sources and sustainable food systems, this finding underscores a potential gap in current culinary curricula. It suggests a need to integrate more comprehensive content related to emerging food technologies.

The data concerning meat consumption revealed that participants generally adopted a balanced approach. Moderate meat consumption (defined as 30%–50% of their diet) was the most frequently reported level, accounting for 62% of the sample. Low levels of consumption (10%–20%) were observed in 25.3% of participants, while only 12.6% reported high levels of meat intake (60% and above). This distribution suggests that students are not overly reliant on meat and may already be making more conscious dietary choices, whether motivated by health, environmental concerns, or other factors.

Regarding eating habits preferences, red meat was the most commonly consumed, with 62.5% of participants indicating it as a staple in their diet. Chicken meat was the second most common (28.5%). Vegetarian and vegan diets were far less prevalent; only 7.9% of respondents followed a vegetarian diet, and a mere 0.2% identified as vegan. These figures reflect the continued dominance of animal-based diets within this student.

The distribution of participants across institutions and departments was nearly equal, enhancing the representativeness and generalizability of the findings. Specifically, 50.1% of the participants were from Sinop

University and 49.9% from Karabük University. Departmental representation was also balanced, with 50.4% enrolled in Cookery programs and 49.6% in Gastronomy and Culinary Arts programs. This even distribution strengthens the reliability of the comparative analyses and helps ensure that the data are reflective of broader trends in the population studied.

The data on the relationship between the university and the health and naturalness of in vitro meat are given in Table 2.

Table 2. The Relationship Between Participants' University and the Health and Naturalness of IVM

Variable	University	N	Mean	T	Df	P Value
IVM, Health and Naturalness	Karabuk University	201	27.62	.551	401	.582
	Sinop University	202	27.33			

*Significance level at p<0.05.

In the table above, the independent sample t-test results of Karabuk University and Sinop University students regarding the variable "In Vitro Meat, Health and Naturalness" are analyzed. While the arithmetic mean of Karabuk University students was 27.62, the arithmetic mean of Sinop University students was calculated as 27.33. The t-test was applied to evaluate whether this difference was statistically significant. As a result of the test, the t-value was found to be .551 and the degree of freedom (DF) was determined as 401. The significance level obtained is (p= 0.582). Since this value is above the generally accepted significance level of (p > 0.05), it is concluded that the difference between the two groups is not statistically significant. This shows that there is a similarity in the perceptions of "IVM, Health and Naturalness" of the students of Karabuk and Sinop Universities.

The data on the relationship between the University and in vitro meat trying, eating and purchasing are given in Table 3.

Table 3. Relationship between Participants' University and IVM Trying, Eating and Purchasing

Variable	University	N	Mean	T	Df	P Value
IVM, Try, Eat, Purchase	Karabuk University	201	22.59	2.151	401	0.032
	Sinop University	202	21.74			

*Significance level at p<0.05.

In the table, the mean of Karabuk University students for the related variable was 22.59, while the mean of Sinop University students was 21.74. As a result of the independent sample t-test applied to evaluate whether this difference is statistically significant or not, the t value was calculated as 2,151, the degree of freedom (DF) as 401 and the significance level Sinop University in the "IVM sampling, eating and purchasing" shows that the difference between the two groups is statistically significant. (p = 0.032).

The data related to the gender of the participants in the study and the difference between trying, eating and purchasing in vitro meat are given in Table 4.

Table 4. Relationship between participants' Gender IVM Trying, Eating and Purchasing

Variable	Gender	N	Mean	T	Df	P Value
IVM Try, Eat, Purchase	Female	287	21.98	-1.503	401	.134
	Male	116	22.63			

*Significance level at p<0.05.

The independent sample t-test examined whether there was a significant difference between the scores of the female and male groups on the variable "Trying, eating and buying IVM". The arithmetic mean of female participants on this variable was calculated as 21.98 and 22.63 for male participants. As a result of the t-test conducted under the assumption of equal variances, T-value was calculated as -1.503, degrees of freedom 401 and p-value 0.134. The p-values of the test being greater than 0.05 indicate that gender does not have a significant effect on "IVM experimentation, eating and purchasing". These findings reveal that gender does not make any significant difference on this variable.

The data on the statements of the participants regarding attitudes towards in vitro meat are given in Table 5.

Table 5. Statements about attitudes towards in vitro meat (1 strongly disagree - 5 strongly agree)

Question	Mean	Sd
In vitro meat, is unnatural	4.02	1.09
In vitro meat, is disrespectful to nature	2.95	1.22
In vitro meat, will reduce the number of happy animals on earth	2.87	1.32
In vitro meat, will encourage the possibility of cannibalism	2.78	1.31
In vitro meat, is ethical	3.20	1.09
In vitro meat, will improve animal welfare conditions	2.59	1.08
In vitro meat, will be able to solve world famine problems	2.58	1.15
In the future, in vitro meat, will be a viable alternative to farmed meat	2.55	1.12
In vitro meat, will reduce the impact of global warming associated with farming	2.61	1.13
The production of in vitro meat, will have negative impacts on traditional farmers	1.68	1.00

*IVM (In Vitro Meat), Sd (Standard Deviation)

The findings presented in Table 5 show that attitudes towards in vitro meat were examined along several dimensions. Participants showed a high level of agreement with the statement "IVM is not natural" (Mean = 4.02). This result reveals that IVM is subjected to an important questioning in the context of perception of naturalness and is evaluated as an unnatural product. In contrast, there was a lower level of agreement with the statement "IVM is disrespectful to nature" (Mean = 2.95), suggesting that some participants may view this technology more positively in an environmental context. On the other hand, the relatively low agreement with the statements "IVM will reduce the number of happy animals in the world" (Mean = 2.87) and "IVM will increase people's cannibalistic tendencies" (Mean = 2.78) suggests that such perceptions are not common among participants. From an ethical perspective, the mean score for the statement "IVM is ethical" (Mean = 3.20) was neutral, suggesting that there is no clear consensus on this issue. Similarly, the low scores for the statements "IVM will improve animal welfare conditions" (Mean = 2.59) and "IVM can solve the world's famine problems" (Mean = 2.58) indicate that the potential benefits of IVM have not yet been widely embraced by respondents. In terms of attitudes towards the future, the low scores for the statements "In the future, IVM will be a viable alternative to farmed meat" (Mean = 2.55) and "IVM will reduce the impact of global warming on farming" (Mean = 2.61) indicate that participants remain skeptical about the future viability and environmental benefits of IVM. On the other hand, the very low mean (Mean = 1.68) for the statement "IVM will have a negative impact on traditional farmers" indicates that concerns on this issue are limited among the respondents. The findings reveal that attitudes towards IVM vary along both ethical and environmental dimensions, and that various perceptions and reservations about the adoption of the technology persist.

The data on the relationship between the University and the attitudes towards in vitro meat of the participants in the study are given in Table 6.

Table 6. The relationship between participants' University and attitudes towards in vitro meat

Variable	University	N	Mean	T	Df	P Value
Attitudes towards in vitro meat	Karabuk University	201	28.31	1.544	401	.123
	Sinop University	202	27.33			

*Significance level at p<0.05.

Table 6 shows that the attitudes of Karabuk University and Sinop University students towards in vitro meat were compared. While the mean attitude score of Karabuk University students was 28.31, the mean attitude score of Sinop University students was 27.33. Independent sample t-test results show that there is no statistically significant difference between the two groups (t= 1.544); (p = 0.123). These findings show that the general attitudes of Karabuk University and Sinop University students towards in vitro meat are similar and there is no significant difference between the two groups. Therefore, it can be concluded that attitudes towards In Vitro Meat do not show a significant difference between the universities and a homogeneous attitude may be exhibited among the participants.

The data related to the gender of the participants in the study and their attitudes towards in vitro meat are given in Table 7.

Table 7. The relationship between participants' gender and attitudes towards in vitro meat

Variable	Gender	N	Mean	T	Df	P Value
Attitudes towards in vitro meat	Female	287	28.15	1.625	401	.105
	Male	116	27.01			

*Significance level at $p<0.05$.

The findings presented in Table 7 show that the attitudes of female and male participants towards in vitro meat were statistically compared. The mean attitude score of the female participants was 28.15 and the mean attitude score of the male participants was 27.01. According to the independent sample t-test results, there was no statistically significant difference between female and male participants in terms of attitudes towards in vitro meat ($t= 1.625$); ($p = 0.105$). These data show that gender does not have a significant effect on attitudes towards in vitro meat. Therefore, it is concluded that gender is not a determining factor in the differentiation of attitudes towards in vitro meat.

4. Conclusions

This study examines the perceptions and attitudes of gastronomy and culinary arts and cookery students towards in vitro meat (IVM), this study offers important implications for the current acceptability and future potential of the technology. The findings revealed that although IVM has made positive contributions to environmental sustainability and animal welfare, a significant proportion of students questioned the technology in terms of naturalness and ethics. It was observed that 66.7% of the participants were not familiar with the concept of in vitro meat, but had a more positive view after being informed about it. The fact that 44.9% of the participants were in the 20-22 age group emphasizes that this group is more open to innovative technologies but not sufficiently informed. While 62.5% of the respondents consume red meat, only 0.2% stated that they are vegan.

While gender ($p=0.105$) and university ($p=0.123$) factors did not create a significant difference on general attitudes ($p>0.05$), significant differences were found between Karabuk and Sinop Universities in "trying, consuming and purchasing" behaviors ($p=0.032$). The Cronbach's Alpha coefficient of the questionnaire form was calculated as 0.831, confirming the statistical reliability of the data. The findings suggest that if cookery and gastronomy and culinary arts students can integrate this technology into their culinary practices, they can make significant contributions to sustainable food systems in the future. In this context, it is recommended to include more innovative technologies such as IVM in education programs.

In conclusion, in order to utilize the significant potential of IVM technology to effectively utilize limited natural resources, reduce environmental impacts and ensure food safety, wider information and widespread education efforts are required throughout the society. In this context, the adoption of this technology by food sector professionals and future chefs will contribute significantly to the creation of a more sustainable food system.

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