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Optimists, moderates and sceptics – identifying consumer groups and their willingness to consume cultured proteins in Finland

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Abstract

Purpose – It is suggested that the detrimental externalities of intensive livestock production can be reduced by manufacturing animal proteins with cellular agriculture technologies. This study explores consumer attitudes towards cultured proteins based on representative Finnish survey data (n = 1,452).

Design/methodology/approach – Sum variables from the principal component analysis were utilized in the cluster analysis to identify potential consumer groups of cultured proteins in Finland. A regression analysis was used to find out the explanatory factors of positive first reaction, willingness to taste, willingness to use and support for the establishment of a national cultured meat sector.

Findings – Most of the respondents (72%) would taste cultured products, but attitudes of optimists (n = 516), moderates (n = 479) and sceptics (n = 457) differ in terms of the environment, livestock farming and cultured proteins. Most optimists (77%), almost quarter (23%) of moderates and less than a fifth (18%) of sceptics support cultured proteins. The environmental concerns are shared by optimists and moderates, whereas moderates and sceptics tend to be more suspicious. Positive attitudes are significantly influenced by social norms and respondents' beliefs regarding their global and national benefits. Major concerns pertain to anticipated dictation force of big companies, negative effects on Finnish agriculture, product attributes, use of genetically modified organisms and experienced (un)naturalness of cultured foods.

Originality/value – This study contributes to the understanding of Finnish consumers' attitudes towards cultured proteins. The identification of potential consumer segments and the elucidation of their attitudes are relevant, given the anticipated acceleration in the development of cultured foods.

Keywords Cellular agriculture, Cultured protein, Attitude, Cluster analysis, Regression analysis, Consumer segmentation

Paper type Research paper

Introduction

Cellular agriculture refers to the production of livestock foods and food ingredients using cell-culturing technologies. It is one of the proposed solutions for the sustainability crisis of the food system (Godfray *et al*., 2018; Poore and Nemecek, 2018; Crippa *et al*., 2021; Xu *et al*., 2021; OECD-FAO, 2024) without changing current dietary preferences considerably. Cellular agriculture is generally divided into tissue-engineering-based and fermentation-based production or cellular and acellular products (Stephens *et al*., 2018). The former includes products made from cells such as meat and leather, whereas milk protein casein and chicken egg white protein ovalbumin are examples of the latter. Cellular products such as muscle cells are grown in a bioreactor from stem or satellite cells taken from an animal (Post, 2014).

Although cultured hamburgers were presented as prototypes in 2013 (Post, 2014), cultured meat is still available to a limited extent (GFI, 2024a). Whole cuts of meat or steaks are more

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challenging to produce but are anticipated as a long-term goal for developers of cellular agriculture (Rubio *et al*., 2020; Stephens *et al*., 2018). In addition to the product properties, cultured meat production is challenged by the availability of cell sources, nutrition medium composition, bioreactor technologies and production upscaling (Rubio *et al*., 2020; Stephens *et al*., 2018). Solving these supply-side problems is necessary but not sufficient for the breakthrough of cultured proteins. The success of cultured meat is determined by legislation (Rubio *et al*., 2020; Stephens *et al*., 2018; Guan *et al*., 2021) and the market, where the price of novel products must meet demand. The production costs of cultured meat have been significantly higher than the consumer prices of conventional meat (Hubalek *et al*., 2022).

The research literature on the demand for cultured proteins has focused on cultured meat, although products of acellular agriculture are estimated to be more easily scaled up for commercial production (Stephens *et al*., 2018; Tuomisto, 2019; Mendly-Zambo *et al*., 2021; Newman *et al*., 2022). Despite that consumer research considering cultured proteins is increasingly conducted, Nordic consumer attitudes towards these products have been scarcely studied. Exceptions are an early study examining potential images of meat consumption in 2030 in Finland (Vinnari and Tapio, 2009), a recent paper studying Swedes' willingness to switch to meat alternatives (Carlsson *et al*., 2022), a survey of cultured protein attributes among the Nordic consumers (Klöckner *et al*., 2022; Engel *et al*., 2024) and a study analysing Dutch and Finnish consumer attitudes towards meat substitutes, cultured meat and hybrid meat products (van Dijk *et al*., 2023). In addition, studies have focused on consumers' attitudes, their willingness to try, eat and pay but analyses considering potential consumer segments are still scarce.

The purpose of our study is to analyse Finnish consumer attitudes towards cellular agriculture by focusing on their willingness to consume what we call as cultured proteins or cultured meat, fish and dairy. We also analyse potential factors influencing acceptance of cultured proteins in Finland. In addition, our study analyses potential cultured protein consumer groups and their characteristics. Identification of potential consumer segments is relevant as the development of novel cultured foods has accelerated, and several product categories are anticipated to reach a market launch stage.

Several characteristics make the Nordic countries a feasible case for cellular agriculture research (Rasmussen *et al*., 2024). Finland is considered as a technology-oriented society, which is also emphasised in the national food policy (Food 2030, 2017). As a European Union (EU) member state, the Finnish food system is partly governed by the common agricultural policy and the EU's climate targets. In addition, Finland has a globally ambitious goal to reach carbon neutrality by 2035 (Government Program, 2019), which pressurises the development of the national food system from decreasing agricultural emissions to minimizing food waste. Geographical location in the North is also a challenge for the Finnish food system: the vegetation period is relatively short, feasible crop varieties are limited, and livestock (dairy and cattle) provides livelihood for farmers. These developments drive novel and closed cycle food technology development in Finland, which is considered as one of the countries advancing the cellular agriculture industry (GFI, 2024b).

Background: consumer acceptance of cultured foods

Consumer acceptance of cultured foods has increasingly been investigated (e.g., Pakseresht *et al*., 2022) but awareness of cellular agricultural technologies and foods varies among the public (Dupont *et al*., 2022; Munz Fernandes *et al*., 2021; Zhang *et al*., 2020), and the information provided to respondents differs across studies (Bryant and Barnett, 2018). Research on the acceptance of cultured proteins is not easily comparable due to the variance of used frames, names, questions and study designs, which significantly impact the results (Bryant and Barnett, 2019; Fidder and Graça, 2023; Malerich and Bryant, 2022).

Cultured meat is commercially available, to a very limited extent, only in Singapore, the United States and Israel (GFI, 2024a). However, 40–70% of studied Brazilian, Chinese, European and US respondents would be willing to taste it (Bryant *et al*., 2019; Bryant and

Dillard, 2019; Chriki *et al*., 2021; Dupont *et al*., 2022; Franceković *et al*., 2021; Jacobs *et al*., 2024; Liu *et al*., 2021, 2023; Mancini and Antonioli, 2019; Verbeke *et al*., 2015; Weinrich *et al*., 2020; Wilks and Phillips, 2017). Willingness for regular consumption is lower: 30–57% of German and US respondents have stated willingness to use cultured meat regularly (Bryant and Dillard, 2019; Jacobs *et al*., 2024; Weinrich *et al*., 2020; Wilks and Phillips, 2017).

Findings vary widely on the key question of willingness to pay; 5–47% of consumers are potentially willing to pay more for cultured meat than conventionally produced counterpart (Asioli *et al*., 2022; Bryant and Sanctorum, 2021; Chriki *et al*., 2021; Mancini and Antonioli, 2019; Munz Fernandes *et al*., 2021; Wilks and Phillips, 2017). Willingness to pay 50% more is limited to only a few percent of respondents (Bryant and Sanctorum, 2021; Munz Fernandes *et al*., 2021). The demand for cultured meat rises when the price drops (Carlsson *et al*., 2022; Mancini and Antonioli, 2019; Munz Fernandes *et al*., 2021), but almost half of Swedish respondents would not change a conventional hamburger for cultured meat even if free (Carlsson *et al*., 2022). Young and highly educated people would pay the most for cultured meat (Jacobs *et al*., 2024; Mancini and Antonioli, 2019; Munz Fernandes *et al*., 2021) as well as those intending to reduce meat consumption (Mancini and Antonioli, 2019).

Comparative studies on Europeans indicate that consumers in Spain, the UK, Belgium and the Netherlands are relatively more willing to engage with cultured meat, whereas the attitudes of French consumers tend to be more negative (Asioli *et al*., 2022; Boereboom *et al*., 2022; Hocquette *et al*., 2022; Siegrist and Hartmann, 2020). In the Nordic countries, the Danish respondents are significantly less willing to accept cultured proteins than the Finns and Norwegians (Klöckner *et al*., 2022). Mexicans and South Africans would eat cultured meat more often than westerners (Siegrist and Hartmann, 2020) while willingness to purchase cultured meat is lower in Brazil and the Dominican Republic compared with the UK and Spain (Gómez-Luciano *et al*., 2019). The proportion of those who are not likely to purchase cultured meat in the USA is significantly higher than in China and India (Bryant *et al*., 2019).

The relationship between socio-demographic factors and the acceptance of cellular agriculture seems to vary. The results imply that younger people (Bryant and Dillard, 2019; Jacobs *et al*., 2024; Klöckner *et al*., 2022; Mancini and Antonioli, 2019; Munz Fernandes *et al*., 2021; Slade, 2018; Wilks *et al*., 2019; Liu *et al*., 2023), men (Bryant and Dillard, 2019; Jacobs *et al*., 2024; Klöckner *et al*., 2022; Mancini and Antonioli, 2019; Slade, 2018; Wilks *et al*., 2019; Wilks and Phillips, 2017; Zhang *et al*., 2020; Liu *et al*., 2023) and liberal leftists (Bryant *et al*., 2019; Slade, 2018; Wilks and Phillips, 2017) are more receptive to cultured meat, as are the highly educated (Jacobs *et al*., 2024; Mancini and Antonioli, 2019; Slade, 2018; Zhang *et al*., 2020) and people with higher income (Wilks *et al*., 2019). However, there are also inconsistent results indicating that higher income can be associated with more reserved attitudes (Wilks and Phillips, 2017) and that gender, education and income effects may be insignificant (Munz Fernandes *et al*., 2021).

There is also supporting (Bryant *et al*., 2019; Klöckner *et al*., 2022; Mancini and Antonioli, 2019) and opposing (Dupont *et al*., 2022; Munz Fernandes *et al*., 2021; Zhang *et al*., 2020) evidence of whether familiarity increases willingness to taste and use cultured proteins. Vegetarians are not that interested in consuming cultured meat (Bryant *et al*., 2019; Franceković *et al*., 2021; Gousset *et al*., 2022; Klöckner *et al*., 2022; Mancini and Antonioli, 2019; Slade, 2018; Wilks *et al*., 2019; Wilks and Phillips, 2017), although they acknowledge its benefits (Franceković *et al*., 2021) and may therefore support cultured meat in principle. Perceived naturalness (Siegrist and Hartmann, 2020) and food neophobia have also been associated with the acceptance of cultured meat (Boereboom *et al*., 2022; Rombach *et al*., 2022; Siegrist and Hartmann, 2020).

Ethical and social advantages, such as avoiding animal suffering, reducing environmental harm and solving global food problems, are emphasized when asked about the benefits of cellular agriculture (Bryant and Sanctorum, 2021; Circus and Robison, 2019; Munz Fernandes *et al*., 2021; Weinrich *et al*., 2020; Wilks and Phillips, 2017). Healthiness and reducing exposure to diseases are commonly selected personal motivators (Bryant and Sanctorum, 2021; Munz Fernandes *et al*., 2021; Wilks and Phillips, 2017). Doubts associated with cultured

meat are mainly private and emotional. These are related to factors such as taste, price, perceived unnaturalness and lack of trust (Ahsan *et al*., 2021; Bryant and Sanctorum, 2021; Circus and Robison, 2019; Weinrich *et al*., 2020; Wilks and Phillips, 2017). Educated respondents have also expressed reservations about the capacity of cultured meat to solve meat production problems (Hocquette *et al*., 2015).

Consumer clustering studies based on meat consumption (Circus and Robison, 2019; Franceković *et al*., 2021) and willingness to consume cultured meat (Garcez de Oliveira Padilha *et al*., 2021; Boereboom *et al*., 2022) have been conducted. Wang and Scrimgeour (2022) used consumer attitudes and purchase intentions towards cultured meat as clustering variables, resulting in three Chinese consumer segments of conservatives (25.7%), acceptors (41.9%) and pioneers (32.4%). Most Chinese participants in the study are acceptors or pioneers that have positive attitudes and are willing to consume cultured meat, whereas a quarter were conservatives with very negative attitudes and purchase intentions towards cultured meat (Wang and Scrimgeour, 2022).

Data and methods

Survey data

The analysed survey data [1] were collected in Finland in the beginning of 2021. The sample (n = 1,452) is representative in terms of the distribution of age, gender, education and income in Finland. Cultured proteins were named "cultured/synthetic meat, fish and dairy products", but the word "synthetic" was omitted in some parts of the survey to simplify questions. We use the term "proteins" to refer to meat, fish and dairy products in this paper.

The survey had several sections, which were only partly utilized in this paper. The data consist of respondents' background variables, such as age group, gender, education, income level and place of residence. In addition, environmental attitudes, various concerns, dietary habits and diet identity were asked about in the first parts of the questionnaire. The questions regarding environmental attitudes were based on the shortened New Environmental Paradigm Scale, which is a validated measure of environmental concerns and world-views (Dunlap and Van Liere, 1978; Dunlap *et al*., 2000). Sum variables for environmental concerns and food concerns were also calculated. All sum variables were computed as averages and are described in Table 1 in Supplementary material.

After the world-view questions, the respondents report on a four-point scale how many times a week they usually consume animal products and plant-based substitutes. The respondents' food identity was described with two sum variables, which emphasize diet identity and gendered diet identity. These variables describe food identity related to consuming or avoiding meat in general and combined with gender identity. At the end of the first part of the survey, the respondents' attitude to the innovations was measured. The sum variables describing the attitude towards food innovations and innovations in general are based on the Food Neophobia Scale (Pliner and Hobden, 1992) and the Motivated Consumer Innovativeness Scale (Vandecasteele and Geuens, 2010).

Before the presentation of survey questions considering cellular agriculture, respondents were provided with information on cultured proteins. Similarity to animal proteins and an absence of genetically modified organisms (GMO) were highlighted in the description. After the introductory text, familiarity with cultured proteins was measured on a four-point scale and then respondents were asked whether they favour cultured proteins. The first reaction is interpreted as positive if the respondents express that they are "in favour" or "probably in favour" of cultured proteins. Next, the respondents were asked whether they were willing to taste and eat (cf. use regularly) cultured meat, fish and dairy products. Respondents who chose "Yes, definitely" or "Yes, maybe" were classified as willing.

The respondents were asked about their beliefs about cultured proteins and conventional agriculture in the last sections of the survey. Items were measured on a five-point Likert scale and the following sum variables were calculated from these questions: "belief in solving global

problems", "belief in impact on local nature and farmers", "belief in increasing dependence on external actors" and "belief in national economic benefits". From the agriculture section, the sum variable "agriculture is an important part of Finland" was used in the analyses. The question of livestock emissions was used in a regression analysis explaining the acceptance of cultured proteins. Answers to the statement "Finland should develop its own cultured meat industry" was used as one of the dummy variables measuring acceptance of cultured proteins. A value of 1 was assigned to those who strongly or somewhat agree with the statement.

Finally, the respondents were asked about social norms. Then respondents chose from a list the three most positive and the three most negative factors that they associated with cultured meat, fish and dairy products. Perceived unnaturalness was used as a dummy variable. A value of 1 was assigned if the respondent mentioned naturalness among the three most negative factors.

Analysis methods

The analyses started by calculating sum variables aggregated based on principal component analysis. These sum variables were utilized in the cluster analysis and then a regression analysis was used to find out the explanatory factors of positive first reaction, willingness to taste, willingness to use and support for the development of a national cultured meat sector. Most of the data processing and analyses were conducted using RStudio 1.3. IBM SPSS Statistics data analysis software was used in conducting the principal component analysis.

The data were examined first with descriptive statistics and dietary clustering to get an overview. Attitude clusters were formed using the sum variables from the principal component analysis (correlation >0.50, Cronbach's alpha >0.70). Clustering variables describe the factors having an impact on the acceptance of cultured proteins – knowledge, identity, beliefs and social norms. Attitude-based clustering was chosen as the main method of the study since it allows a comparison of willingness to consume cultured proteins in various consumer groups without the differences automatically created by the algorithm. The variables selected for attitude clustering (Table 5 in Supplementary materials) are correlated at the 95% significance level with the sum variable describing the intention to consume cultured proteins.

Cluster analysis is a descriptive multivariate method, which aims to find groups with maximum internal homogeneity parallel to maximum heterogeneity between groups (Hair *et al.*, 2019). The *k*-means algorithm was used in this study due to its robustness and the size of the data (Hair *et al.*, 2019). Using the built-in functions in *R*, several seeds (nstart = 25) and iterations (max.iter = 25) were tried, choosing the best of the solutions. Clustering variables were scaled, and dissimilarity measured using the Euclidean distance. Outliers were not removed – the groups were similar when they were repeatedly defined based on a randomly halved dataset.

The number of clusters was selected by using the *R* package NbClust, which determines the optimal number of clusters based on 30 different measures (Charrad *et al.*, 2014). Twelve of these measures suggested two attitude clusters and six measures suggested three clusters. The second-best solution of three groups was the final choice – the middle cluster was interesting and differs statistically significantly from the other clusters. When clustering diets, vegetarians and vegans were separated first and then meat eaters were clustered into two groups as suggested by the function. The first group consists of moderate meat eaters called "flexitarians" and the second group "meat eaters". Differences between the clusters are examined with Kruskal–Wallis and chi-square tests.

Finally, binary logistic regression was used to find out the factors influencing the acceptance of cultured proteins. The outcome variables were positive first reaction, willingness to taste at least one cultured protein, willingness to eat at least one cultured protein regularly and support for the development of a national cultured meat sector. In addition to the clustering variables, socio-demographic factors, perceived unnaturalness and attitude towards livestock emissions were used as explanatory variables. The variance inflation factor did not show multicollinearity in the regression models. The significance of the regression coefficients was assessed using the Wald test.

Results

Descriptive statistics

Most respondents are at least somewhat concerned about climate change caused by human activities (90%) and the loss of biodiversity (93%). More than a third of the respondents are very worried about the loss of biodiversity. Less than half of the respondents believe that conventional livestock farming makes a significant contribution to GHG emissions in Finland. One in three of the respondents thinks that livestock farming has a negative impact on biodiversity because it reduces the area of untouched land, while almost half stated that livestock farming has a positive effect on biodiversity. A large majority (87%) of Finns consider agriculture to be socially important, and 78% of respondents believe that livestock farming secures citizens access to food in times of crisis in Finland.

Five per cent of respondents report being vegetarians and 2% vegans, while the rest consume meat or fish at least sometimes. About 30% of meat consumers belong to the data-based flexitarians cluster, in which people consume more plant-based and less animal-based products than the meat eaters. The weekly food consumption of flexitarians and meat eaters differs statistically significantly ($p < 0.001$), except for fish. The biggest difference is in the consumption of plant-based milk and meat substitutes.

Flexitarians are most willing to eat less meat and vegetarians most willing to eat fewer dairy products. Willingness to reduce fish consumption is minor (5%) among flexitarians and meat eaters. Reasons were not asked for willingness to change eating habits. Vegetarians and vegans avoid meat most often for reasons related to the environment (81%), ethics (77%) and animal welfare (75%). Less than half report avoiding meat because of health reasons. Feasible arguments were listed in the questionnaire, and the number of choices was unlimited.

Finnish consumers' first reaction to studied cultured proteins is cautiously positive, as 40% of respondents are in favour or probably in favour of cultured proteins. The uncertainty is indicated by the fact that "I don't know" was the most common (33%) answer. Only 7% of respondents report that they had a clear idea about what cultured proteins are, but 88% report they had heard about them.

Sixty-six per cent of all respondents would taste, and 35% use, cultured meat regularly. Willingness to taste cultured fish or dairy products is lower than meat, but in regular use cultured fish is the most popular option (Table 2 in Supplementary materials). Willingness to consume cultured meat, milk and fish correlates with each other ($r > 0.75$) statistically significantly ($p < 0.001$) both for tasting and regular use.

Willingness to consume studied cultured proteins is the highest among flexitarians, both in terms of tasting and regular use (Table 2 in Supplementary materials). Flexitarians would prefer cultured fish, just as meat eaters would prefer cultured meat. Vegetarians and vegans would prefer to consume cultured dairy products. Meat eaters are the most reluctant to use all cultured proteins studied, but they would taste cultured meat and fish more often than vegetarians and vegans. The differences between the dietary clusters in both willingness to taste and use are statistically significant ($p < 0.001$).

Cluster analysis

The *k*-means algorithm resulted in three consumer groups with different attitudes towards cultured proteins when the cluster analysis was performed based on variables that correlated with willingness to consume. Clusters are optimists ($n = 516$), moderates ($n = 479$) and sceptics ($n = 457$). Optimists most often believe in the benefits of cultured proteins and have a more positive attitude towards food innovations. Moderates are most concerned about food-related issues and show the least interest in innovations. Compared with optimists, moderates are more suspicious of cellular agriculture and consider conventional livestock farming significantly more important. The appreciation of conventional livestock farming is highest among sceptics, whose other characteristics are the strongest food identity, the least environmental concern and the greatest disbelief in the benefits of cultured proteins. The

cluster averages and the statistical significance of the differences are summarized in Table 5 in Supplementary material.

Optimists and moderates resemble each other in their views on the environment and animal welfare. The most typical respondent in both clusters is very concerned about loss of biodiversity and climate change caused by human activities. Clusters differ from each other in perceptions towards innovations and the potential of cultured proteins to provide environmental benefits. The difference in social norms is rather large, as 73% of optimists and 23% of moderates estimate that people who are important to them would consume cultured proteins when they become available.

Items regarding food innovations unite moderates and sceptics. In both clusters, the most typical respondent prefers food innovations "very rarely". Sceptics and moderates report that they are less familiar with cultured proteins compared with optimists. They also state lower belief in the benefits of cultured proteins and mind more their disadvantages, such as negative impacts on livestock farmers and increasing dependence on external factors, such as foreign operators and big companies, resulting in a decrease in local food production.

The most significant differences between moderates and sceptics concern environmental views, dietary identity and concerns about hunger in the world, food safety and security of access to food. Most typical moderate individuals totally disagree with feeling strong ties to people who have the same diet. Gendered dietary identity is weak all along the line, but about a fifth of sceptics think their diet is part of being a male.

The views of optimists and sceptics differ in almost all questions. However, the groups are equally uncertain about whether cultured proteins will change how agricultural and rural landscapes will look in the future in Finland. The biggest disagreements between optimists and sceptics are about environmental issues, livestock farming and the anticipated benefits of cultured proteins. Eighty-nine per cent of optimists and 21% of sceptics trust the potential of cultured proteins to reduce the impact of global warming associated with livestock farming.

In addition to the clustering variables, clusters also differ in their socio-demographic characteristics (Table 3 in Supplementary material). Optimists are younger and more educated, but the gender distribution of the cluster is even. The age distribution of the moderates is focused on the older age groups, and they are commonly women (63%). A sceptic is most typically a meat-eating man living outside the metropolitan area. People with middle income are evenly divided into different clusters, but people with low and high income are most often optimists.

Optimists would have most often voted for the Greens, the National Coalition Party (a liberal-conservative party) and the Left Alliance during the data collection period. Moderates would have preferred to vote for the Social Democratic Party of Finland, but the National Coalition Party, the Left Alliance and the Greens were also supported. The Finns Party (a right-wing nationalist-conservative party) was clearly the most popular among the sceptics, with the National Coalition Party and the Centre Party of Finland (an agrarian social-liberal party) following.

The attitude of the clusters to cultured proteins differs statistically significantly (Tables 4 and 6 in Supplementary materials). Optimists are the most receptive and sceptics the most reserved. The views of moderates fall between optimists and sceptics but are closer to sceptics. Seventy-seven per cent of optimists are in favour, or probably in favour, of cultured proteins. In the clusters of moderates and sceptics, the corresponding shares are 23% and 18%, respectively. The development of a domestic cellular agriculture industry is especially hoped for by optimists – 91% of them agree that Finland should develop its own cultured meat industry. A moderate or a sceptic is most typically unsure of their opinion ("Neither agree nor disagree").

Climate benefits seem to be the most important advantage of cultured proteins and dependency on big companies correspondingly the most significant disadvantage for the Finnish consumers.

However, rankings of other aspects vary between clusters. When the respondents were asked to choose the three most important positive aspects of cultured proteins, the climate

benefits were most often mentioned first in the entire sample and among the optimists and moderates. Dependency on big companies is the most mentioned disadvantage for optimists and moderates, and the second most mentioned for sceptics, immediately after the anticipated adverse impacts on Finnish agriculture. Other most frequently mentioned negative aspects of cultured proteins are sensory properties for optimists, the use of genetically modified organisms for moderates and the impacts on Finnish livestock farming for sceptics.

Binary logistic regression

Social norms and belief in the global benefits and national economic benefits of cultured proteins are statistically significant predictors of each outcome variable: positive first reaction, willingness to taste, willingness to use and support for the development of a national cultured meat sector (Table 7 in Supplementary materials).

Age, perceived naturalness, and familiarity explain the first reaction ($p < 0.001$) but have no effect on the probability of willingness to taste ($p > 0.05$). Willingness to taste studied cultured proteins is increased by social norm, belief in national economic benefits and positive attitude towards food innovations. Belief that animal farming produces emissions seems to decrease willingness to taste cultured proteins.

Younger age groups would be more likely to regularly use cultured meat, fish or dairy products. Other factors predicting willingness to use are social norms, belief in national economic benefits and the potential of cultured proteins to solve global problems. Belief in national economic benefits increases the probability of supporting the development of a national cultured meat sector the most.

Discussion

This study analysed the attitudes of Finns towards cellular agriculture and cultured proteins by identifying potential consumer groups and investigating the willingness to consume cultured meat, fish and dairy products. When consumer acceptance of cultured meat was first studied in Finland, replacing meat with "laboratory-grown artificial meat" was considered an undesirable and improbable future image (Vinnari and Tapio, 2009). Based on our study, Finns' first reaction to cultured proteins is cautiously positive, and willingness to consume cultured meat corresponds to the European average level (Bryant and Barnett, 2018). Willingness to taste cultured proteins is higher than willingness to use them regularly, which aligns with existing cultured meat research (e.g. Rolland *et al*., 2020). A recent study from the Netherlands and Finland shows that cultured meat is considered as an unnatural and high-priced in comparison to plant-based meat alternatives and hybrid products (van Dijk *et al*., 2023).

One of the strengths of this study is the analysis of several cultured proteins or cultured meat, fish and dairy simultaneously. In cluster and regression analyses, willingness to consume cultured proteins has been pooled due to high correlation, but descriptive statistics reveal some differences between proteins. Vegetarians and vegans favour cultured dairy products, whereas flexitarians would prefer cultured fish and meat eaters favour cultured meat. In the entire dataset, cultured meat is the preferred choice for tasting and cultured fish for regular use. The studies on cultured dairy products indicate that people are more inclined to consume cultured cheese than cultured meat (Kühl *et al*., 2024; Zollman Thomas and Bryant, 2021), with flexitarians who already eat cheese identified as the prime target group (Zollman Thomas and Bryant, 2021; Slade and Zollman Thomas, 2023). Additionally, cultured fish has been found to be the least popular among meat types (Wilks and Phillips, 2017).

The results of the cluster analysis indicate that Finns are divided into three distinctive consumer groups in their attitude towards cultured proteins. Sceptics, moderates and optimists resemble, with minor differences, the clusters of pioneers, acceptors and conservatives resulting from the Chinese analysis (Wang and Scrimgeour, 2022). Willingness to taste cultured proteins is above average in all Finnish clusters, but only optimists show a positive

willingness to use them regularly. Sceptics' views favouring conventional animal farming have been observed in Finnish online news comments on cultured meat while positive online news comments emphasized environmental and animal welfare issues important to optimists and moderates (Ryynänen and Toivanen, 2022).

In this study, climate benefits are perceived as the most significant advantage of cultured proteins, environmental reasons are the main motive to avoid conventional meat, and flexitarians are the most potential consumer group. However, both cluster and regression analyses indicate that environmental concerns or attitudes do not predict acceptance of cultured proteins. Optimists believe in the potential of cultured proteins to solve global problems related to food production, climate change and livestock, and trust that people important to them will also approve cultured proteins. The significance of social norms and perceived societal benefits in cultured protein acceptance has been increasingly validated by research (Dupont *et al*., 2022; Engel *et al*., 2024; Ford *et al*., 2024; Monaco *et al*., 2024; Onwezen *et al*., 2022; Weinrich *et al*., 2020) while disgust, fear, food neophobia and familiarity are prominent according to a recent review of emotional and socio-cultural factors (Monaco *et al*., 2024).

Dependency on big companies is the most significant negative aspect that the Finns associate with cultured proteins. The emergence of a monopoly in the cultured meat market has been considered possible (Treich, 2021), and consumers seem to be aware of this. The power of multinational companies is a potential reason for Belgians not to eat cultured meat (Bryant and Sanctorum, 2021), and the concerns related to a dominant market position and a threat to farmers' livelihoods have been observed in Germany (Kühl *et al*., 2024). Impact on Finnish livestock agriculture is the second most frequently associated negative factor with cultured proteins, followed by sensory properties, the use of genetically modified organisms in, and experienced (un)naturalness. Personal disadvantages such as taste and perceived unnaturalness have been repeated in previous studies (Ahsan *et al*., 2021; Bryant and Sanctorum, 2021; Circus and Robison, 2019; Weinrich *et al*., 2020), but the social concerns are still distinctive.

Existing regression analyses explaining the willingness to purchase or eat cultured meat show that diet and perceived unnaturalness (Bryant *et al*., 2019; Slade, 2018), food neophobia (Bryant *et al*., 2019; Wilks *et al*., 2019), political views (Bryant *et al*., 2019; Slade, 2018; Wilks *et al*., 2019) and product properties having an impact on an individual (Bryant *et al*., 2019; Gómez-Luciano *et al*., 2019) have been repeatedly significant explanatory factors. However, the impact of naturalness bias or an individual's preference for natural things was insignificant when studied indirectly (Wilks *et al*., 2019). It is also shown that age and gender (Wilks *et al*., 2019), familiarity, disgust, and perceived goodness (Bryant *et al*., 2019), as well as conscious food choices and the importance of conventional agriculture (Slade, 2018) have significant explanatory power when all other variables were standardized. The findings of this study imply that, in Finland, consumer acceptance of cultured proteins is partly determined by social norms and belief in societal impacts, such as economic and climate benefits.

The results of our study suggest that further research on the impact of various interventions considering cellular agriculture would be valuable from the perspectives of potential market development, policymaking and well-being of both the planet and its people. Given the emission reduction goals set by the EU and Finland, it would be beneficial to explore the substitution effect or whether cultured proteins would replace plant- or animal-based alternatives. With increasing awareness and alternatives available in the future, more research is needed to examine specific consumer segments and the demand for different cultured foods, including hybrid products containing cultured ingredients.

Conclusions

Consumer acceptance and actual dietary changes are essential prerequisites for cellular agriculture products to effectively reduce the detrimental externalities of livestock production.

Social norms and belief in the benefits of cultured proteins seem to be the strongest predictors of support and willingness to consume cultured proteins in Finland. Despite the potential emission reductions from cultured protein production, environmental attitudes and concerns do not explain the level of acceptance of cultured proteins.

Finns are divided into three consumer groups: optimists, moderates and sceptics, the first two being environmentally conscious and the latter two showing no interest in innovative products. Moderates and sceptics have no clear idea about cultured proteins and the social norm, or the impact of how close others perceive cultured proteins, is lower compared with the optimists. Younger optimistic flexitarians with high social norm seem to be the most promising group for cultured protein consumption.

Almost three-quarters (72%) of Finns would taste, and more than a third (42%) regularly use, cultured meat, fish or dairy products. Furthermore, 8% of respondents expressed their total willingness to regularly use each of the studied cultured proteins. Attitudes are still uncertain; when asked for their first reaction, the most common answer was "Do not know" (32.5%). Climate benefit was the most stated positive aspect of cultured proteins, but the negative aspects that emerged were also social. The leverage of big companies and the impact of cultured proteins on Finnish livestock agriculture are considered the biggest disadvantages. Uncertain attitudes, perceived concerns and the importance of believing in benefits could be addressed by clearly explaining the production and impact assessments of cellular agriculture.

Notes

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In Finland, neither legislation nor the Finnish National Board on Research Integrity's (TENK) guidelines require ethical review by an ethics committee for research based purely on public and published data, registry and documentary data or archive data.

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Supplementary material
The Supplementary material for this article can be found online.

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