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No meat, lab meat, or half meat? Dutch and Finnish consumers' attitudes toward meat substitutes, cultured meat, and hybrid meat products

Birgit van Dijk [a], Kirsi Jouppila [b], Mari Sandell [b], Antti Knaapila [b,*]

[a] Wageningen Food and Biobased Research, Wageningen University and Research, P.O. Box 17, NL-6700 AA Wageningen, The Netherlands
[b] Department of Food and Nutrition, University of Helsinki, P.O. Box 66, FI-00014 Helsinki, Finland

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ABSTRACT

As a result of the ongoing climate crisis, there is a growing need to decrease meat consumption worldwide. This study sought to investigate Dutch and Finnish consumers' attitudes toward plant-based meat substitutes, cultured meat, and hybrid meat products. It also aimed to determine how those attitudes relate to the consumers' meat attachment, food neophobia, and food sustainability knowledge. An online survey was conducted among omnivore and flexitarian participants from the Netherlands (n = 126, 72% female, 62% flexitarian) and Finland (n = 250, 71% female, 52% flexitarian). The results showed that the omnivore participants tended to be more meat attached, score higher in terms of food neophobia, and exhibit less knowledge of food sustainability when compared with the participants with flexitarian diets. Furthermore, the results revealed that meat substitutes and hybrid meat products scored significantly higher regarding the participants' overall attitude score than cultured meat, although the participants' willingness to buy both hybrid meat products and cultured meat was significantly lower than their willingness to buy meat substitutes. The willingness to buy the three types of alternatives to meat was influenced by the country, diet, age, gender, familiarity, food sustainability knowledge, food neophobia, and meat attachment. Based on these results, it can be concluded that flexitarians represent an important target population for the promotion of meat alternatives and that hybrid meat products could be a viable option for reducing meat consumption if it is properly promoted.

1. Introduction

The global human population is estimated to grow to 9.7 billion by 2050 (United Nations, 2019). This increase in the number of mouths that need to be fed will place added pressure on the environment. A recent Intergovernmental Panel on Climate Change (IPCC, 2022) report indicates that, while the rate of global greenhouse gas (GHG) emissions growth has slowed, climate changes will irreversibly increase in the coming decades if no immediate action is taken. Our food system represents one of the major contributors to GHG emissions, which means that it plays a crucial role in climate change (Vermeulen et al., 2012). Thus, the need for more sustainable food production and consumption patterns is evident (de Haen & Requillart, 2014; Garnett, 2011). Livestock farming is under particular scrutiny in this regard, as it is estimated that this branch of farming alone contributes approximately 14.5% of the total GHG emissions (Gerber et al., 2013). Furthermore, the conversion of livestock feed to consumable meat is incredibly inefficient, especially for beef and pork products (Goodland, 1997; Steinfeld et al., 2006).

In addition to influencing global warming, meat consumption has consequences for both animal welfare and human health (Aiking, 2011). For instance, high levels of meat consumption, particularly red and processed meats, has been linked to various diseases, including colorectal cancer and heart disease (Godfray et al., 2018). Yet, global meat consumption appears to be increasing (Henchion et al., 2014). While technological advances could optimize the production of meat protein, this alone will not overcome the problem at hand. Indeed, to make impactful progress in terms of sustainability, the cooperation of consumers in the much-needed protein transition is required (de Bakker & Dagevos, 2012).

To make this transition easier for consumers, researchers are increasingly exploring meat alternatives: sustainably produced meat or meat-like products. A category of meat alternatives that is already available on the market is plant-based meat substitutes. These products closely resemble the taste and texture of meat, and they are meant to replace the meat component in meals (Elzerman et al., 2013). Another

* Corresponding author.
E-mail address: antti.knaapila@helsinki.fi (A. Knaapila).

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method proposed to address the ethical and environmental issues associated with meat consumption is the production of cultured meat. Cultured meat is produced *in vitro* using cell cultures (Post, 2012), which means that its production does not generally involve the raising and slaughtering of animals. Although there are some doubts towards the benefits of cultured meat production in regard to its environmental impact (for a review, see Treich, 2021), studies indicate it could have a lower impact if the culturing technology is developed into large-scale production (Bhat et al., 2015; Chriki & Hocquette, 2020; Mattick et al., 2015; Smetana et al., 2023; Tuomisto &Teixeria de Mattos, 2011).

A third meat alternative proposed for reducing or changing meat consumption habits is the use of hybrid meat products. In the case of hybrid meat products, part of the meat is replaced with more sustainable protein sources such as protein concentrates and isolates from vegetables, legumes and oilseeds (Grasso & Jaworska, 2020). Some hybrid meat products are already available on the market, although their development is an ongoing process.

However, the widespread adoption of these three meat alternatives is hindered by different barriers. In many European countries, the protein intake is higher than the requirement (de Boer & Aiking, 2018). An obvious solution then would be to encourage consumers to eat less meat. However, meat is an important part of the Western diet. In Northern and Western European countries in particular, people often have hot meals made up of potatoes, vegetables, and a protein source (i.e., a meat product) (de Boer & Aiking, 2018; Schösler et al., 2012). In these countries, meat is often the most important and valued part of the meal. Studies show that the more consumers are attached to meat, the less willing they are to reduce their level of meat consumption (Graça et al., 2015a; Graça et al., 2015b; Graça et al., 2016; Lentz et al., 2018). Food neophobia is also often suggested to be an important barrier in relation to the adoption of different meat alternatives (Facco & Guiotto Nai Fovino, 2019; Jahn et al., 2021). Moreover, multiple studies indicate that consumers are not aware of the environmental impact of meat consumption (e.g., de Boer & Aiking, 2018; Hartmann et al., 2022; Malek et al., 2019).

Despite these barriers, an increasing number of consumers in European countries appear to be adopting a so-called flexitarian diet (de Bakker & Dagevos, 2010; Knaapila et al., 2022; Verain et al., 2020). While definitions of flexitarianism differ, this group of consumers are known to purposefully abstain from eating meat in certain situations due to varying reasons (Dagevos, 2021; Verain et al., 2022). The differences in attitudes and motivations between vegetarians or vegans and meat-eaters are relatively well known. However, this "middle group" of flexitarians remains rather understudied, although their increasing number means that they may offer possibilities with regard to the promotion of sustainable meat consumption (de Bakker & Dagevos, 2012; Sanchez-Sabate & Sabaté, 2019). In addition, few prior studies include cross-cultural comparisons within Europe. The Netherlands and Finland both have a rich history of farming, and the potatoes, vegetables, and meat meal structure remains dominant in these two countries (de Bakker & Dagevos, 2010; Vinnari et al., 2010).

In light of the above, the present study uses an explorative approach to investigate Dutch and Finnish omnivore and flexitarian consumers' attitudes toward meat substitutes, cultured meat, and hybrid meat products. Furthermore, it examines how the theoretical constructs of food neophobia (Pliner & Hobden, 1992) and meat attachment (Graça et al., 2015a), as well as knowledge concerning food sustainability (Hartmann et al., 2021), are related to those attitudes. The results will provide cross-cultural insights into consumers' attitudes toward different sustainability strategies with regard to meat consumption and, hopefully, elucidate ways to stimulate sustainable meat consumption.

2. Material and methods

2.1. Survey procedure

The data for this study were collected during April and May 2021 in the Netherlands and Finland using the online questionnaire application Qualtrics (Qualtrics, Provo, UT). The participants were recruited by means of convenience sampling through the researchers' professional and personal networks. The participants had to meet the following criteria: aged 18 or above, lived in the Netherlands or Finland for at least 10 years, and demonstrated a good command of the Dutch or Finnish language. Any participants who did not meet these criteria or who did not fully complete the questionnaire were excluded from the study. This resulted in 479 completed survey responses. However, to focus on those participants who could actively reduce their meat consumption, the decision was made to also exclude vegetarians and vegans from the study (21.5% of all responses). This resulted in a dataset consisting of 376 responses, of which 126 responses were from the Netherlands and 250 were from Finland.

The questionnaire was originally developed in English and then translated into Dutch and Finnish by the researchers. Only the Dutch and Finnish versions of the questionnaire were used for data collection in this study. For each language version, a pilot study was conducted with participants who were native speakers of the relevant language to ensure that the questions could be understood. Any necessary alterations to the translations were made after the pilot studies (see the Supplementary Materials for the full questionnaire in English, Dutch, and Finnish).

The questionnaire began with a short explanation of the aims of the study, and informed consent was obtained by asking if the respondents agreed to participate (if they selected "I do not agree," the questionnaire ended immediately). After the respondents agreed to participate, questions regarding their demographics, including their age, gender, and years of education, were asked. Due to the high likelihood of respondents with related academic experience participating in the study due to the convenience sampling method applied, the respondents were asked to indicate whether they were enrolled in any related academic program, and if so, which program. After this, the respondents were asked to indicate how long they had lived in the Netherlands/Finland; whether they identified as an omnivore, flexitarian, vegetarian, or vegan; and whether they followed any special diet (if they answered "Yes" to this question, they were asked to indicate which diet they followed). A flexitarian diet was defined as "I refrain from eating meat at least one day a week", according to the definition by Verain et al. (2020), which has been also used by Elzerman et al. (2021).

The frequency with which the respondents ate meat (e.g., beef, pork, chicken) and meat substitutes was assessed using the following answer categories: "Never," "Less than once a month," "1–3 times a month," "1–2 times a week," "3–4 times a week," "5–6 times a week," and "Every day". For meat substitutes, the answer category "Tried them only a few times" was also included. The definition used for meat substitutes is shown in Table 1.

Next, the respondents' knowledge of sustainability issues regarding food was measured using the Food Sustainability Knowledge Questionnaire (FSKQ) (Hartmann et al., 2021). This tool includes 16 multiple-choice questions designed to evaluate knowledge of food sustainability. As Hartmann et al. (2021) suggest, some country-specific items had to be adapted slightly to fit both the Dutch and Finnish contexts (see the Supplementary Materials for the exact changes made). The Food Neophobia Scale (FNS) (Pliner & Hobden, 1992) was used to measure the respondents' degree of food neophobia. In the case of this tool, validated Dutch (Schickenberg et al., 2008) and Finnish translations were used (Tuorila et al., 2008, which represents a minor revision of the original translation published in Tuorila et al., 2001). The 10 items were measured on a 7-point Likert scale, which was anchored from "Strongly disagree" and "Neither agree nor disagree" to "Strongly agree." Then, the respondents' degree of meat attachment was measured using the

Table 1
Definitions of conventional meat, meat substitutes, cultured meat, and hybrid meat products used in this study.

Conventional meat	"Conventional meat is the meat you would normally find at a grocery store, restaurant, butcher or market (e.g., beef, pork, chicken etc.)."
Meat substitutes	"By the term meat substitute we refer in this study to protein-containing products that are primarily vegetable based and replace the function of meat as a meal component. These products do not contain any meat. Examples include vegetarian burgers, sausages, or minced meat-like products, tofu, tempeh, and stir-fry products." Some country-specific brands were mentioned to clarify further.
Cultured meat	"Cultured meat is a new food innovation. This type of meat is identical at the cellular level to conventional meat. Cultured meat is meat grown directly from animal cells. It is produced in a clean facility, similar to a brewery. The process does not involve raising and slaughtering of farm animals. The final product has a similar taste and texture to meat. Several companies have already successfully produced cultured meat. The products are not available yet, but it is expected to be on the market in the next few years."
Hybrid meat products	"Hybrid meat products are products that contain both meat and plant-based ingredients. They are foods in which a portion of meat has purposefully been replaced by plant-based protein sources, like vegetables or legumes. Hybrid meat products include about 20 to 50% plant-based ingredients. Although a few hybrid meat products are already available on the market, it is expected that more products will be developed in the coming years. Some examples of hybrid meat products are burgers with part mushrooms or lentils mixed in, or sausages containing tempeh."

Meat Attachment Questionnaire (MAQ) (Graça et al., 2015a). This tool includes 16 items measured on a 5-point Likert scale, which was anchored from "Strongly disagree" to "Strongly agree."

The respondents' willingness to reduce their meat consumption was measured using four items with increasing intensity. They were asked to indicate how willing they would be to consider the following in the coming weeks: "Reduce your meat consumption," "Follow a meat-free diet most of the time," "Avoid eating meat all together," and "Follow a strictly plant-based diet" (based on items from Malek et al., 2019). These items were rated on a five-point Likert scale anchored from "Not willing at all" to "Extremely willing."

After this, the respondents were consecutively introduced to the concepts of conventional meat, meat substitutes, cultured meat, and hybrid meat products (see Table 1 for the definitions used). Their familiarity with the concepts of meat substitutes, cultured meat, and hybrid meat products was measured using the following categories: "Not familiar at all," "Slightly familiar," "Moderately familiar," "Very familiar," and "Extremely familiar." Then, a set of 11 attitudinal terms was used to probe the respondents' attitudes toward conventional meat, meat substitutes, cultured meat, and hybrid meat products. The respondents rated their attitudes using five-point semantic differential scales where the end points were labelled with the following item pairs: "Unhealthy–Healthy," "Unnatural–Natural," "Bad for the environment–Good for the environment," "Inconvenient for (daily) use–Convenient for (daily) use," "Boring–Exciting," "Unnecessary–Necessary," and "Disgusting–Appealing" (based on items from Bryant et al., 2019). Finally, the respondents rated their willingness to buy meat substitutes, cultured meat, and hybrid meat products using a 5-point Likert scale ranging from "Very unwilling" (1) to "Very willing" (5).

2.2. Data analysis

All the statistical analyses in this study were performed using R (version 4.1.0). Unless otherwise indicated, a value of $p < 0.05$ was defined as the criterion for statistical significance.

For all scales used, the internal reliability was determined by calculating the Cronbach's alpha. The participants' eating frequency and familiarity with the three meat alternatives were analyzed as categorical data by calculating the percentages of the different answer categories. Moreover, the four items used to measure their willingness to reduce meat consumption were analyzed separately using two-way analysis of variance (ANOVA) tests, with the country (the Netherlands or Finland) and diet (omnivore or flexitarian) as independent variables.

The negatively worded statements within the FNS and MAQ were recoded before any analysis took place, as described by Pliner and Hobden (1992) and Graça et al. (2015a), respectively. The FSKQ scores were calculated as described in Hartmann et al. (2021). The differences in the scores for the three tools between the countries (the Netherlands or Finland) and diets (omnivore or flexitarian) were determined using two-way ANOVAs.

With regard to the semantic differential attitude terms, one-way ANOVAs, followed by post-hoc Tukey tests were used to evaluate the differences among the products (conventional meat, meat substitutes, cultured meat, and hybrid meat products) for each attitude term. Furthermore, the overall "attitude score" for each product was calculated by averaging the scores for all 11 attitude terms, which was also analyzed using a one-way ANOVA and post-hoc Tukey test.

The respondents' willingness to buy (WTB) the three meat alternatives was evaluated using a one-way ANOVA followed by a post-hoc Tukey test, and a set of two-way ANOVAs for each meat alternative was used to evaluate the differences between the countries and diets. Finally, linear regression models were created to estimate the influence of the country, age, gender, diet, years of education, whether people followed a related academic program, familiarity, food sustainability knowledge, food neophobia, and meat attachment on the WTB the three meat alternatives.

3. Results

3.1. Participant characteristics

Table 2 presents the socio-demographic characteristics of the sample separated by country. Overall, the majority of participants were female (71.3%). The mean age of the participants was 36.1 years, ranging from 18 to 68 years. With regard to diet, 52.4% (n = 197) of participants referred to themselves as flexitarians.

3.2. Frequency of meat and meat substitute consumption

The frequencies of meat and meat substitute consumption in both the Netherlands and Finland are shown in Table 3. There were relatively

Table 2
Characteristics of the Dutch and Finnish participants.

		The Netherlands (n = 126)	Finland (n = 250)
Age (mean, SD)		35.0 (13.4)	36.7 (12.7)
Gender (n, %)			
	Female	91 (72.2%)	177 (70.8%)
	Male	33 (26.2%)	69 (27.6%)
	Other	1 (0.8%)	4 (1.6%)
	Rather not say	1 (0.8%)	n/a
Years of education[1] (mean, SD)		9.1 (2.9)	9.4 (5.4)
Relevant education[2] (%)		54.2%	60.8%
Diet (n, %)			
	Omnivore	48 (38.1%)	131 (52.4%)
	Flexitarian	78 (61.9%)	119 (47.6%)

[1]Number of years of education after primary school.
[2]Relevant education was defined as any nutrition, food science, or environmental-related programs.

Table 3
Frequency of meat (products) and meat substitute consumption.

	The Netherlands (n = 126)		Finland (n = 250)	
	Meat	Meat substitutes	Meat	Meat substitutes
Never	n/a	14.3%	n/a	2.8%
Tried them only a few times*	n/a	18.3%	n/a	20.4%
Less than once a month	1.6%	8.7%	2.8%	13.6%
1–3 times a month	7.1%	23.8%	9.6%	20.0%
1–2 times per week	14.3%	22.2%	14.4%	22.0%
3–4 times per week	31.7%	11.9%	28.4%	13.6%
5–6 times per week	33.3%	n/a	24.0%	6.8%
Every day	11.9%	0.8%	20.8%	0.8%

* This item was not asked in relation to meat products.

more participants from the Netherlands who never consume meat substitutes when compared with Finland. Overall, the results show that the Dutch participants consume meat slightly more often, while the Finnish participants consume meat substitutes more often.

3.3. Familiarity with meat alternatives

Table 4 displays the familiarity of the Dutch and Finnish participants with regard to concepts of meat substitutes, cultured meat, and hybrid meat products. When comparing the two countries, the Finnish participants are more familiar with all three meat alternatives. Meat substitutes are the most familiar products in both countries, while hybrid meat products are the least familiar.

When comparing the omnivores and flexitarians, a similar pattern emerges. Meat substitutes are the most familiar product for both groups, with 54.7% of the omnivores and 80.2% of the flexitarians being very to extremely familiar with these types of products, respectively. In terms of cultured meat, 27.4% of the omnivores are very to extremely familiar, and a similar level of familiarity can be seen for 32.0% of the flexitarians. Again, hybrid meat products is the least known product for both groups, with only 15.1% of the omnivores and 14.7% of the flexitarians indicating that they are very to extremely familiar with it.

3.4. Willingness to reduce meat consumption

The participants were asked to indicate their willingness to (1) reduce your meat consumption, (2) follow a meat-free diet most of the time, (3) avoid eating meat altogether, and (4) follow a strict plant-based diet. Cronbach's alpha for these questions together was 0.845. In this regard, four two-way ANOVAs were conducted to evaluate the effects of the country (the Netherlands, Finland) and the diet (omnivore, flexitarian) on the participants' willingness to adopt those behaviors. In terms of reducing meat consumption, there are significant differences between the diets ($F = 92.74$, $p < 0.001$), with the flexitarians being more willing to reduce their meat consumption when compared with the omnivores (mean scores of 4.2 and 3.2, respectively). There is no significant difference between countries ($F = 0.12$, $p = 0.727$), nor a significant interaction ($F = 0.41$, $p = 0.524$). When it comes to consuming a meat-free diet most of the time, both the country ($F = 7.23$, $p = 0.008$) and the diet ($F = 160.43$, $p < 0.001$) are significant. The interaction effect is not significant ($F = 3.23$, $p = 0.073$). With a mean score of 3.4, the Finnish participants are slightly more willing to consume a meat-free diet most of the time than the Dutch participants (3.1). Furthermore, the flexitarians are more willing to consume a meat-free diet most of the time than the omnivores (mean scores of 4.0 and 2.5, respectively). With regard to avoiding meat consumption, only the effect of diet is significant ($F = 118.90$, $p < 0.001$), with the flexitarians (3.0) being more willing than the omnivores (1.7). Again, both the effect of country ($F = 1.38$, $p = 0.240$) and the interaction ($F = 2.47$, $p = 0.117$) is not significant. Finally, for following a strictly plant-based diet, the effect of diet significant ($F = 53.86$, p =, $p < 0.001$), whereas the effect for country is not ($F = 0.25$, $p = 0.618$). However, the interaction between the country and diet and the willingness to follow a strictly plant-based diet is significant ($F = 5.58$, $p = 0.02$).

3.5. Food neophobia, meat attachment, and food sustainability knowledge

Before performing further analyses, the Cronbach's α scores in each country were calculated for the FSKQ, FNS, and MAQ. All the α scores are above 0.7, indicating good internal consistency within these tools. Three two-way ANOVAs were used to examine the effect of the country and diet on the FNS, MAQ, and FSKQ. The mean scores for the three measures are presented in Table 5.

3.5.1. Food neophobia

In this sample, the food neophobia scale had an α score of 0.835. The main effects for both the country ($F = 11.07$, $p < 0.001$) and the diet ($F = 12.34$, $p < 0.001$) are significant for the FNS. The interaction between the country and the diet is not significant ($F = 2.00$, $p = 0.157$). The Dutch and omnivore participants are more food neophobic than the Finnish and flexitarian participants.

3.5.2. Meat attachment

The meat attachment questionnaire had an α score of 0.923 For the MAQ, the main effects for both the country ($F = 6.48$, $p = 0.011$) and the diet ($F = 210.65$, $p < 0.001$) are significant. The Dutch participants and omnivores have higher meat attachment scores. Furthermore, there is a significant interaction between the country and the diet in relation to the meat attachment score ($F = 10.36$, $p = 0.001$), with the omnivores in the Netherlands having the highest meat attachment score, while the flexitarians in Finland have the lowest.

3.5.3. Food sustainability knowledge

In terms of the food sustainability knowledge questionnaire, the α score was 0.739. The two-way ANOVA showed that both the country ($F = 10.68$, $p = 0.001$) and the diet ($F = 26.51$, $p < 0.001$) have significant effects. However, the interaction is not significant ($F = 0.02$, $p = 0.901$). On average, the Finnish participants score 1 point higher on the FSKQ than the Dutch participants and the flexitarians score 1.5 points higher than the omnivores.

Table 4
Familiarity of Dutch and Finnish participants with concepts of meat substitutes, cultured meat, and hybrid meat.

	The Netherlands (n = 126)			Finland (n = 250)		
	Meat substitutes	Cultured meat	Hybrid meat products	Meat substitutes	Cultured meat	Hybrid meat products
Not familiar at all	6.3%	29.4%	58.7%	0.4%	5.2%	34.0%
Slightly familiar	19.8%	41.3%	26.9%	12.4%	30.8%	32.0%
Moderately familiar	22.2%	21.4%	7.9%	10.8%	23.2%	14.8%
Very familiar	31.0%	4.0%	4.0%	31.6%	22.8%	10.0%
Extremely familiar	20.6%	4.0%	2.4%	44.8%	18.0%	9.2%

Table 5
Mean ± SD scores for the Food Neophobia Scale (FNS), Meat Attachment Questionnaire (MAQ), and Food Sustainability Knowledge Questionnaire (FSKQ) across countries and diets.

	Overall score (n = 376)	NL (n = 126)	FI (n = 250)	Omnivores (n = 179)	Flexitarians (n = 197)	NL-Omnivores (n = 48)	NL-Flexitarians (n = 78)	FI-Omnivores (n = 131)	FI-Flexi-tarians (n = 119)
FNS (scale 10–70)	27.18 ± 10.04	29.54 ± 9.23[a]	26 ± 10.23[b]	29.02 ± 10.98[1]	25.52 ± 9.08[2]	30.46 ± 9.45	28.97 ± 9.11	28.17 ± 11.22	23.61 ± 8.44
MAQ* (scale 1–5)	2.93 ± 0.84	3.06 ± 0.64[a]	2.88 ± 0.92[b]	3.46 ± 0.75[1]	2.47 ± 0.63[2]	3.48 ± 0.58	2.80 ± 0.53	3.43 ± 0.80	2.27 ± 0.60
FSKQ (scale 0–16)	11.13 ± 2.93	10.46 ± 3.02[a]	11.46 ± 2.82[b]	10.35 ± 3.18[1]	11.83 ± 2.5[2]	9.56 ± 3.54	11.01 ± 2.53	10.73 ± 2.99	12.26 ± 2.39

Different letters or numbers in the same row denote significant differences according to the two-way ANOVA comparing the country and the diet, respectively.
* Interaction effect between the country and the diet is significant.

3.6. Attitudes toward conventional meat and meat alternatives

To compare the participants' attitudes toward the three meat alternative products when compared with conventional meat, a set of 11 semantic differential attitude terms was used. The participants rated the terms on a scale ranging from 1 to 5. Internal consistency had an α score of 0.787. A set of 11 one-way ANOVAs was used to evaluate the differences in the attitude terms between conventional meat and the three meat alternatives (averaged over all the participants). The post-hoc analysis using Tukey's HSD test shows significant differences among conventional meat, meat substitutes, cultured meat, and hybrid meat products for all the attitude terms. A visualization of the attitude data with the 95% confidence intervals is presented in Fig. 1 (a table including the mean scores and results from the post-hoc test can be found in the Supplementary Materials). While the scores for conventional meat, meat substitutes, and cultured meat vary among the different attitude terms, the scores for hybrid meat products remain near the middle of the scale.

Furthermore, the average "attitude score" per product was calculated and another one-way ANOVA was conducted to evaluate the differences among conventional meat and the three meat alternatives ($F = 25.26$, $p < 0.001$). The post-hoc Tukey test showed that meat substitutes (mean score of 3.33) score significantly higher than conventional (mean score of 3.07) and cultured meat (mean score of 3.03) ($p < 0.001$ for both comparisons). A similar pattern emerges for hybrid meat (mean score of 3.30), which scored significantly higher than conventional and cultured meat ($p = < 0.001$ for both comparisons).

3.7. Willingness to buy meat alternatives

The participants' willingness to buy the three different meat alternatives, as measured on a five-point scale, was first analyzed using a one-way ANOVA ($F = 13.79$, $p < 0.001$). The post-hoc analysis using Tukey's HSD test shows that, averaged over all the participants, there is a significantly higher WTB with regard to meat substitutes (mean score of 3.64) when compared with cultured meat ($p < 0.001$) and hybrid meat products ($p < 0.001$) with mean scores of 3.18 and 3.29, respectively.

Furthermore, a set of three two-way ANOVAs was performed to evaluate the effects of the country and the diet on the participants' willingness to buy the different meat alternatives. The results are presented in Table 6. For meat substitutes, the effect of diet is significant ($F = 117.21$, $p < 0.001$), whereas the effects of country ($F = 0.23$, $p =$

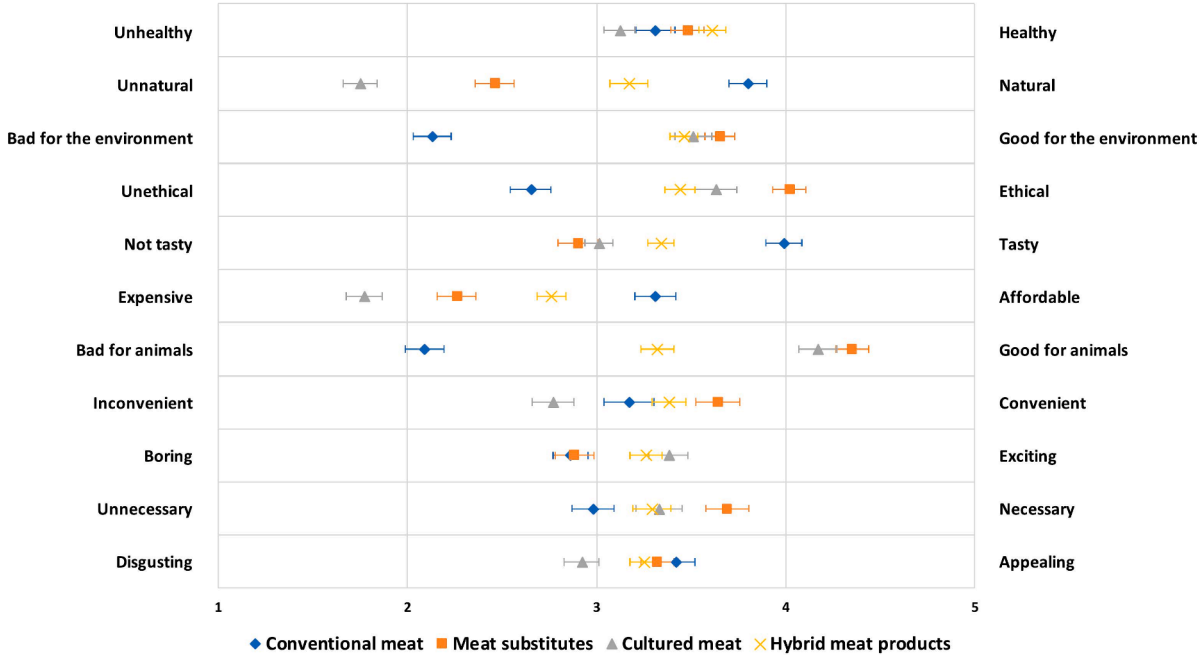

Fig. 1. Semantic differentials for conventional meat and the three alternatives, including all the participants (n = 376). Mean and 95% CI are shown for each product (values can be found in the Supplementary Materials).

Table 6
Mean ± SD scores for the participants' willingness to buy (WTB) meat substitutes, cultured meat, and hybrid meat products across countries and diets.

WTB (scale 1–5)	Overall score (n = 376)	NL (n = 126)	FI (n = 250)	Omnivores (n = 179)	Flexitarians (n = 197)	NL-Omnivores (n = 48)	NL-Flexitarians (n = 78)	FI-Omnivores (n = 131)	FI-Flexitarians (n = 119)
Meat substitutes	3.65 ± 1.24	3.60 ± 1.17[a]	3.66 ± 1.27[a]	3.01 ± 1.20[1]	4.21 ± 0.97[2]	2.96 ± 1.18	4.00 ± 0.97	3.04 ± 1.21	4.34 ± 0.95
Cultured meat	3.18 ± 1.31	3.25 ± 1.18[a]	3.15 ± 1.37[a]	2.96 ± 1.35[1]	3.39 ± 1.23[2]	3.08 ± 1.05	3.35 ± 1.26	2.91 ± 1.45	3.42 ± 1.22
Hybrid meat products*	3.29 ± 1.19	3.31 ± 1.08[a]	3.28 ± 1.25[a]	3.31 ± 1.17[1]	3.28 ± 1.21[1]	3.10 ± 0.99	3.44 ± 1.11	3.38 ± 1.22	3.18 ± 1.27

Different letters or numbers in the same row denote significant differences according to the two-way ANOVA comparing the country and the diet, respectively.
* Interaction effect between the country and the diet was significant.

0.631) and the interaction are not ($F = 1.20, p = 0.273$). The flexitarians are more willing to buy meat substitutes when compared with the omnivores. For cultured meat, again only the effect of diet is significant ($F = 10.23, p = 0.002$), with the effects of country ($F = 0.44, p = 0.507$) and the interaction ($F = 0.74$, $p = 0.389$) not being significant. Here, the flexitarians exhibit a higher WTB cultured meat than the omnivores. Finally, for hybrid meat products, no significant effects are found for the country ($F = 0.04$, $p = 0.845$) and the diet ($F = 0.06$, $p = 0.797$). However, the interaction between these two effects is marginally significant ($F = 4.09$, p = 0.04), with the Dutch flexitarians exhibiting the highest WTB hybrid meat products.

Results from the linear regressions models predicting the WTB for meat substitutes, cultured meat and hybrid meat products are presented in Table 7. Respondents that did not indicate a female or male gender were excluded from this analysis (n = 6), and the variables country, gender, diet, and relevant education were dummy coded. The model for meat substitutes explains 52% of the variance for WTB, whereas this is only 17% and 5% for cultured meat and hybrid meat products, respectively. For meat substitutes, being from Finland, having an older age, being male, being more food neophobic and more attached to meat results in a lower WTB. Participants who are flexitarian, more familiar with meat substitutes and have more knowledge on food sustainability rated a higher WTB for meat substitutes. The WTB ratings for cultured meat are influenced negatively by being from Finland, being older and having a higher food neophobia score, and familiarity has a positive effect. Finally, male participants and those with a higher food neophobia score results in a lower WTB for hybrid meat products, whereas familiarity with these products had a positive influence.

Table 7
Regression table depicting the coefficients, t-value and p-value for the willingness to buy of meat substitutes, cultured meat and hybrid meat products.

Predictor	β	Std.error	t-value	*p*
Meat substitutes	F(10,359) = 40.44, P < 0.001. $R^2 = 0.53$, adj. $R^2 = 0.52$			
(Intercept)	3.945	0.432	9.130	**<0.001**
Country	−0.288	0.105	−2.733	**0.007**
Age	−0.010	0.004	−2.506	**0.013**
Gender	−0.265	0.111	−2.392	**0.017**
Diet	0.302	0.116	2.617	**0.009**
Years of education	0.014	0.010	1.373	0.171
Relevant education	−0.061	0.104	−0.588	0.577
Familiarity	0.328	0.048	6.806	**<0.001**
FSKQ	0.045	0.018	2.504	**0.013**
FNS	−0.016	0.005	−3.385	**<0.001**
MAQ	−0.435	0.073	−5.933	**<0.001**
Cultured meat	F(10,359) = 8.72, P < 0.001. $R^2 = 0.20$, adj. $R^2 = 0.17$			
(Intercept)	4.717	0.553	8.532	**<0.001**
Country	−0.392	0.150	−2.610	**0.009**
Age	−0.021	0.005	−3.964	**<0.001**
Gender	0.187	0.153	1.222	0.222
Diet	−0.030	0.158	−0.190	0.849
Years of education	0.009	0.014	0.635	0.526
Relevant education	−0.106	0.144	−0.738	0.461
Familiarity	0.125	0.058	2.143	**0.033**
FSKQ	0.037	0.025	1.497	0.135
FNS	−0.028	0.007	−4.305	**<0.001**
MAQ	−0.192	0.101	−1.896	0.059
Hybrid meat products	F(9,359) = 3.12, P < 0.001. $R^2 = 0.08$, adj. $R^2 = 0.05$.			
(Intercept)	3.403	0.525	6.482	**<0.001**
Country	−0.240	0.139	−1.725	0.085
Age	<0.001	0.005	0.033	0.973
Gender	−0.335	0.148	−2.257	**0.025**
Diet	−0.158	0.152	−1.036	0.300
Years of education	0.021	0.014	1.473	0.142
Relevant education	−0.091	0.138	−0.658	0.511
Familiarity	0.164	0.053	3.125	**0.002**
FSKQ	0.011	0.024	0.478	0.633
FNS	−0.020	0.006	−3.177	**0.002**
MAQ	0.054	0.010	0.543	0.588

Note: n = 370. Country: 0 = the Netherlands, 1 – Finland. Gender: 0 = female, 1 = male. Diet: 0 = omnivore, 1 = flexitarian. Relevant education: 0 = yes, 1 = no.

4. Discussion

This study sought to investigate Dutch and Finnish omnivore and flexitarian consumers' attitudes toward plant-based meat substitutes, cultured meat, and hybrid meat products using an explorative approach. Furthermore, it assessed how food neophobia, meat attachment, and knowledge of food sustainability affects the willingness to buy these alternatives to conventional meat.

Overall, the results showed that meat substitutes are the most preferred of the three meat alternatives based on the participants' willingness to buy. Similar results are reported by Gómez-Luciano et al. (2019), who find that consumers exhibit a higher WTB plant-based meat substitutes when compared with cultured meat and insect-based products. The high WTB meat substitutes when compared with cultured and hybrid meat in this study may be related to the participants' greater familiarity with these types of products. Meat substitutes have been readily available in the Dutch and Finnish markets for some time now, and this is reflected in the high familiarity and usage ratings of meat substitutes in the present sample. The study by Bryant and Sanctorum (2021) shows that positive attitudes toward plant-based meat substitutes have increased between 2019 and 2020 among Belgian consumers, likely due to the increasing variety and quality of these types of products. However, the consumption of meat substitutes remains still quite low in both the Netherlands (Dagevos et al., 2021) and Finland (Knaapila et al., 2022). Consumer tests among regular meat consumers often show low acceptance of meat substitutes due to food neophobia, in addition to low expectations regarding the sensory quality and healthiness of such products (Hartmann et al., 2022; Weinrich, 2018, 2019). Similarly, in the present sample the regression analysis showed that food neophobia negatively influenced the willingness to buy meat substitutes. Furthermore, meat substitutes were rated as being significantly higher in terms of healthiness than conventional meat. In terms of tastiness, however, the respondents rated meat substitutes as much less tasty compared to conventional meat, together with cultured meat.

Consistently with previous findings, attitudes toward cultured meat are somewhat negative in the present sample (Bryant & Sanctorum, 2021; Siegrist et al., 2018; Verbeke et al., 2015). More specifically, cultured meat is seen as unnatural and expensive by the participants in this study. Consumer acceptance is said to be the main barrier to the

success of cultured meat products (Sharma et al., 2015). However, it is expected that once cultured meat products enter the market and consumers become more familiar with them, acceptance will increase (Bryant & Barnett, 2018). The regression analysis in this study corroborates this; higher familiarity with all three meat alternatives positively influences WTB. Although some of the attitude terms in this study are rated low, the total attitude score for cultured meat is relatively neutral and – although significant – does not differ that much from the scores for meat substitutes and conventional meat. Once cultured meat products these types of products enter the market, proper promotion and communication regarding the production process and benefits should be applied to ensure their successful implementation (Bryant & Barnett, 2018; Rolland et al., 2020).

Although meat substitutes and hybrid meat products both score significantly higher in terms of the overall attitude score when compared with conventional meat and cultured meat in this study, the participants' WTB cultured meat and hybrid meat is similar. The results concerning the semantic differential attitude terms seem to indicate that the participants are quite neutral or unsure regarding hybrid meat products. When looking at Fig. 1, the patterns for hybrid meat differ from those for the other meat alternatives. Whereas the participants' attitude scores concerning conventional meat, meat substitutes, and cultured meat vary from positive to negative depending on the attitude term, their scores for hybrid meat tend to remain around the middle of the five-point semantic scale. This neutral or unsure perception of hybrid meat products may be due to the fact that hybrid meat products are relatively new types of products that have only just entered the Dutch and Finnish markets. As a consequence, consumers may not yet have had a chance to form an opinion separately from the introduction of these products. This line of thinking is corroborated by the finding that hybrid meat products are rated as being the least familiar products in both countries. While the unfamiliarity and novel technology of cultured meat products might lead to more negative attitudes, hybrid meat products tend to include ingredients and involve production processes that are not new to consumers. This neutral attitude toward hybrid meat products may represent a chance for the successful promotion of these types of products. The linear regression model for hybrid meat products only explained around 5% of the variance, indicating that the variables measured in this study do not explain what influences the participants' willingness to buy this meat alternative. Unfortunately, scientific research on consumers' acceptance of hybrid meat products is scarce. To date, most studies focus on the development and sensory perceptions of hybrid meat products (e.g., Grasso et al., 2019; Neville et al., 2017; Taylor et al., 2020), with less attention being paid to consumers' attitudes, although interest in this is increasing (e.g., Ryder et al., 2023). A few recent studies focusing on consumer acceptance of the hybrid meat concept report that, in contrast to the present results, there is an overall positive response, with consumers believing these products to be tasty, good for the environment and healthier due to the addition of vegetables (Banovic et al., 2022; Grasso & Jaworska, 2020; Lang, 2020). Grasso and Jaworska (2020) showed that the perceived healthiness of these types of products could be an important determinant of the positive perception of hybrid meat when compared with conventional meat. De Boer et al. (2013) argued that hybrid meat products might be good options for consumers who do not actively search for more environmentally friendly products. Overall, there appears to be a need to increase consumers' familiarity with the concept of hybrid meat products. Additionally, the positive effects of such products on health and sustainability should be highlighted to shift consumers' attitudes from neutral to more positive.

Although significant differences can be seen in the FNS scores between the Dutch and Finnish participants, as well as between the omnivores and flexitarians, these differences are very small. Furthermore, the overall FNS scores are relatively low (Rabadán & Bernabéu, 2021). Food neophobia has been shown to decrease acceptance of meat alternatives (Bryant et al., 2019; Hoek et al., 2011; Profeta et al., 2021; Siegrist & Hartmann, 2020). The present results seem to confirm this, as food neophobia was an important negative predictor for the WTB of all three meat alternatives. However, doubt has recently been raised about the effect of food neophobia on the adoption of novel foods, indicating that more complex decision-making systems may be at play (Faccio & Guiotto Nai Fovino, 2019).

With regard to meat attachment, it is unsurprising that the flexitarian participants score lower on the MAQ than the omnivores. Comparing the results concerning the MAQ scores to the questions about willingness to reduce meat consumption, it appears that a higher attachment to meat leads to a lower willingness to reduce meat consumption, as Graça et al. (2015a), Graça et al. (2015b), Graça et al. (2016), and Lentz et al. (2018) all note. Not surprisingly, meat attachment was only a significant predictor for the WTB of meat substitutes, the only of the three meat alternatives that does not contain real meat. Thus, an approach to reducing meat consumption and promoting the consumption of meat alternatives could involve reducing consumers' attachment to meat.

Finally, the FSKQ results are particularly interesting. The flexitarians score significantly higher on the FSKQ when compared with the omnivores. This finding suggests that a better understanding of food sustainability might lead to more plant-based diets, as Mullee et al. (2017) and Tan et al. (2021) argued. Importantly, the FSKQ scores in this study are higher when compared with the scores for the countries evaluated during the development of the tool (Hartmann et al., 2021), suggesting a high knowledge of food sustainability in the present sample. The FSKQ focusses on food sustainability in a broad sense, although it also includes specific questions regarding meat and meat alternatives as well as plant-based diets. While the majority of these types of questions had high correct answer scores, the two questions comparing the sustainability of local meat products to tofu "from overseas" are often answered incorrectly. Overall, the findings imply that to lower meat consumption, consumers should be educated about food sustainability, especially the environmental effects of meat production when compared with plant-based products.

It must be acknowledged that this study has several limitations. First, convenience sampling was used to distribute the questionnaire via the researchers' professional and personal networks. This resulted in the majority of participants having some form of educational history relevant to the research (49% in the Netherlands and 63% in Finland). Although having a relevant academic history was not a significant predictor in all three linear regression analysis, the generalization of the results to the general population should be performed cautiously. Many of the present results indicate significant differences between the countries. More specifically, the Finnish consumers are less food neophobic, less meat attached, know more about food sustainability, and are more familiar with all three meat alternatives than the Dutch consumers. However, this is most likely a direct result of the higher frequency of "experts" in the Finnish sample. Furthermore, in the Finnish questionnaire more examples for meat substitute products were given, as there were more products available in Finland at the time. Future studies on this topic should include a more representative sample of Dutch and Finnish consumers.

The second limitation of this study relates to the translation of the questionnaire from English to Dutch and Finnish. These translations were performed by the researchers themselves, and no back translating was performed. Although the FNS has validated translations in both languages, the same is not true for the relatively new MAQ and FSKQ. While the questionnaire was piloted to ensure that the participants could understand all the questions, some respondents indicated that they struggled with some of the questions in the MAQ and the FSKQ. Validated translations of these tools need to be developed if they are to be properly used in cross-cultural research.

Furthermore, this study adopted an explorative approach to investigating attitudes toward the three meat alternatives. Although definitions were provided for each type of product, many variations exist within each product category. The participants rated their opinions of the concepts of the meat alternatives, not of a specific product. It could

be the case that when consumers see these meat alternatives in stores and start preparing and tasting them, their attitudes toward them change. The studies by Michel et al. (2021) and Elzerman et al. (2021) showed that the appropriateness of eating meat alternatives differs between consumption situations. Moreover, the meal context in which an alternative product is consumed also appears to affect acceptance (Elzerman et al., 2011; Hoek et al., 2013).

Finally, the chosen definition for a flexitarian diet ("I refrain from eating meat at least one day a week" by Verain et al. 2020, also used by Elzerman et al. 2021) might have caused an overestimation of the number of flexitarians in our sample. While there is still no established definition of a flexitarian, there is a consensus that it relates to a consumer who purposefully restricts their meat consumption (Dagevos, 2021). However, as the proportion of omnivores was quite high in our sample, it can be expected that the participants were aware of the suggested difference between the two diet groups. Nevertheless, future studies should indicate this purposeful intention to reduce meat intake in their definition of a flexitarian diet, and include information about how much these consumers reduce their meat intake to possibly find differences in this heterogeneous group.

The present study investigated hybrid meat products in comparison to consumers' perception of meat substitutes and cultured meat. Future studies should focus more on hybrid meat products as well as on the growing population of flexitarian consumers, as the latter could be more open to consuming different types of meat alternatives. Longitudinal studies concerning cultured meat and hybrid meat products could evaluate the changes in consumers' acceptance of these products once they enter the market and consumers become more familiar with them.

5. Conclusions

The findings of this study revealed plant-based meat substitutes to be the most positively perceived meat alternative when compared with cultured meat and hybrid meat products. Although the participants' mean willingness to buy cultured meat and hybrid meat products are similar, cultured meat is associated with more polarized opinions, whereas the participants are quite neutral about hybrid meat products. This may be due to the participants' unfamiliarity with this novel meat alternative product, which indicates that following an appropriate introduction to the market – emphasizing the positive effects of eating less meat – hybrid meat products could be a viable option for reducing meat consumption alongside meat substitutes. This study also shows that flexitarians represent a promising target group when it comes to promoting meat alternatives, as they might be more open to trying different types of products. Finally, the findings suggest that decreasing meat attachment and food neophobia, as well as increasing familiarity and knowledge of food sustainability, are important challenges that need to be overcome in order to decrease meat consumption. While previous studies have reported that consumers are not aware of the environmental impact of meat consumption, we observed an association between higher knowledge on food sustainability (FSKQ score) and lower use of meat. This implies that educational campaigns for increasing knowledge on food sustainability (e.g., in schools, restaurants, and grocery stores) could be a potential way to promote use of meat alternatives. As the world of meat alternatives is constantly evolving, longitudinal studies can provide more insight into changing views towards the much-needed protein transition.

CRediT authorship contribution statement

Birgit van Dijk: Conceptualization, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Kirsi Jouppila:** Methodology, Resources, Writing – review & editing, Project administration, Funding acquisition. **Mari Sandell:** Resources, Writing – review & editing. **Antti Knaapila:** Conceptualization, Methodology, Investigation, Writing – review & editing, Supervision.

Declaration of Competing Interest

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

Data availability

Our informed consent does not allow public sharing of the data. The code used for analyses can be shared by request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2023.104886.

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