Norwegian consumers' acceptance of sustainable dietary alternatives

Norske forbrukeres aksept for bærekraftige kostholdsalternativer

Philosophiae Doctor (PhD) Thesis

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To my dad and mum, Charles Muiruri and Ruth Njoki Muiruri

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Ås, December 2024
Sarah Wangui Muiruri

Table of Contents

1 List of papers

This thesis contains the following four papers

Paper 1.: **The impact of consumers' preferences for domestic food on dietary sustainability**
Milford, A. B., & Muiruri, S. W. (2024). The impact of consumers' preferences for domestic food on dietary sustainability. *Appetite*, *195*, 107206. https://doi.org/10.1016/j.appet.2024.107206

Paper 2.: **Norwegian consumers' willingness to try cultured meat**
Muiruri, S. W., & Rickertsen, K. (2024). Norwegian consumers' willingness to try cultured meat. *Future Foods*, 10, 100409. https://doi.org/https://doi.org/10.1016/j.fufo.2024.100409

Paper 3.: **Norwegian consumers' willingness to try food made from insects: The role of trust, food choice motives and OCEAN personality traits**
Muiruri, S. W. (2024). Norwegian consumers' willingness to try food made from insects: The role of trust, food choice motives and OCEAN personality traits. *Journal of Agriculture and Food Research*, 101381. https://doi.org/https://doi.org/10.1016/j.jafr.2024.101381

Paper 4.: **Norwegian consumption of plant-based meat analogues**
Authors: Sarah Wangui Muiruri, Anna Birgitte Milford and Kyrre Rickertsen
Working Paper

2 Abstract

This thesis focuses on sustainable food consumption, consumer behaviour and food choice and contains four papers. The first paper uses data from an online survey conducted in Norway and the three remaining papers use data from a repeated cross-sectional Norwegian survey. Specifically, the papers investigate the consumer acceptance of sustainable diets among Norwegian consumers.

The first paper investigates the factors affecting dietary sustainability with a focus on preference for domestic foods and its relation to consumption of red and white meat, fish and plant-based foods and self-identification as a meat reducer. The paper also investigates the role of environmental and health attitudes. Preference for domestic food is associated with higher likelihood of consuming plant-based food and higher consumption of red meat. Health concern is associated with high white meat and fish consumption and environmental concern with a higher likelihood of consuming plant-based foods and identifying as a meat reducer.

The second paper investigates the consumer acceptance of cultured meat. It examines the effects of trust, food choice motives and socioeconomic factors, on the willingness to try cultured meat. The paper also investigates changes in the importance of the determinants over time. No significant changes over time are found. Social trust and support for green parties are positively associated with being willing to try cultured meat and trust in food authorities is negatively associated with being unwilling to try. Emphasizing the environment, health, novelty and price are also positively associated with being willing to try while emphasizing naturalness and safety has a negative association. Being younger, higher educated and living in an urban area has a positive association with being willing to try cultured meat while being female, religious and vegetarian has a negative association.

The third paper evaluates the consumer acceptance of food made from insects. It investigates the effect of trust, food choice motives and the big five personality traits (openness, conscientiousness, extraversion, agreeableness and neuroticism (OCEAN)) on the willingness to try food made from insects. Furthermore, the paper examines the mediating role of safety concerns and the moderating role of sociodemographic factors. Social trust, trust in food authorities and emphasis on the environment, health and novelty are positively associated with willingness to try while emphasizing naturalness and safety has a negative association. Safety concern is also a significant mediator. For personality traits, openness is positively associated with willingness to try food made from insects while conscientiousness, extraversion, and agreeableness have a negative association. Gender, education, age and urban living moderate some paths.

The fourth paper delves into the consumer acceptance of plant-based meat analogues (PBMA). It investigates the effect of food choice motives and socioeconomic factors on the consumption of PBMA. The paper also investigates changes in the importance of determinants of PBMA consumption over time. Emphasizing the environment, animal welfare, and novelty were positively associated with PBMA consumption while emphasizing familiarity and Norwegian origin were negatively associated. Younger, higher educated, urban, and vegetarian respondents were more likely to consume PBMA. Use of social media had a positive effect on the consumption, for the total sample but not on each survey round. A declining effect of social media is found.

The findings of the four papers identify important factors affecting consumers' food choice behaviour. Moreover, they identify potential drivers and barriers towards the uptake of more sustainable dietary alternatives. These results also highlight the similarities and differences in consumers' preferences for different meat alternatives which could be useful for marketing and policy recommendations.

3 Norsk Sammendrag

Denne avhandlingen fokuserer på bærekraftig matforbruk, forbrukeratferd og matvalg og inneholder fire artikler. Den første artikkelen bruker data fra en spørreundersøkelse gjennomført i Norge, mens de tre resterende artiklene bruker data fra gjentatte spørreundersøkelser i Norge. Spesifikt undersøker artiklene aksept for bærekraftige kosthold blant norske forbrukere.

I den første artikkelen undersøkes faktorer som påvirker bærekraftig kosthold, med fokus på preferanser for norskprodusert mat og forbruk av rødt og hvitt kjøtt, fisk og plantebasert mat og selvidentifikasjon som en som reduserer kjøttforbruket (veganer, vegetarianer eller flexitarian). Artikkelen undersøker også betydningen helse og miljø har på bærekraftig kosthold. . Preferanse for norskprodusert mat henger sammen med lavere sannsynlighet for å spise plantebasert mat og et høyere forbruk av rødt kjøtt. Helsebekymring er knyttet til høyt forbruk av hvitt kjøtt og fisk, mens miljøbekymringer har sammenheng med høyere sannsynlighet for å konsumere plantebasert mat samt reduksjon i kjøttforbruket.

Den andre artikkelen handler om forbrukeraksept for laboratoriedyrket kunstig kjøtt. I den artikkelen analyseres effektene av tillit, motivasjon og sosioøkonomiske faktorer på villighet til å prøve kunstig kjøtt. Artikkelen undersøker også endringer i betydningen av disse faktorene over tid, men finner ingen signifikante endringer. Høy sosial tillit og støtte til grønne partier indikerer villighet til å prøve laboratoriedyrket kjøtt mens mens tillit til matmyndigheter indikerer mindre uvillighet. Vektlegging av miljø, helse, nyhet og pris er positivt assosiert med økt villighet, mens vektlegging av naturlighet og sikkerhet er negativt assosiert. Yngre, høyere utdannede og urbane forbrukere er mer villige til å prøve, mens kvinner, religiøse og vegetarianere er mindre villige.

Den tredje artikkelen handler om forbrukeraksept for mat laget av insekter. Den handler om effekten av tillit, motivasjon og personlighetstrekk på villighet til å prøve insektbasert mat. Videre analyserer artikkelen om matsikkerhetsbekymringer medierer relasjonen mellom tillit og villighet til å prøve insektbasert mat samt om sosiodemografiske faktorer har en modererende relasjon. Sosial tillit og tillit til matmyndigheter er positivt assosiert med villighet. Vektlegging av miljø, helse og nyhet indikere mer villighet mens vektlegging av naturlighet og matsikkerhet mindre villighet. Matsikkerhetsbekymringer medierer relasjonen mellom tillit og villighet til å prøve insektbasert mat. Høy åpenhet indikere mer villighet, mens planmessighet, ekstroversjon og medmenneskelighet har en negativ sammenheng. Kjønn, utdanning, alder og urbant miljø modererer relasjon mellom villighet til å prøve insektbasert og noen variabler.

Den fjerde artikkelen utforsker forbrukeraksept for plantebaserte kjøtterstatninger. Den undersøker effekten av motivasjonsfaktorer og sosioøkonomiske faktorer på forbruket av plantebaserte kjøtterstatninger. Artikkelen undersøker også endringer i betydningen av disse faktorene over tid . Vektlegging av miljø, dyrevelferd og nyhet var positivt relatert med forbruk av plantebaserte kjøtterstatninger, mens vektlegging av kjennskap og norsk opprinnelse var negativt relatert Vegetarianere, yngre, høyere utdannede og urbane respondenter var mer tilbøyelige til å konsumere plantebaserte kjøtterstatninger. Bruk av sosiale medier hadde en positiv effekt på hele utvalget men ikke på hver enkelt undersøkelsesrunde. Over tid var det en nedgang i effekten av sosiale medier.

Funnene fra de fire artiklene identifiserer viktige faktorer som påvirker forbrukernes matvalg. Videre fremhever de mulige drivere og barrierer for en overgang til mer bærekraftige kostholdsalternativer. Resultatene belyser også likheter og forskjeller mellom forbrukernes preferanser for ulike alternativer til kjøtt, noe som er nyttig for markedsføring og politiske anbefalinger.

4 Synopsis

The introduction is made up of four main sections. First, I give a background of the thesis and discuss sustainable food consumption. Second, a literature review of food consumption and food choice is provided. The first part of the review discusses the importance of economic factors, which, as discussed below, are not the focus of this thesis. The second part of the review discusses the factors included in the thesis papers. Third, I give an overview of the thesis papers including the data and methods and summary findings of the four papers and, lastly, I describe the contributions, implications and limitations of the thesis.

4.1 Background of the thesis

This thesis is part of a four-year research project Sustainable Eaters, launched in 2021 and financed by The Research Council of Norway (n.d.). The goal of the project is to understand and strengthen the role of the consumer in the transition towards a sustainable Norwegian food system. Global food systems pose environmental, economic and social challenges that require the direct involvement of the consumer as part of the solution. In line with the project's objective to understand individuality in consumer behaviour, this thesis focused on investigating food choice behaviour related to meat alternatives and plant-based foods given the negative environmental, health and animal welfare effects of meat production and consumption.

4.2 Sustainable food consumption

What is sustainable food consumption? Assessing food sustainability is a complex problem and integrating the economic, social, environmental and good governance dimensions of food sustainability are among the pressing challenges (Garnett, 2013; Movilla-Pateiro et al., 2021).

Although there is no single answer with general agreement to what is "sustainable food consumption", some pressing issues need attention. First, there is a need to reduce the emission footprint resulting from food systems. About a third of the global greenhouse gas (GHG) emissions are associated with the current global food systems (Crippa et al., 2021). It is further anticipated that global food consumption could contribute to an almost 1°C increase in global warming most of which would be linked to methane emissions (Ivanovich et al., 2023). Second, the burden of diet related diseases continues to build with diet related risk factors being associated with high global mortality (Afshin et al., 2019). Third, the costs of the present global food systems seem to exceed the gains and sticking to the status quo would mean increased food waste, malnutrition and deforestation, among other risks (Ruggeri Laderchi et al., 2024). These, among other factors, call for action towards sustainable food consumption.

Aguirre Sánchez et al. (2021) reviewed and summarized proposed sustainable food consumption practices into five umbrella thematic areas: "sustainable production and processing, reduced food miles, reduced packaging, sustainable dietary patterns and food and waste management". Frequently there are claims related to the benefits of consuming local foods, demanding more organic food, avoiding ultra-processed food and reducing food waste and plastic packaging. However, such claims as we will see are highly context dependent. For example, while reduced food miles is highly recommended, countries with long and harsh winter seasons may benefit from importing tropical food products as opposed to trying to grow them locally in energy-intensive greenhouses (Avetisyan et al., 2014; Kinnunen et al., 2020). The

adoption of organic foods is also faced with its advantages and challenges. Organic foods are merited for less additives, not exposing consumers and the soil to pesticides, maintaining ecosystem biodiversity and, though inconclusive, being healthier (Forman et al., 2012; Gamage et al., 2023). Nevertheless, organic foods face economic sustainability challenges due to higher prices driven by lower productivity, higher labour costs, longer production times, and greater land use (Forman et al., 2012; Gamage et al., 2023; Niggli, 2015).

Another ongoing challenge is the extent ultra-processed plant-based foods can be considered sustainable given the nutritional, health and environmental challenges of ultra-processed foods (Gibney, 2021; Ohlau et al., 2022). Reducing food waste has also been met with dilemmas. In the efforts to reduce food waste, consumers sometimes overlook food safety measures and adopt risky behaviours such as removing mould from food and eating overstored food which may have negative health implications (Kasza et al., 2022). Lastly, reduced packaging also has its challenges. Reduced use of single-use plastic bags is highly encouraged but it can sometimes result in cross-contamination of foods when foods are not properly separated (Kasza et al., 2022). Food contamination may also result from overusing reusable bags without cleaning them up (Kasza et al., 2022).

Reducing meat consumption and shifting to more plant-based foods and novel protein alternatives such as cultured meat, insects and plant-based meat analogues are among the recommended sustainable dietary shifts, particularly for Western countries (Smetana et al., 2023). Meat and animal products are the largest contributor to food-related GHG emissions and meat production is associated with deforestation, land degradation and high water use (Rust et al., 2020; Zhu et al., 2023). Meat consumption is also associated with serious health challenges including cardiovascular diseases and cancer (Grosso et al., 2022). To achieve a sustainable dietary shift by 2050, it is recommended that global meat consumption be reduced by more than half (Willett et al., 2019). As discussed, meat reduction is undeniably needed. Nevertheless, it is expected to cause economic and social sustainability disruptions including loss of livelihood and cultural traditions (Newton & Blaustein-Rejto, 2021).

4.3 Literature review

4.3.1 The economics of food consumption and food choice behaviour

Food consumption and food choice behaviour have been studied using different economic approaches. In this section, I briefly cover some of the economic approaches that have been applied. The discussed approaches and studies are not exhaustive of the available alternatives but offer an overview.

The classical constrained utility maximisation approach has been widely applied within food consumption research to estimate food demand systems (Piggott & Marsh, 2011; Ritson & Petrovici, 2001). This approach is founded on the axioms of choice and provides a framework for transitioning utility into demand functions (Deaton & Muellbauer, 1980). Consumers are assumed to be rational with stable preferences known to them and to maximise their utility subject to budgetary constraints (Piggott & Marsh, 2011; Ritson & Petrovici, 2001). In a Norwegian context, it has been studied in, for example, Rickertsen (1998a) and Gustavsen and Rickertsen (2003)

Many studies have estimated the demand systems for different food products, for example meat (Chavas, 1983; Rickertsen, 1996; Tonsor et al., 2010; Verbeke & Ward, 2001), vegetables (Naanwaab & Yeboah, 2012; Rickertsen et al., 1995; Seale et al., 2013) and dairy products (Bouamra-Mechemache et al., 2008; Rickertsen & Gustavsen, 2002). These and other studies have also looked at the effect of information on demand including safety information (Piggott & Marsh, 2004), advertising (Rickertsen, 1998b; Rickertsen et al., 1995; Rickertsen & Gustavsen, 2002) and health information (Rickertsen et al., 2003; Tonsor et al., 2010).

In the context of sustainable food consumption, literature on the demand for more sustainable dietary alternatives is growing. Studies on the demand for organic foods seem to be most prevalent, for example, demand for organic fruits and vegetables (Fourmouzi et al., 2012; Lin et al., 2009), organic milk (Lindström, 2022; Schröck, 2012) and organic fish (Chen et al., 2015). For novel foods, the literature appears limited. Zhao et al. (2023) estimated the demand for plant-based meat analogues and fresh meat in the US using the almost ideal demand system (AIDS). They found that PBMA was a complement to beef and pork but a substitute for chicken. Capps and Wang (2024) and Huang (2022) estimated the demand system for plant-based milk alternatives and dairy milk, in the US and Sweden respectively. Capps and Wang (2024) found that plant-based milk was a complement to traditional flavoured milk and a substitute for traditional white milk and organic milk. Huang (2022), on the other hand, found that plant-based milk was a complement to reduced-fat milk and a substitute for low-fat and standard milk. Overall this approach uses revealed preferences and requires the availability of product prices.

The household production theory introduced by Becker (1965) offers a second approach that considers households not only as consumption units but also production units. This approach considers time as a key resource that may constrain households' decisions. The opportunity cost of time is therefore a key factor, and a household considers for example time spent preparing a meal at home versus ordering a takeout or going to a restaurant. Households therefore aim to maximise the utility from the produced goods subject to budgetary and time constraints (Becker, 1965). Within the food literature, the application of the household production theory has been moderately used (Huffman, 2011b). Studies that have applied the household production theory have mostly focused on a household's decision to consume food at home or away from home (Hamermesh, 2007; Huffman, 2011a; Prochaska & Schrimper, 1973). In the context of sustainable food consumption, the household production theory has been applied to study issues such as food waste (Lusk & Ellison, 2017; Smith & Landry, 2021; Yu & Jaenicke, 2020) and demand for a healthy diet (Drescher et al., 2009).

In the context of food waste, food waste can from a production perspective be viewed as inefficient food production (Smith & Landry, 2021). Smith and Landry (2021) using data on food stock usage and food consumption investigated the determinants of food waste inefficiency in the US and found that food shopping frequency and the distance to the food store were among the factors associated with food waste. Yu and Jaenicke (2020) used food acquisition data to study food waste in the US and found that households wasted 31.9% of their purchased food and that food waste was positively associated with higher income and negatively associated with household size. Regarding demand for healthy diets, Drescher et al. (2009) investigated the determinants of healthy food diversity in Germany. Health food diversity was considered as an input factor to produce an individual's health. The authors found that age and participation in health training were among the factors that affected the demand for a healthy diet.

The hedonic price theory formally introduced by Lancaster (1966) provides another approach to study food choice behaviour. This approach focuses on the fact that a consumer's utility is not found in the product itself but on its quality attributes (Costanigro & Mccluskey, 2011). Given product differentiation, consumers distinguish products based on their characteristics such that "the observed equilibrium market price is a function of the (implicit) prices of each quality attribute" (Costanigro & Mccluskey, 2011, p. 153). Hedonic modelling involves two stages, first estimating the implicit prices of product attributes which corresponds to consumer's willingness to pay for the product attributes and second estimating the aggregate demand for the product attributes (Costanigro & Mccluskey, 2011). The second stage is however empirically complicated due to identification issues, and most studies stick to only estimating the first stage (Costanigro & Mccluskey, 2011), two exceptions being Kristofersson and Rickertsen (2004) and Kristofersson and Rickertsen (2007).

Within the food literature hedonic modelling has been used to model various attributes including meal prices in restaurants (Yim et al., 2014), seafood (Roheim et al., 2007) beef (Hahn & Mathews Jr, 2007; Ward et al., 2008) and cheese (Schröck, 2014). In the context of sustainable food consumption, though limited, hedonic modelling has been used to study demand for organic meat (Staudigel & Trubnikov, 2022) and nutritional attributes of plant-based milk alternatives (Yang & Dharmasena, 2020) and meat substitutes (Petersen et al., 2023).

Staudigel and Trubnikov (2022) estimated the implicit prices of organic meat, type of meat cuts and distribution channels. They found that the price premiums for organic meat significantly varied by the type of species and type of meat cut. Yang and Dharmasena (2020) in their estimation of the implicit prices of nutrition attributes of plant-based milk alternatives found that protein content was the highest valued nutrition attribute but other attributes such as calories and vitamin A and D contents were also significant. Petersen et al. (2023) studied the implicit prices of plant-based sausages' attributes and found significant valuation variation based on ingredients, healthiness and sustainability labels.

A fourth approach that has been commonly used is discrete choice modelling. The approach is used to model discrete choices for example selecting a product from multiple alternatives (Adamowicz & Swait, 2011) or deciding whether to consume a particular food or food attribute consideration (Hanemann, 1984). In the case of multiple alternatives, consumers are presented with a choice set containing several product alternatives with different product attributes. The consumer then chooses the product that maximizes their utility given the specified attributes and the marginal willingness to pay for each attribute estimated (Lancaster, 1966; Adamowicz & Swait, 2011). This approach is of particular interest for investigating attributes not yet available in a market, for example, genetic modification in some countries (Alfnes & Rickertsen, 2003; Chern & Rickertsen, 2001; Rickertsen et al., 2017)

Discrete choice modelling has mostly been applied through stated preferences methods; hypothetical choice experiments (Lizin et al., 2022) and contingent valuation studies (Adamowicz & Swait, 2011). Non-hypothetical approaches such as real choice experiments (Alfnes et al., 2006; Bazzani et al., 2017; Grimm et al., 2023; Olesen et al., 2010), experimental auctions (Alfnes & Rickertsen, 2003; Corrigan et al., 2012; Migliore et al., 2022) and scanner data analysis (Brooks & Lusk, 2010; Laassal & Kallas, 2019) have also been used. Mainly the effect of price and non-price attributes of food products, including safety, brand, origin, health, environmental impact and production method have been investigated (Bastounis et al., 2021; Lizin et al., 2022; Øvrum et al., 2012). Additionally, framing effects (Alcantara et al., 2020; Chen et al., 2024), information treatment effects (Van Loo et al., 2020), naming effects (Asioli et al., 2021) and contextual treatment effects (Jaeger & Rose, 2008) have also been studied.

In the context of sustainable food consumption, discrete choice modelling has been used to evaluate the willingness to pay and consumer acceptance for different novel products including cultured meat (Asioli et al., 2021; Slade, 2018; Van Loo et al., 2020), plant-based meat analogues (Caputo et al., 2023; Van Loo et al., 2020) and insect-based foods (Puteri et al., 2024; Videbæk & Grunert, 2020).

A fifth approach that has been applied is behavioural economics. Behavioural economics acknowledges that consumers are not often predisposed to making optimal rational consumption decisions (Just, 2011). They are faced with limited knowledge of the choices available to them and often depend on heuristics and systematic biases in decision making (Just, 2011; Reisch & Zhao, 2017). This approach aims at better understanding consumer behaviour and identifying interventions and policy instruments that could change consumption behaviour without necessarily appearing restrictive or price induced (Just, 2011). Nudges such as product placement, plate size, increased exposure/availability and labelling are among the commonly applied approaches within food research (Bucher et al., 2016; Vandenbroele et al., 2020; Vecchio & Cavallo, 2019).

In the context of sustainable food consumption, different nudging strategies aimed at reducing food waste have been tested. Zhang et al. (2023) in their review study, categorized nudges used to reduce food waste into two: cognitively oriented (e.g., information and recording food waste levels) and behaviourally oriented (e.g., smaller plate size and plate attributes. They found that behaviourally oriented nudges had stronger effects than cognitively oriented nudges. Other studies have also reviewed nudges towards reducing meat consumption and increasing the consumption of vegetarian meals and meat substitutes (Harguess et al., 2020; Meier et al., 2022; Vandenbroele et al., 2020). Some of the nudges that have been tested include positioning meat substitutes next to meat products on supermarket shelves, increasing vegetarian meal options in menus, verbal prompting signalling benefits and default menus.

Since consumers make approximately 200 food decisions daily (Wansink & Sobal, 2007) increasing sustainable food consumption must involve adopting measures that encourage sustainable food choices and discourage unsustainable ones. Taxes and subsidies are among the economic policy instruments applied to change food consumption behaviour. Food prices are an important factor for individuals' food choices as raising (through taxes) or lowering (through subsidies) relative prices affects food consumption. Taxes have been found to for example, reduce the consumption of sugar-sweetened beverages (Andreyeva et al., 2022; Gustavsen & Rickertsen, 2011, 2013), alcohol (Elder et al., 2010; Guindon et al., 2022) and high fat foods (Pineda et al., 2024) while subsidies have been found to increase the consumption of fruits and vegetables (Afshin et al., 2017; Gustavsen & Rickertsen, 2013) and low-fat foods (An, 2013).

The effects of taxes and subsidies in the context of sustainable food consumption have been an important topic. Studies investigating the effect of a meat tax have found that meat taxes could reduce meat consumption and its related environmental and health costs including reduced GHG emissions (Abadie et al., 2016; Broeks et al., 2020). Subsidizing horticultural products with higher environmental and health benefits, such as legumes, is also projected to result in higher consumption and production and reduced GHG emissions and mortality (Springmann & Freund, 2022).

Economic factors are not in focus in this thesis for several reasons. First, several of the papers study consumer acceptance of novel food products whose price information is either unavailable or difficult to obtain. Second, there is a need to investigate the effect of non-economic factors given the political and public resistance associated with taxation (Kenny et al., 2023). A good example is the proposed red meat tax in Norway which was met with heavy public resistance (Grimsrud et al., 2020). Third, while taxes and subsidies are effective measures, they have been found to selectively affect some groups for example younger lower-income households and not always result in the anticipated food consumption changes (Niebylski et al., 2015; Pineda et al., 2024). Investigating the broad factors that may affect food choice highlights the complexity of food decisions and could present nuanced strategies towards facilitating change in consumption behaviour.

Even though economic factors are not in focus some of the approaches are used in the thesis. Discrete choice modelling is linked to the first and fourth papers which investigate the factors affecting the consumption of plant-based food and plant-based meat analogues respectively. The second and third papers focus on the consumer acceptance of cultured meat and food made from insects using a willingness to try framework. Cultured meat is currently commercially unavailable and the sale of insect-based foods is very negligible resulting in a lack of price data. While hedonic pricing relies on product prices to estimate the implicit prices of product attributes, evaluating the willingness to try extent for products not priced in the market such as novel foods can be viewed as an indirect application of hedonic pricing. The marginal effects of the different product attributes can be interpreted as the consumers' implicit valuation of these attributes. The papers in the thesis include the effects of food choice motives some of which can be interchangeably linked to different food attributes, personality traits, socioeconomic factors and other factors such as trust, political affiliation and social media.

4.3.2 Food choice and non-economic factors

In the previous section, I have discussed the potential for changing food consumption patterns through taxes and subsidies. Beyond the effect of prices, a broad spectrum of other factors affecting food choices have been studied. In this section, I discuss the non-economic factors that affect food choices, most of which are included in the thesis papers.

4.3.2.1 Trust

To ease decision-making processes, consumers often depend on heuristics such as trust as simplification strategies to assist them in their choices (Just, 2011; Lewicki & Brinsfield, 2011). Trust or distrust is part of an individual's mental toolbox that tends to be stable over some time, until an individual is exposed to different experiences (Lewicki & Brinsfield, 2011).

In food choices, trust, commonly assessed as either generalized/social trust or institutional trust, is an important factor since most food quality attributes are credence attributes (Fernqvist & Ekelund, 2014; Grunert, 2002; Hobbs & Goddard, 2015; Wu et al., 2021). Generalized/social trust refers to the trust that an individual has on other people while institutional trust refers to the trust that an individual has in different institutions (Hobbs & Goddard, 2015; Wu et al., 2021). In the context of food consumption, trust in different institutions in the food systems including farmers, manufacturers, retailers, food scientists and food authorities appears to affect food choices (Hobbs & Goddard, 2015; Wu et al., 2021).

4.3.2.2 Salient food choice motives

While several factors affect food consumption behaviour some are particularly salient. Included in the thesis papers are factors such as health, environment, animal welfare, additives, familiarity, novelty, safety, domestic origin, price, social media, and religious and political affiliation. The Food Choice Questionnaire (FCQ), developed by Steptoe et al. (1995) is a pioneering tool for studying food choice motives. The FCQ is a 36-item questionnaire consisting of nine food choice motives: health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity and ethical concern (Steptoe et al., 1995, pp. 271-273). The FCQ provided a strong foundation for food choice research and remains a valuable starting point.

Over the years, advancements in the FCQ have been developed. Lindeman and Väänänen (2000) built on the original FCQ and developed another food choice questionnaire that added animal welfare, environmental protection, political values and religion, alongside the original FCQ items. Sautron et al. (2015) modified the original FCQ by developing another food choice questionnaire with a focus on sustainability. Their questionnaire included 104 items covering both general food consumption and specific food groups with significant sustainability implications (e.g. meat, fish and fruits and vegetables). The food choice motives covered in their questionnaire included "environment, pollution, resource wastage, animal welfare, impacts of food on health, concern about well-being, social norms, price, price/quality ratio, label, brand, seasonal production, local production, natural food, convenience, innovation, religious conviction and familiarity" (Sautron et al., 2015, p. 91).

Given the length and the cognitive demand of the earlier developed questionnaires, Onwezen et al. (2019) developed a single-item food choice questionnaire.[1] The food choice motives included health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity, environment, animal

[1] All the factors consisted of single items except sensory appeal that had two-items, for taste and appearance.

welfare and social justice. This questionnaire met the validity requirements and provided a shorter version of the FCQ.

Beyond the FCQ, other studies have reviewed food choice motives. For example, Chen and Antonelli (2020) in their review study summarized these factors into three main categories. First, consumers may make their food choices based on food-related characteristics. These characteristics may either be extrinsic (e.g. health information) or intrinsic (e.g. food colour). Second, consumers' food choices may be influenced by individual differences. Individual differences may result from biological (e.g. appetite), cognitive (e.g. attitudes) and social (e.g social networks) factors (Chen & Antonelli, 2020, p. 2). Lastly, society related attributes including culture may influence food choice.

4.3.2.3 Personality traits

Personality traits, defined as "dimensions of individual differences in tendencies to show consistent patterns of thoughts, feelings and actions" (McCrae & Costa Jr, 2003, p. 27), are also among the factors that affect food choice. The five-factor model (FFM) is among the most common personality measurement framework.

The FFM groups personality into five traits: openness, conscientiousness, extraversion, agreeableness and neuroticism (OCEAN) (McCrae & John, 1992). The traits are also referred to as The Big Five. Openness is associated with being creative and willing to try out new adventures, conscientiousness is associated with being well organized, responsible and objective, extraversion is associated with being sociable, agreeableness is associated with being kind and willing to conform and neuroticism is associated with being depressive (McCrae & John, 1992).

Research on the effect of personality traits on food choices has been growing and much focus has been on healthy foods, novel foods, obesity and eating disorders (Esposito et al., 2021; Gerlach et al., 2015; Ioannis & Aglaia, 2024; Lunn et al., 2014; Machado-Oliveira et al., 2020). Openness is positively associated with the consumption of healthy foods like fruits and vegetables and the pro-acceptance of novel foods (Lunn et al., 2014; Machado-Oliveira et al., 2020). Conscientiousness appears to be positively associated with low risk of obesity and pro-health behaviour for example, preference for healthy foods and acceptance of novel foods (Esposito et al., 2021; Lunn et al., 2014; Machado-Oliveira et al., 2020).

The findings for extraversion appear mixed. Extraverted people appear to be less drawn to healthy foods and have a higher obesity risk (Esposito et al., 2021; Gerlach et al., 2015). They have, however, a lower score on food neophobia and are more open to novel foods (Machado-Oliveira et al., 2020). Agreeableness appears to be positively associated with healthy eating behaviour and openness to novel foods (Esposito et al., 2021; Machado-Oliveira et al., 2020).

Neuroticism appears to be positively associated with unhealthy food choices and obesity (Esposito et al., 2021; Ioannis & Aglaia, 2024; Machado-Oliveira et al., 2020). The effect of neuroticism on acceptance of novel foods appears to be largely mixed and different depending on the product. Jin et al. (2025) found a positive association with acceptance of cultured meat. Wang & Park (2024) found a negative association for disgust towards consuming insects while (Lin et al., 2019) did not find any association for genetically modified pork.

Some Norwegian studies have investigated the effect of OCEAN personality traits on sustainable food consumption. Among Norwegians, openness has been positively associated with the consumption of sustainable foods (Ardebili & Rickertsen, 2024), organic foods (Gustavsen & Hegnes, 2020b) and local foods (Gustavsen & Hegnes, 2020a). Conscientiousness was negatively associated with aversion towards genetically modified food (Ardebili & Rickertsen, 2020), willingness to pay for organic food (Gustavsen & Hegnes, 2020b) and consumption of unsustainable foods (Ardebili & Rickertsen, 2024). Extraversion was positively associated with consumption of local foods (Gustavsen & Hegnes, 2020a) and unsustainable

foods (Ardebili & Rickertsen, 2024), and negatively associated with willingness to pay for organic foods (Gustavsen & Hegnes, 2020b). Agreeableness, on the other hand, was positively associated with higher willingness to pay for local foods (Gustavsen & Hegnes, 2020a) and openness for genetically modified (Ardebili & Rickertsen, 2020), organic (Gustavsen & Hegnes, 2020b) and traditional diets (Ardebili & Rickertsen, 2024). Lastly neuroticism was positively associated with acceptance of genetically modified soybean oil (Ardebili & Rickertsen, 2020), unsustainable foods (Ardebili & Rickertsen, 2024) and consumption of local foods (Gustavsen & Hegnes, 2020a).

4.3.2.4 Socio-economic factors

The effects of socio-economic factors on food choice have been widely studied. The results of the effects of these factors appear to overlap in some cases and in other cases differ depending on the food type.

Kenny et al. (2023) in their review on sustainable diets found that, generally, women, higher educated and urban individuals were more open to adopting sustainable dietary behaviour and lower income households less likely. Regarding the acceptance of novel meat alternatives, there appears to be a consensus of higher acceptance among younger, higher educated, higher income, politically liberal and urban individuals (Onwezen et al., 2021). The results for gender are mixed, with men showing higher acceptance of insects and cultured meat and women preferring plant-based meat analogues (Onwezen et al., 2021; Onwezen & Dagevos, 2024).

4.4 The thesis

4.4.1 Objectives

The overall objective of this thesis is to contribute to the current literature on sustainable food consumption with a focus on the dietary shift towards meat reduction. Table 1 summarizes the main research objectives, data sets, statistical methods and key findings of the four papers.[2]

The main objectives of the four papers are:

i. To investigate the effect of consumers' preference for domestic origin on dietary sustainability (Paper 1).
ii. To investigate the Norwegian consumers' willingness to try cultured meat and the effects of trust, green politics and other food choice motives (Paper 2).
iii. To investigate the Norwegian consumers' willingness to try food made from insects, the effects of trust, personality traits and other food choice motives and the mediation effects of food safety concerns. (Paper 3).
iv. To investigate the Norwegians' consumption of plant-based meat analogues and the effect of social media and other food choice motives. (Paper 4).
v. To investigate the change in the acceptance of novel meat alternatives over time and the change in the importance of their determinants (Paper 2, 3 and 4).

[2] The findings of the four papers do not imply causal relationships but associations even though the term "effects" is used.

Table 1. Key objectives, data sources, statistical models and key findings

Paper	Key objectives	Data	Statistical models	Key findings	Implications
1	❖ To investigate the effect of consumers' preference for domestic origin on dietary sustainability	Online survey	➢ Logit regression model ➢ Interval regression model	• Preference for domestic food origin was positively associated with red meat consumption and negatively associated with consumption of plant-based dinners and identifying as a meat reducer.	• Providing domestically produced plant-based alternatives could promote the transition to reduced meat consumption. • Policy measures towards more sustainable diets should consider farmers' livelihoods
2	❖ To investigate the effects of trust, support for green parties and other food choice motives on the willingness to try cultured meat. ❖ To investigate the effect of COVID-19 on the importance of trust, support for green parties and other food choice motives.	Norwegian monitor survey	➢ Partial proportional odds model	• Social trust and support for green parties were associated with being more willing to try and less unwilling to try cultured meat. • Trust in food authorities was associated with being more willing to try. • Emphasizing natural components and food safety was associated with being less willing to try cultured meat while emphasizing health, novelty, the environment, and price was associated with being more willing to try. • Identifying with a religion or being vegetarian was associated with being less willing to try cultured meat. • No effects of trust in retailers were found. • No significant COVID-19 effects were found.	• Food authorities could provide information on cultured meat benefits. • Marketers should consider promoting cultured meat in social settings to promote social acceptability. • Cultured meat should be produced in environmentally friendly ways focusing on sustainability and consumers should be informed of this.
3	❖ To investigate the effects of trust, personality traits	Norwegian monitor survey	➢ Confirmatory factor analysis	• Social trust and trust in food authorities were positively	• Food authorities can be important in informing consumers about the

	and other food choice motives on the willingness to try food made from insects. ❖ To investigate the mediation effect of food safety concerns on the relationship between trust and willingness to try food made from insects.		➢ Generalised structural equation modelling	associated with willingness to try. • Food safety concern was a significant mediator. • Openness was positively associated with willingness to try while conscientiousness, extraversion, and agreeableness had a negative association.	safety of insect-based foods. • Insect-based food marketers and retailers may focus on advertising and serving insect-based foods in social settings and adopting personality targeted marketing initiatives.
4	❖ To investigate the effect of social media and other food choice motives on PBMA consumption. ❖ To investigate changes in the importance of food choice motives and socioeconomic factors over time are studied.	Norwegian monitor survey	➢ Logit regression model	• PBMA consumption appeared to have stagnated. • Emphasizing the environment, animal welfare and novelty were positively associated with PBMA consumption, while emphasizing familiarity and Norwegian origin were negatively associated. • Use of social media had a positive effect on the total sample, but it was not a stable determinant across the survey rounds. • Declining social media effect over time.	• Dietary recommendations should, in addition to health, also highlight environmental and animal welfare benefits. • PBMA producers should aim for minimal use of additives and use of domestically produced ingredients.

4.4.2 Data sources

The first paper in the thesis is based on an online cross-sectional survey conducted in Norway. The survey was distributed by the market research company, Kantar as part of their weekly omnibus survey that targets a nationally representative sample of 1000 respondents (Kantar, n.d.). The three other papers are based on data from the Norwegian Monitor Survey (NMS). The NMS is a biannual national representative survey that has been conducted in Norway since 1985 (IPSOS, 2021). The survey covers a broad range of subjects within the Norwegian society including food preferences and attitudes with each survey having at least 3000 respondents.

4.4.3 Statistical models

Several statistical models were used in the papers as discussed below.

4.4.3.1 Logistic regression model

The logistic (logit) regression model used to model binary outcomes was used in paper 1 and paper 4. In paper 1, it was used to model the probability of consuming plant-based dinners and identifying as a meat reducer. In paper 4, given the skewed distribution of PBMA consumption, the model was chosen to model the probability of consuming PBMA. The logit model can be specified as

$$y_i^* = x_i\beta + e_i, \qquad y_i = 1 \text{ if } y_i^* > 0 \text{ and } y_i = 0 \text{ otherwise} \tag{1}$$

where y_i^* is a latent continuous variable, y_i is the observed binary outcome, x and β are the vectors of the explanatory variables and their associated coefficients and $e_i$is the error term assumed to be logistically distributed. The probability of $y_i = 1$ can then be estimated as

$$\mathrm{E}[y_i^*|x_i] = \Pr(y_i = 1|x_i) = \frac{\exp(x_i\beta)}{1 + \exp(x_i\beta)} \tag{2}$$

4.4.3.2 Partial proportional odds model

The partial proportional odds (PPO) model used to model ordered responses with more than two outcomes was used in paper 2. Given the three response alternatives in our WTT dependent variable, it was chosen over the ordered logistic model since our data did not meet the proportional odds assumption. The PPO is a special case of the ordered logistic regression model. Let y be the ordered responses ranging from $y = 1,2,3, \ldots, K$. The ordered logistic (logit) regression model can be specified as

$$\begin{aligned} y^* = x\beta + e, \qquad & y = 1 \text{ if } y^* \leq \omega_1 \\ & y = 2 \text{ if } \omega_1 < y^* \leq \omega_2 \\ & \vdots \\ & y = K \text{ if } y^* > \omega_{K-1} \end{aligned} \tag{3}$$

where $y^*$is the latent continuous dependents variable, x and β are the vectors of the explanatory variables and their associated coefficients and e is the error term assumed to be logistically distributed. $\omega_1, \omega_2, \ldots, \omega_{K-1}$ are unknown cutoff points that must be estimated and a model with K responses will have $K - 1$ cutoff points.

The ordered logit model assumes proportional odds meaning that the magnitude of the effect of an independent variable x on y^* is the same across all the response categories. When this assumption does not hold, the PPO model provides an alternative estimation model. The PPO model allows that the proportional odds assumption is relaxed for the variables that do not fulfill it by allowing the coefficients

of the violating variables to differ by the response category. Assume that a set of variables x_1 meet the proportional odds assumption, and a set of variables x_2 do not. The PPO model can be expressed as

$$\Pr(y > j|x_1, x_2) = \frac{\exp(\omega_j + x_1\beta + x_2\beta_j)}{1 + \exp(\omega_j + x_1\beta + x_2\beta_j)}, j = 1,2, \dots, K-1 \quad (4)$$

The β's for the $x_1$set are the same for all response categories, j, but they are allowed to differ by the values of j for the x_2 set.

4.4.3.3 Interval regression model

The interval regression model used when you have an interval censored outcome variable was used in paper 1. It was used to model the consumption of red, white meat and fish consumption. Our dependent variable included eight intervals which were transformed to yearly intervals representing the number of days in a year that the respondents had consumed these meals as dinners, with "never" equal to zero and "daily" indicating 365 days. In an interval, only the range of the frequency would be known but not the exact number of times.

An interval regression can be specified as

$$y_i^* = x_i\beta + e_i, \;\; y_i^*|x \sim Normal(x_i\beta, \sigma^2) \quad (5)$$

where y_i^* is the latent continuous dependent variable assumed to be normally distributed, x and β are the vectors of the explanatory variables and their associated coefficients, e is the error term and σ^2 is the variance assumed to be homoscedastic. Let $a_1 < a_2 < \dots < a_J$ be the known cut-off points and y the selected response, then

$$\begin{aligned} y &= 1 \text{ if } y^* \leq a_1 \\ y &= 2 \text{ if } a_1 < y^* \leq a_2 \\ &\vdots \\ y &= J \text{ if } y^* > a_{J-1} \end{aligned} \quad (6)$$

β and σ^2 are estimated using maximum likelihood estimation.

4.4.3.4 Confirmatory factor analysis

Confirmatory factor analysis (CFA) was used in paper 3., to measure the personality traits. Exploratory factor analysis (EFA) and CFA are techniques based on the common factor model aiming to identify latent characteristics or patterns, also referred to as factors, based on a set of observed/indicator variables (Brown, 2015). The main difference between EFA and CFA is the factor specification. EFA is data-driven and neither the number of factors nor the pattern between the indicators and factors not pre-specified while the reverse holds for CFA (Brown, 2015). In our analysis CFA is chosen over EFA given that we use a pre-developed personality scale.

CFA relies on the covariance matrix and evaluates how the variations and covariations of the indicator variables are linked to the factors (Brown, 2015). The variance from the indicator variables is divided into two, common variance and unique variance. Common variance represents the amount of variation in the indicator resulting from the factor while unique variance represents the variation resulting from measurement error and/or reliable variance that is the variation unique to only the indicator itself (Brown, 2015).

Assume that we have a single factor CFA model with 4 indicator variables (A_1, A_2, A_3, A_4), the CFA model can be specified as

$$y_j = \lambda_j\chi_1 + e_j \quad (7)$$

where y_j represents the j[th] indicator variable out of the 4 indicators and λ_j is its corresponding factor loading, χ_1 is the factor and e_j is the unique variance. The CFA model assumes a linear relationship between the indicator and the factor, and the error term is assumed to be independent of any other factors and unique variance of the other indicators (Brown, 2015). In our example of 4 indicators, 4 separate linear equations can be specified

$$\begin{aligned} A_1 &= \lambda_1\chi_1 + e_1 \\ A_2 &= \lambda_2\chi_1 + e_2 \\ A_3 &= \lambda_3\chi_1 + e_3 \\ A_4 &= \lambda_4\chi_1 + e_4 \end{aligned} \tag{8}$$

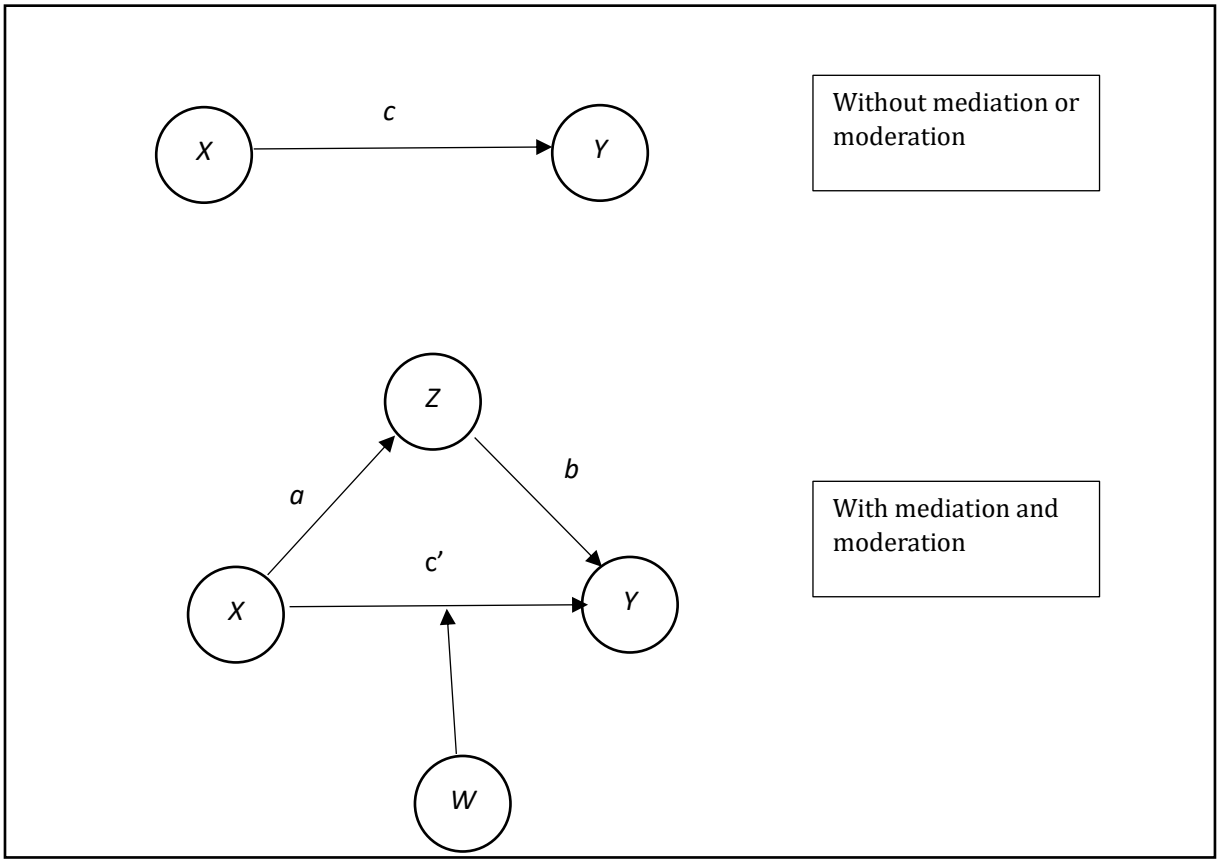
4.4.3.5 Generalized structural equation modelling

Generalized structural equation modelling (GSEM) used in paper 3., is a special form of structural equation modelling (SEM). SEM is used to model complex linear relationships using path analysis and may include measuring direct, mediation and moderation effects. Unlike SEM, GSEM does not assume multivariate normality allowing modeling of non-linear responses (Baum, 2016; Huber, 2014). Given that our dependent variable was measured as an ordinal response and the objective to estimate mediation effects, GSEM was chosen over SEM and other ordered response models.

Figure 1. shows an example of a path analysis where *Y* is the dependent variable, *X* is the independent variable, *Z* is the mediator variable and *W* is the moderator variable. Mediation analysis seeks to understand the underlying mechanism for the relationship between an independent variable and the dependent variable (Judd et al., 2014). Is the total effect of *X* on *Y* influenced by a third variable, *Z*? The part of the effect influenced by the mediating variable is known as the indirect or mediation effect (Judd et al., 2014). Moderation analysis on the other hand seeks to understand how the magnitude of the total effect of *X* on *Y* changes depending on a third variable, *W* (Judd et al., 2014). Does the magnitude of the total effect of *X* on *Y* change depending on the value of *W*? Moderation analysis can be likened to evaluating the interaction effect.

Let *c* be the total effect of *X* on *Y* when mediation is not considered. In the case of mediation, a third variable *Z* is included such that *X* has a direct effect on *Z*, *a,* while *Z* has a direct effect on *Y*, *b*. Under mediation the direct effect of *X* on *Y* is now *c'*. The indirect effect also known as the mediation effect is calculated as the product of *a* and *b* (*ab*) while the total effect is the sum of the direct effect and the indirect effect, $c = c' + ab$.

Figure 1: Path analysis diagram



4.4.4 Summary of Papers

In this section, the findings of the papers are summarised.

Paper 1: The impact of consumers' preferences for domestic food on dietary sustainability

Understanding the drivers and barriers of dietary sustainability is needed to enable a smoother transition towards sustainable food consumption, yet the role of preference for domestic food on sustainable food choice has been little investigated. Generally, food origin and domestic origin preference have been found to affect food choices (Balabanis & Siamagka, 2022; Thøgersen, 2023).

This paper used data from an online survey conducted in Norway in June 2020 to primarily investigate the role of domestic origin preference on dietary sustainability. Moreover, the role of attitudes towards the environment, health and Norwegian agriculture were investigated, as well as demographic characteristics. Three interval regression models were estimated to test the effect of these factors on red and white meat and fish consumption while two binary logistic regression models were estimated to test the effect on plant-based dinners consumption and identifying as a meat reducer (vegan, vegetarian or flexitarian).

Preference for domestic food origin was positively associated with red meat consumption and negatively associated with consumption of plant-based dinners and identifying as a meat reducer. Health concerns were positively associated with white meat and fish consumption while environmental concerns were negatively associated with white meat consumption and positively associated with consumption of plant-based dinners and identifying as a meat reducer.

Believing that red meat could be harmful for health was negatively associated with red meat consumption and positively associated with fish and plant-based dinners consumption and identifying as a meat reducer. Believing in the negative environmental impact of meat was negatively associated with red meat consumption and positively associated with plant-based dinner consumption and identifying as a meat reducer. Respondents that believed that Norway's landscape was better suited for livestock production had higher red and white meat consumption and they were less likely to consume plant-based dinners and identify as meat reducers. Lastly, being more open to buying new foods was positively associated with eating plant-based dinners.

For demographics, being male was associated with higher red meat consumption while plant-based dinner consumption and identifying as a meat reducer first decreased with age and then increased with higher age.

Paper 2: Norwegian consumers' willingness to try cultured meat

Cultured meat (CM) is anticipated to reduce the negative environmental, health and animal welfare implications associated with meat production and consumption (Tuomisto & Teixeira de Mattos, 2011). While CM is still novel and unavailable for sale in most parts of the world, its development is rapidly growing. In Singapore, public sale of cultured chicken has already started (Eat Just, 2022) and approval efforts are being seen in North America and Europe (FDA, 2022; Lorenzo, 2022; The Cultivated B, 2023).

This paper used the 2019/2020 and 2021/2022 rounds of the NM survey to investigate Norwegian consumers' willingness to try cultured meat (WTT CM). The effects of trust, support for green parties, individual characteristics and other food choice motives were investigated, and the hypotheses tested using the partial proportional odds model. Notably, the paper investigated the effect of social trust and specific trust in food authorities and retailers. The potential effects of Covid-19 on the WTT CM were also assessed by investigating the changes in the importance of the determinants before COVID-19 (2019/2020) and during COVID (2021/2022).

Most of the respondents were unwilling to try CM (43 %) and an almost equal proportion were either somewhat willing (30 %) or willing to try (27 %). Identical coefficients before and during COVID-19 were not rejected implying non-significant changes over time. To test the hypotheses, only the conclusions from the unwilling and willing group were considered. The effect of trust in food authorities were mixed. Higher trust in food authorities was associated with less probability of being unwilling to try but no effect on being willing to try. Higher social trust was associated with being less unwilling and more willing.

Respondents that supported green parties were less unwilling and more willing to try CM. Those that emphasized natural components and the fear of getting sick from food were less willing and more unwilling to try CM. For those that emphasized health, the environment, novelty and price, the probability of being unwilling to try decreased and that of being willing increased.

Females, vegetarians and people that identified with a religion were more unwilling and less willing. Higher educated and urban respondents were less unwilling and more willing. No associations were found for trust in retailers, income and emphasizing familiarity and animal welfare. The low effect of emphasizing price and no effect of income is not surprising given that CM is a hypothetical product currently not for sale.

Paper 3: Norwegian consumers' willingness to try food made from insects: The role of trust, food choice motives and OCEAN personality traits

Entomophagy, the consumption of edible insects is among the proposed sustainable diets shifts, especially in Western countries where it is almost non-existent. Entomophagy is supported by its healthiness, low environmental impact and its potential to combat food insecurity (Aidoo et al., 2023; van Huis, 2022; van Huis et al., 2013).

This paper used the 2019/2020, 2021/2022 and 2023/2024 rounds of the NM survey to investigate the Norwegian consumers' willingness to try (WTT) food made from insects. The effects of trust, personality traits and other food choice motives were investigated, and the hypothesis tested using generalized structural equation modelling (GSEM). Moreover, the mediation effects of food safety concerns on the relationship between trust and the WTT food made from insects and the moderation effects of sociodemographic factors were also investigated. A series of Pearson Chi-Square test of association were used to test whether there were differences in WTT across the years and whether the importance of food choice motives varied across the survey rounds.

Most of the respondents were unwilling to try food made from insects (40 %) and an almost equal proportion were either somewhat willing (31%) or willing to try (29 %). No associations between WTT and survey round were found. Social trust and trust in food authorities were positively associated with WTT food made from insects while food safety concerns (fear from getting sick from eating food) had a negative association. Social trust and trust in food authorities had a negative association with food safety concerns. Moreover, safety concerns mediated the paths between social trust, trust in food authorities and WTT food made from insects.

Emphasizing environmental friendliness, health and novelty were positively associated with WTT food made from insects while emphasizing natural ingredients and familiarity had a negative association. For personality traits, openness was positively associated with WTT food made from insects while conscientiousness, agreeableness and extraversion had a negative association.

Gender, education, age and urban living were significant moderators for some paths. The negative effects of emphasizing natural ingredients and familiarity were stronger among male respondents compared to their female counterparts. The effect of extraversion was reversed among women. The negative effect of emphasizing natural ingredients and the positive effect of openness were stronger among the non-higher educated respondents. The positive effects of trust in food authorities and emphasizing health were stronger among younger respondents. Lastly, the negative effect of conscientiousness was stronger among urban respondents.

Paper 4: Norwegian consumption of plant-based meat analogues

The call for reduced meat consumption and increased plant-based food consumption has led to the emergence of plant-based meat analogues (PBMA) products. These products mimic the taste of meat and are expected to give consumers the sensory feeling of meat eating while staying away from meat, mostly attracting vegetarians and flexitarians (Gastaldello et al., 2022). Compared to meat, PBMA are associated with less environmental impact and animal welfare impacts (Santo et al., 2020) and they are anticipated to help in the transition towards more sustainable global food systems (Pathak et al., 2022). The nutritional composition of PBMA appears to vary from product to product. While, generally, PBMA may have high nutritional value thus appealing in the healthiness, some products contain high amounts of sodium and saturated fats (Bryant, 2022; El Sadig & Wu, 2024; Gastaldello et al., 2022).

This paper used data from the 2017/2018, 2019/2020 and 2021/2022 rounds of the NM survey to investigate the consumption of PBMA among Norwegian consumers. The effects of food choice motives, including social media and domestic origin, and socioeconomic factors were investigated. The changes in the effects of the independent variables over time were also investigated.

About two-thirds of the respondents had not consumed PBMA and among those that had consumed, half of them were in the seldom category that could be translated to 1-2 times a year. Due to the skewed consumption distribution, a binary logistic regression model was estimated. In the total sample, PBMA consumption probability increased with emphasis on health, environment, animal welfare, no additives, novelty and use of social media. In contrast, PBMA consumption probability decreased with emphasis on familiarity and Norwegian origin. For socioeconomic factors, PBMA consumption probability decreased with age, being female and living with a partner and increased with being higher educated, urban living and being vegetarian. PBMA consumption probability was also higher in both 2019/2020 and 2021/2022 compared to 2017/2018.

Among the variables, stable determinants, representing variables with similar significance conclusion across the survey rounds and the total sample, were identified. Among the unstable determinants with inconsistent significance conclusions, health, use of social media and living with children were only significant in 2019/2020 and being female and living with a partner were only significant in 2017/2018. Lastly placing emphasis on no additives was not significant in any of the individual survey rounds. No effect of price and income were found which may be attributed to the novelty of PBMA and the fair-income distribution in Norway.

4.5 Contributions, implications and limitations of the thesis

This thesis contributes to the broader literature on sustainable food consumption behaviour and sustainable diets. The first paper implies that preference for domestic food may impede the adoption of plant-based foods and reduction in meat consumption. Norwegian livestock production lies at the core of Norwegian agriculture (Knutsen, 2020) and the demand for plant protein, fruits and vegetables is largely met through imports (Gorena & Milford, 2018). This may therefore explain why consumers with a strong preference for domestic food may view consuming more plant-based foods and reducing meat consumption as a threat to Norwegian agriculture. The newly released dietary guidelines by The Norwegian Directorate of Health placed strong emphasis on increased fruits, vegetables and plant protein intake and limited meat consumption (Helsedirektoratet, 2024). To encourage more plant-based consumption, policies supporting domestic production and creating a smooth transition for livestock farmers while protecting rural livelihoods should be prioritized.

The second paper shows that social trust, trust in food authorities and green politics may drive the acceptance of CM. While CM is currently not publicly available for sale in Norway, interest for it can be seen through the allocation of funds towards CM research (Haegermark, 2022). Food authorities are expected to play a key role in offering safety assurances and informing the public about the benefits of CM. Green politics are also expected to propel the uptake of CM and having an active political discussion about CM may educate the public.

The third paper shows that trust in food authorities, social trust and personality traits are among the factors that may affect consumer acceptance of entomophagy. The significant mediation effects of safety concerns further imply that higher social trust and trust in food authorities may reduce safety concerns thus encouraging entomophagy. The importance of personality-targeted strategies to promote entomophagy was also found. Educational campaigns aimed at promoting insect-based products to individuals high in openness and tackling the concerns of individuals high in conscientiousness, extraversion and agreeableness may be adopted. Personality-based marketing strategies should also consider sociodemographic factors. For example, the negative effect of conscientiousness was stronger among urban living individuals which may be due to higher food safety concerns in urban areas than rural ones.

The fourth paper, like the first one, shows that emphasizing domestic origin may negatively affect the consumption of PBMA. The importance of domestic origin points to the need to use domestically produced ingredients in PBMA products which may encourage some consumers to transition to reduced meat consumption. Animal welfare concern was also found to be important, and communicating the animal welfare benefits related to shifting to PBMA may promote PBMA consumption, which will contribute to a more sustainable diet. The unstable effect of health concern highlights the uncertainty about the healthiness of PBMA products. The recently published dietary guidelines included the consumption of PBMA products placing a caution on avoiding products high in salt and fat (Helsedirektoratet, 2024). Proper assessments and communication on the healthiness of these products should be prioritized to build consumer trust and awareness.

The last three papers studied the consumer acceptance of some of the recommended meat alternatives and drawing comparisons and contrasts may offer helpful insights. For all three papers emphasizing the environment and novelty had a positive effect while emphasizing familiarity had a negative one. While the recently released dietary guidelines advocated for reduced meat consumption, they received criticism for only focusing on the health effects of food (Mittenzwei et al., 2024). Other countries, such as Finland, have also included environmental sustainability to their dietary guidelines. Beyond health, environmental concerns are a motivation for reduced meat consumption and adoption of meat alternatives. Dietary recommendations should therefore consider including environmental-related motivations to encourage a sustainable dietary transition. For both CM and food made from insects, emphasizing natural ingredients had a negative association while a positive association was found in PBMA. It may therefore be assumed that consumers perceive PBMA as more natural due to the presence of plant ingredients (Szenderák et al., 2022) but in the case of cultured meat and insects, they may perceive it as less natural (Kouarfaté & Durif, 2023). Emphasizing animal welfare was positively associated with PBMA consumption but no effect was found for CM. This may imply that consumers are yet to understand the animal welfare benefits of CM given the commercial unavailability of the product and the ongoing uncertainties regarding stem cell extraction and the culture medium (Chriki et al., 2022). Lastly, being vegetarian was positively associated with PBMA but negatively associated with CM acceptance supporting that CM is likely to be adopted more by flexitarians or consumers with higher meat attachments (Onwezen & Dagevos, 2024).

While this thesis provides useful insight into sustainable food consumption, its limitations should be considered. One of the limitations is the potential hypothetical bias that survey studies face. The papers in the thesis capture hypothetical decisions and reported behaviour may differ from actual behaviour. Secondly, the papers did not cover the effect of price-based instruments which are important economic factors in changing dietary behaviour. Thirdly, the NMS questions in several cases were not formulated as we would have liked, and we had to use proxy variables. For instance, in the PBMA paper, the question on PBMA consumption did not capture the range of PBMA products specifications currently available. Additionally, the questions capturing the food choice motives were mostly dummy variables, and using questions from validated scales or with more response alternatives may have provided more nuanced responses. Fourthly, The OCEAN personality traits were measured using the BFI-20 which contains 20 items. While this scale is effective given time limitations in long surveys using a scale with more items may have provided more information. Lastly, some important factors within the novel foods' literature such as disgust and food neophobia were missing in the survey questions and therefore not included.

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6 Papers

Paper I

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The impact of consumers' preferences for domestic food on dietary sustainability

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ABSTRACT

A sustainable dietary transition requires knowledge of the drivers and barriers of dietary choices. We investigate the role of preferences for domestic food, as well as environmental and health concerns, as drivers for the consumption of red and white meat, fish, ready-made plant-based food products and self-identification as some type of meat reducer (flexitarian, vegetarian, or vegan). A survey of 1102 consumers was conducted in Norway with questions about food attitudes, beliefs and preferences regarding health, the environment and domestic food as well as dietary habits and demographics. The results from interval and logistic regression analyses show that stronger preferences for domestic food are associated with higher consumption of red meat and a lower likelihood of eating plant-based food and identifying as a meat reducer. Health concerns are associated with higher consumption of white meat and fish, and environmental concern is associated with lower consumption of white meat and a higher likelihood of eating plant-based food. The results also confirm previous research results that disbelief regarding the negative health and environmental impacts of meat correlate with higher meat consumption and a lower likelihood of eating plant-based food. In addition, we find that people who believe that Norway is a country primarily suited for livestock production have higher consumption of meat and a lower likelihood of eating plant-based food. We conclude that to make certain consumers transition away from meat, it is important to provide domestically produced, plant-based alternatives and to implement policy measures that will generate positive storylines of improved farmer livelihoods.

1. Introduction

It has long been proposed that to prevent global warming and loss of biodiversity, there is a need for a sustainable food transition, particularly a move away from meat (Jongen & Meerdink, 2001; Machovina, Feeley, & Ripple, 2015; Poore & Nemecek, 2018; Stehfest et al., 2009; Willett, Rockstrom, & Loken, 2019). Total greenhouse gas emissions from animal-based food are estimated to be twice those of plant-based food (Xu et al., 2021), and animal-based food production causes more water and soil pollution and biodiversity loss than plant-based food (Gonzalez, Marques, Nadal, & Domingo, 2020; Henry et al., 2019; Machovina et al., 2015; Poore & Nemecek, 2018; Tilman & Clark, 2014). Furthermore, excess consumption of red and processed meat is associated with an increased risk of cancer and cardiovascular diseases (Grosso et al., 2022), and a dietary transition towards more environmentally friendly food could therefore be beneficial to health (Springmann et al., 2018).

Global population growth and increasing household incomes in developing countries are expected to lead to a continued increase in global demand and the production of meat (Milford, Le Mouel, Bodirsky, & Rolinski, 2019, p. 141), with accompanying dire environmental consequences (Tilman, Balzer, Hill, & Befort, 2011). A dietary transition away from meat in the global North could, to some extent, compensate for this trend, but such a transition has thus far not taken place on a large scale. Although many people are actively reducing their meat consumption, large segments of the population are not moving away from highly meat-based diets (Dagevos, 2021; Kemper, 2020; Sanchez-Sabate & Sabate, 2019).

To identify policy measures that could accelerate a sustainable dietary transition, there is a need for more knowledge about the factors that influence consumers' food choices, particularly for those who are reluctant to change. In recent years, extensive literature has emerged in the field of vegetarianism and meat reduction that has focused on motivations, attitudes and demographic characteristics that influence the

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willingness to transition from animal-based to plant-based food (Graca, Godinho, & Truninger, 2019; Miki, Livingston, Karlsen, Folta, & McKeown, 2020; Stoll-Kleemann & Schmidt, 2017). Considerable attention has been given to personality characteristics and attitudes towards health and the environment.

However, researchers have thus far not paid attention to how a sustainable food transition can be influenced by consumers' preferences for domestic food. Such preferences, which can also be termed consumer ethnocentrism (Shimp & Sharma, 1987), is an important influential factor for food choices in many countries (Balabanis & Siamagka, 2022). Due to differences in the market availability of domestically produced sustainable food products, it can be assumed that, at least for some countries, the prospects of a sustainable food transition may be influenced by the prevalence of ethnocentric attitudes among inhabitants.

The main research objective of this study is to examine the impact of consumers' preferences for domestic food on dietary sustainability. Through statistical analysis, we investigate whether the consumption of red and white meat, fish and plant-based food is influenced by preferences for and beliefs about domestic food products as well as attitudes and beliefs regarding food, health and the environment while controlling for demographic variables. The survey data used in the analysis are from Norway, a country that is highly reliant on the import of plant-based food but that also has an abundant supply of fish.

2. Factors that influence the sustainability of dietary choices

2.1. The healthiness and sustainability of different food choices

When comparing the sustainability of different types of food, animal-based food is the largest contributor to environmental degradation. It is estimated that between 12% and 18% of total global greenhouse gas (GHG) emissions stem from the production of animal-based food (Allen & Hof, 2019; Gomez-Zavaglia, Mejuto, & Simal-Gandara, 2020). Meat production is also associated with more land use than other food products and therefore poses a significant threat to biodiversity (Gonzalez et al., 2020; Henry et al., 2019; Machovina et al., 2015; Poore & Nemecek, 2018; Tilman & Clark, 2014). Compared with other food products, meat is also a much larger contributor to acidification and eutrophication, which has a negative impact on natural ecosystems, reducing biodiversity and ecological resilience (Poore and Nemecek 2018).

Furthermore, while plant-based foods such as fruits, vegetables and pulses have important health benefits, some animal-based foods are associated with increased health risks. In 2015, the International Agency for Research on Cancer (IARC) stated that the consumption of processed meat was carcinogenic to humans, while the consumption of red meat (i.e., ruminants and pork) was "probably carcinogenic" (Gonzalez et al., 2020). The negative association between excess meat consumption and human health, including cardiovascular disease, has since been confirmed by several other studies (Grosso et al., 2022; Zhang et al., 2022; Zhong et al., 2020).

However, there are substantial differences in the health and environmental impact of different types of meat. Poultry meat does not have the same negative association with health as red meat (Mottet & Tempio, 2017; Zhong et al., 2020). Furthermore, higher land use requirements and methane emissions from enteric fermentation by ruminants (i.e., cattle, sheep and goats) increase their contribution to greenhouse emissions and other forms of environmental degradation compared with monogastric animals (i.e., pork and poultry) (de Vries & de Boer, 2010; Poore & Nemecek, 2018). In contrast, fish have been associated with health benefits and do not cause the same environmental degradation as land-based livestock production, but they are also associated with risks of pollution from aquaculture and biodiversity loss from overfishing (Clonan, Holdsworth, Swift, Leibovici, & Wilson, 2012; Olesen, Myhr, & Rosendal, 2011).

Plant-based meat substitutes such as vegetarian burgers made from pulses are environmentally sustainable alternatives for those who would like to eat less meat without feeling they are changing their habits (Coucke, Vermeir, Slabbinck, Geuens, & Choueiki, 2022). Research shows that plant-based substitutes generally have a lower carbon footprint than meat, especially ruminant meat (Mejia et al., 2020; Santo et al., 2020; Shanmugam, Bryngelsson, Ostergren, & Hallstrom, 2023), and many of these products can be a healthier alternative to meat (Alessandrini et al., 2021; Farsi, Uthumange, Munoz Munoz, & Commane, 2022).

2.2. Consumer characteristics and motivation for sustainable food choices

Given that meat reduction has benefits to health and the environment, it is perhaps unsurprising that the main motivations for consumers to reduce meat consumption are health and environmental concerns (Graca et al., 2019; Miki et al., 2020). Several studies also find that prior beliefs regarding the negative impact of meat consumption on health and the environment influence the likelihood of eating a more plant-based diet (Graca et al., 2019; Vainio, Irz, & Hartikainen, 2018). Refutation of information regarding the negative impacts of meat has been linked with cognitive dissonance, i.e., an uncomfortable feeling that arises from conflicting ideas and behaviour, such as eating meat while knowing about its negative impacts. People try to avoid this feeling by adjusting their beliefs or avoiding information that increases cognitive dissonance (Bergmann, von der Heidt, & Maller, 2010; Stoll-Kleemann & Schmidt, 2017).

Eating a more plant-based diet has also been associated with openness to new experiences (Hoek, Luning, Stafleu, & de Graaf, 2004; Mullee et al., 2017; Rosenfeld, 2018); this is also the case for the willingness to try plant-based meat substitute products (Bates, Mesler, Chernishenko, & MacInnis, 2023). On the other hand, opposition to reduced meat consumption has been linked with conservative attitudes and a strong valuation of individual freedom of choice (Grünhage & Reuter, 2021; Hodson & Earle, 2018; Michielsen & van der Horst, 2022; Yule & Cummings, 2023, p. 187) as well as meat attachment (Graca et al., 2019). Regarding demographic factors, previous research has found that plant-based diets are more likely to be followed by women and people who are younger, have higher education and live in more urban areas (Graca et al., 2019).

2.3. Consumers' preferences for domestic food

For some consumers, the country of origin of a product is important, and many people have stronger preferences for domestic than for imported products (Vabo & Hansen, 2016; Yeh & Hirsch, 2023). This can be defined as consumer ethnocentrism, i.e., consumer bias in favour of domestic over foreign products (Shimp & Sharma, 1987). Consumer ethnocentrism can be explained by patriotism, a feeling that domestic products are first and best (Siamagka & Balabanis, 2015). For instance, domestic products may be perceived as healthier (Gineikiene, Schlegelmilch, & Ruzeviciute, 2016; Uzdavinyte, Aubel, & Gineikienė, 2019) or safer (Milford, Trandem, & Pires, 2021) than imported food products. On the other hand, consumer ethnocentrism can also be seen as a prosocial behaviour to protect domestic workers and the economy by buying domestic products (Casado-Aranda, Sanchez-Fernandez, Ibanez-Zapata, & Liebana-Cabanillas, 2020). Furthermore, consumer ethnocentrism can be driven by subjective norms regarding what is appropriate or inappropriate purchasing behaviour and can provide people with a sense of belonging to a group (Siamagka & Balabanis, 2015; Vabo & Hansen, 2016).

Consumers with stronger preferences for local, domestic products tend to be older and less educated (Carpenter, Moore, Alexander, & Doherty, 2013; Siamagka & Balabanis, 2015), live in rural areas, give importance to tradition and conformity, and be more risk averse and less likely to seek new experiences (Steenkamp, 2019). On the other hand, there are also consumers with salient preferences for local food, so-called "gourmets", who are explorative and taste- and

quality-oriented (Schösler & de Boer, 2018). Studies have found preferences for domestic products to be correlated with health consciousness (Gineikiene et al., 2016).

In their meta-study, Balabanis and Siamagka (2022) found that countries with stronger cultural values of collectivism and masculinity also had higher levels of consumer ethnocentricity. This study, which uses data from 240 different studies of consumer ethnocentrism across the globe, found that Norway's level of consumer ethnocentricity was slightly higher but still close to the global average.

2.4. Food and agriculture in Norway

The relevance of consumers' preferences for domestic food for a sustainable food transition depends on the extent to which such a transition requires a change towards food products that are imported. In Norway, a large share of agricultural land is only suitable for grass production, and large-scale commercial production of vegetables, cereals and pulses only takes place in a few regions with suitable topography and climate (Milford, Lien, & Reed, 2021). Livestock production is considered the backbone of Norwegian agriculture but strongly depends on government subsidies as well as the import of protein-rich feed (Vik, 2020; Vinge, 2015). High production costs caused by harsh weather conditions, long winters and high labour costs make it difficult to compete with food imports, but there is high willingness to support domestic agriculture in the Norwegian population (Mittenzwei, Mann, Refsgaard, & Kvakkestad, 2016). Cattle and beef production receive the largest share of government subsidies, and pork and poultry producers are also heavily supported, such as by import tariffs that enable competition with imports (Mittenzwei, Milford, & Grønlund, 2017). Due to these policy measures, for many years Norway has been almost self-reliant on all livestock products. However, the country depends on food and feed imports for approximately 64% of the total food energy intake (Bay-Larsen, Risvoll, Vestrum, & Bjorkhaug, 2018) and imports many plant-based foods, including approximately 90% of all fruits and berries (OFG, 2023). On the other hand, Norway is also an important fishing nation, exporting 1.5 million tonnes of wild-caught fish in 2020 in addition to 1,2 million tonnes of fish from aquaculture, primarily salmon (NSC, 2023).

The impact of reduced meat consumption on national self-sufficiency, employment and land use depends on what consumers will eat instead. The fish supply is abundant, and Norway has the capacity to substantially increase its production of vegetables, peas and fava beans if demand increases (Abrahamsen, Uhlen, Waalen, & Stabbetorp, 2019; Mittenzwei et al., 2017). However, thus far, most commercial processed meat replacement products (e.g., vegetarian burgers) sold in Norway are either imported or made from imported ingredients such as soya (Gonera & Milford, 2018).

The prospect of a transition away from meat and dairy has been met with strong resistance from the livestock sector in Norway (Farstad, Vinge, & Straete, 2021; Larsson & Vik, 2023; Ronningen, Fuglestad, & Burton, 2021). Large investments in the sector have created path dependencies (Ronningen et al., 2021), and it is argued that reduced meat consumption will reduce national food security, the use of grassland resources and farm incomes and employment (Farstad et al., 2021; Larsson & Vik, 2023). Differing points of view among supporters and adversaries of reduced meat consumption have led to a polarised debate in the media, similar to those experienced in other meat-producing countries (Larsson & Vik, 2023; Sievert, Lawrence, Parker, Russell, & Baker, 2022; Simmonds & Vallgarda, 2021). In these debates, doubt is cast on the environmental and health arguments for meat reduction (Clare, Maani, & Milner, 2022; Sanford, Painter, Yasseri, & Lorimer, 2021; Simmonds & Vallgarda, 2021), and claims are made that domestic livestock production is more sustainable than in other countries (Farstad et al., 2021; Sievert et al., 2022; Simmonds & Vallgarda, 2021).

2.5. Research objectives

In the ongoing public debate in Norway, the argument is made that eating more plant-based and less animal-based food will negatively impact farmers and national self-sufficiency, indicating a dilemma between making more environmentally friendly and healthy food choices and supporting Norwegian food production. Accordingly, for this research study, we hypothesise that the more strongly consumers value domestic food production, the less likely they are to change their diet from meat to plant-based food. Furthermore, we can assume that a stronger belief that Norway's main resource capacity is livestock production can also impact plant-based consumption negatively and meat consumption positively. As found in previous studies, we would expect to find healthier and more sustainable food consumption habits among people with stronger environmental or health concerns (Graca et al., 2019; Miki et al., 2020) and those who believe more strongly in the negative health and environmental effects of meat consumption (Graca et al., 2019; Vainio et al., 2018). In the study of these potential drivers of sustainable food consumption, we control for demographic factors (gender, age, education and location) as well as interest in new food products (Mullee et al., 2017; Rosenfeld, 2018).

3. Data and method

3.1. Data collection

A quantitative survey was conducted by the market research company Kantar in June 2020. Kantar collects data from a panel of approximately 40,000 people who answer questionnaires regularly and updates background variables once a year Participants are randomly recruited (no self-selection), and attention checks are conducted to filter out participants who provide random answers. The data for this study were collected as part of a weekly "omnibus" online survey with questions from different institutes, with approximately 1000 respondents that represent the general population in terms of socio-demographics. Burmeister and Aitken (2012) and Ogundimu, Altman, and Collins (2016) propose that the required number of observations (participants) in regression models should be at least 20 participants per predictor variable, while Peduzzi, Concato, Feinstein, and Holford (1995) propose at least 10 participants per predictor variable. With about 900 participants in our study with 12 predictor variables we have approximately 75 participants per predictor variable, and we assume this will be enough to detect reasonable sized effects of interest and to avoid overfitting. The survey was performed in relation to a larger project on plant-based protein products based on Norwegian ingredients (for more details, see (Gonera et al., 2023). Prior to the survey, qualitative information on consumer preferences for plant-based food products was gathered in the form of focus group interviews (Varela et al., 2022) and written feedback from conference participants on a set of product designs that were developed in the project (Gonera et al., 2023).

For this study, three parts of the survey were used for analysis: 1) dietary habits, i.e., frequency of eating white and red meat, fish and plant-based dinners, and self-identification as vegan, vegetarian or flexitarian, 2) attitudes and beliefs regarding food, and 3) demographic variables.

In the dietary habit questions, the respondents were asked how often they ate "red meat (beef, pork, lamb/mutton)", "white meat (chicken, turkey)", "fish", and "plant-based ready-made products for dinner (for example, vegetarian burgers)". Answers were ranked from 8 (every day/daily) to 1 (never) (see Table 1). In addition, the respondents were asked whether they identified as "vegan (do not eat egg, dairy or meat products", "vegetarian (do not eat meat products)", "flexitarian (reduce my meat consumption actively, but sometimes eat)" or "omnivore (none of the above applies to me)".

The food attitude and belief questions are shown in Table 3. Most of the attitude questions were related to food preferences. We asked about

Table 1
Dietary frequencies and percentage answers for each group.

Value	Answer	Red meat	White meat	Fish	Ready-made plant-based dinners
8	Every day/ daily	1%	1%	1%	0%
7	3-5 times a week	21%	13%	20%	1%
6	1-2 times a week	46%	48%	58%	5%
5	2-3 times a month	21%	25%	13%	8%
4	Approx once a month	4%	6%	4%	5%
3	3-11 times a year	4%	3%	2%	7%
2	More seldom	1%	1%	1%	29%
1	Never	3%	3%	2%	45%

the importance of different aspects regarding domestic production (ProdNor, BuyNor), health (Healthy, Fibre, Protein, HealthImp) and environment (ProdEnv, Footprint, EnvEngaged) as well as interest in new food products (NewFood). We also asked about beliefs regarding Norway being primarily suitable for livestock production (GrassNor) and the health and environmental benefits of meat reduction (MeatHealth and MeatEnv).

In some cases, the question formulations were based on previous literature, such as the questions regarding the importance of healthiness, proteins and fibre ((Steptoe, Pollard, & Wardle, 1995), the environment (Lindeman & Väänänen, 2000) and belief in the health and environmental benefits of meat reduction (Milford & Kildal, 2019). Other questions, such as those regarding the importance of Norwegian origin and the belief that Norway's production capacities are primarily for livestock, were created for this survey. The rating of answers to questions about importance ranged from 1 ("not important") to 7 ("very important"). For agreement with statements, the rating ranged from 1 ("totally disagree") to 7 ("totally agree").

The demographic variables included gender, age, education and municipality. The latter was transformed into a rural–urban discrete variable using the centrality index provided by Statistics Norway (SSB, 2020).

A total of 1102 responses were received. Because some of the questions were optional, not all were complete. We deleted 203 responses with missing answers to questions used in the data analysis (see Tables 2 and 3). In addition, we deleted 14 observations suspected of random answering due to inconsistencies in the dietary questions (identifying as vegan or vegetarian but eating meat regularly). The final number of respondents used for the analysis was 899.

As expected, there was an equal distribution of males and females. However, the average age was 55, which is higher than the average age of Norwegians between 18 and 90 in 2020, which was 48 (SSB, 2023).

3.2. Data analysis

We next investigated the effect of these different attitudes and demographics on dietary habits by estimating a series of interval regression models and logistic regression models. Our study included five dependent variables that measured the frequency of eating red and white meat, fish and ready-made plant-based products for dinner. Additionally, we estimated the determinants of self-identification as some type of meat reducer using a binary variable with values 1 = flexitarian, vegetarian or vegan and 0 = omnivore.

Table 2
Descriptive statistics of dietary habits and demographics.

Variable	Label	Obs	Missing obs	Mean	Std. Dev.	Min	Max
Red meat frequency	RedMeat	899	14	3.34	1.28	1	8
White meat frequency	WhiteMeat	899	11	3.53	1.27	1	8
Fish frequency	Fish	899	19	3.18	1.13	1	8
Eat plant-based ready-made dinners regularly	PlantDinner	899	11	0.26	0.44	0	1
Identify as vegan, vegetarian or flexitarian	VegiFlexi	899	10	0.15	0.36	0	1
Female	Female	899	0	0.49	0.5	0	1
Age	Age	899	0	55	16	18	87
University or college education	University	899	0	0.58	0.49	0	1
Centrality index	Centrality	899	0	833.58	120.59	393	1000

Table 3
Descriptive statistics, attitude questions and latent variables.

It is important to me that food I eat on a normal weekday:	Label	Obs	Missing obs	Mean	Std.Dev.	Min	Max
(1 Not important; 2; 3; 4; 5; 6; 7 Very important)							
Keeps me healthy	Healthy	894	9	5.46	1.12	1	7
Is produced in Norway	ProdNor	892	10	4.9	1.49	1	7
Is high in fibre	Fibre	896	5	4.83	1.24	1	7
Has been produced in an environmentally friendly way	ProdEnv	897	7	4.79	1.39	1	7
Is high in protein	Protein	892	11	4.52	1.25	1	7
Has been produced with low greenhouse gas emissions	Footprint	894	12	4.37	1.46	1	7
To what degree do you agree or disagree with the following statements:							
(1 Totally disagree; 2; 3; 4; 5; 6; 7 Totally agree)							
It is important to buy Norwegian food to support Norwegian agriculture	BuyNor	894	9	5.71	1.37	1	7
It is important for me to eat foods that are healthy	HealthImp	898	6	5.69	1.13	1	7
Food produced in Norway is safer than imported food	SafeNor	889	34	5.3	1.58	1	7
I am interested in what I can personally do to protect the environment & natural resources	EnvEngaged	898	9	5.02	1.36	1	7
Norway is a grassland country best suited for livestock production	GrassNor	899	92	4.94	1.37	1	7
I like to buy new types of food that come in the store	NewFood	899	9	4.5	1.39	1	7
High meat consumption can be harmful to health	MeatHealth	899	41	4.43	1.68	1	7
Reducing meat consumption is an effective environmental measure	MeatEnv	899	51	4.22	1.87	1	7
Latent variable domestic food preferences	Domestic	899	0	0.01	1.01	−2.8	1.71
Latent variable health concern	Health	899	0	0.01	0.98	−3.4	2.3
Latent variable environmental concern	Environment	899	0	−0.003	0.99	−2.6	2.23

To assess consumption frequencies, respondents were asked how often they consumed these meals, as shown in Table 1. The table also shows percentage answers for each category.

We transformed the consumption frequencies to yearly intervals representing the number of days in a year that the respondents had consumed these meals as dinners, with "never" equal to zero and "daily" indicating 365 days.

The frequency consumption of red meat, white meat and fish appeared to have a normal distribution. We therefore estimated interval regression models to evaluate the determinants of the consumption of red meat, white meat and fish. For ready-made plant-based dinners, the frequency distribution was skewed, with 45% of respondents reporting having never consumed plant-based dinners. Among those who had consumed plant-based dinners, the majority consumed them only 3–11 times a year or less. Given the skewed nature of the plant-based dinner frequency data, we decided to model the determinants of regular consumption of plant-based dinners (answer value 3 or higher) with a logistic regression model.

Interval regression is used when the dependent variable is interval-censored. The actual outcome level is not observed, but the interval it lies within is known. The interval regression model is a modification of the ordered probit model but with known cut-off points, and the parameters are estimated using maximum likelihood estimation (MLE) (Wooldridge, 2002). We specified the interval regression model as follows:

$$Freq^{*} = X\beta + e \; Freq^{*}|x \sim Normal(X\beta, \sigma^{2}) \tag{1}$$

where $Freq^{*}$ is the unobserved frequency level, X is the vector of explanatory variables, β is the vector of parameters associated with the explanatory variables and e is the error term.

The observed frequency is such that

$$\begin{aligned} Freq &= 0 \; if \; Freq^{*} \leq \kappa_1 \\ Freq &= 1 \; if \; \kappa_1 < Freq^{*} \leq \kappa_2 \\ &\vdots \\ Freq &= j \; if \; Freq^{*} > \kappa_j \end{aligned} \tag{2}$$

where $\kappa_1 < \kappa_2 < \ldots \kappa_j$ are the known interval points.

The logistic regression model is used to model binary outcomes. The probability of being a regular consumer of plant-based dinners and the probability of being vegan, vegetarian or flexitarian is specified as

$$Pr\,(y = 1) = \frac{exp\,(x_i^{'}\beta)}{1 + exp\,(x_i^{'}\beta)} \tag{3}$$

where y = 1 if plant-based dinners were consumed at least 3 times a year in the plant-based dinners model and y = 1 if the respondent was vegan, vegetarian or flexitarian in the vegan, vegetarian or flexitarian status model.

We estimated latent variables for health concerns, environmental concerns and preferences for domestic food using the graded response model (Samejima, 1969). For preferences for domestic food, we used the three variables BuyNor, ProdNor and SafeNor (see Table 3 for variable explanations). We used three graded questions (1–7): one was neutral (to what extent the respondents found it important to buy food from Norway, no reasons given) and the second concerned safety (extent of agreement that Norwegian food is safer than imported food), which previous studies have found to be an important food value (Bazzani, Gustavsen, Nayga, & Rickertsen, 2018; Milford, Trandem, & Pires, 2021). The third question was the extent of agreement that it is important to buy Norwegian food to support Norwegian agriculture, which many Norwegians see as important (Mittenzwei et al., 2016; Roos, Hansen, & Skuland, 2016). This question had a moral dimension in line with the Cetscale.

The latent variable for health concern was estimated from the variables Healthy, Protein, Fibre and HealthImp, while the latent variable for environmental concern was estimated from ProdEnv, Footprint and EnvEngaged (see Table 3 for variable explanations).

The descriptive statistics, correlation and regression model analyses were conducted using Stata 17. To examine the impact of preferences for domestic food, health and environmental beliefs and attitudes on the consumption of red and white meat, fish and plant-based food, interval regression models and binary logistic models were estimated using the latent variables for health concern, environmental concern and preferences for domestic food as independent variables. All models were estimated using robust standard errors. We checked for multicollinearity using the variance inflation factor test, and no severe multicollinearity was detected.

4. Results

4.1. Descriptive statistics and simple correlation

The descriptive statistics for the food frequencies and demographics of our sample are shown in Table 2. Table 3 shows the descriptive statistics from the questions regarding attitudes towards food.

For the question regarding what the respondents found most important regarding the food they ate on normal weekdays, the highest mean value was found for "*Keeps me healthy*", while the lowest value was found for "*Has been produced with low greenhouse gas emissions*".

The respondents agreed most with the statements "*It is important to buy Norwegian food to support Norwegian agriculture*" and "*It is* important *for me to eat food that is healthy*". They agreed least with the statements "*Reducing meat consumption is an effective environmental measure*" and "*High meat consumption can be harmful to health*".

The matrix for pairwise linear correlation for variables used in the analysis is shown in Table 4.

Domestic food preferences are negatively correlated with centrality; hence, they are stronger among the rural population. Fish consumption is positively correlated with environmental and health concerns. Furthermore, red meat consumption is positively correlated with white meat and fish consumption and negatively correlated with eating plant-based dinners and identifying as a meat reducer.

4.2. Regression results

The results of the interval regression analyses for the consumption frequencies of white and red meat and fish are shown in Table 5. The results of the logistics regression analyses for plant-based dinners and self-identification as vegan, vegetarian or flexitarian are shown in Table 6. The coefficients of Tables 5 and 6 are not comparable since Table 5 shows the interval regression results for dietary habits and Table 6 shows the logistic regression results, but the direction of the relationships between the outcomes and predictors is comparable.

The results of the regression analyses show that preferences for domestic food have a positive effect on red meat consumption and a negative effect on eating ready-made plant-based dinners and the likelihood of self-identifying as a meat reducer. Health concerns influence the consumption of white meat and fish positively, while environmental concern has a negative effect on white meat consumption and a positive effect on eating plant-based products and identifying as a meat reducer. Believing that high meat consumption can be harmful to health reduces the consumption of red meat and increases the consumption of fish and the likelihood of eating plant-based dinners and identifying as a meat reducer. Belief in the negative impact of meat on the environment reduces the consumption of red meat and increases the likelihood of eating plant-based meat and identifying as a meat reducer. A strong belief that Norway is a grassland most suited for livestock has a positive impact on red and white meat consumption and a negative impact on the

Table 4
Pairwise correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16
(1) RedMeat	1.00															
(2) WhiteMeat	0.39	1.00														
(3) Fish	0.10	0.13	1.00													
(4) PlantDinner	−0.21	−0.07	−0.03	1.00												
(5) VegiFlexi	−0.39	−0.17	0.00	0.41	1.00											
(6) Domestic	0.10	0.03	0.03	−0.04	−0.01	1.00										
(7) Health	−0.08	0.05	0.16	0.08	0.17	0.41	1.00									
(8) Environment	−0.19	−0.12	0.09	0.25	0.34	0.38	0.52	1.00								
(9) MeatEnv	−0.27	−0.05	0.03	0.35	0.41	−0.02	0.22	0.45	1.00							
(10) MeatHealth	−0.24	−0.06	0.07	0.30	0.37	0.02	0.25	0.42	0.70	1.00						
(11) GrassNor	0.25	0.11	0.06	−0.18	−0.21	0.33	0.11	−0.01	−0.27	−0.22	1.00					
(12) NewFood	−0.03	0.02	−0.04	0.28	0.17	0.07	0.17	0.22	0.23	0.21	0.00	1.00				
(13) Female	−0.18	0.01	−0.03	0.07	0.14	0.18	0.14	0.17	0.17	0.14	−0.11	0.09	1.00			
(14) Age	0.00	−0.08	0.24	−0.30	−0.15	0.00	0.10	0.02	−0.21	−0.11	0.13	−0.27	−0.11	1.00		
(15) University	−0.06	−0.03	0.09	0.05	0.08	−0.04	0.11	0.11	0.13	0.14	−0.05	0.01	0.06	−0.01	1.00	
(16) Centrality	−0.11	0.01	−0.08	0.14	0.10	−0.20	−0.01	0.02	0.21	0.14	−0.16	0.07	−0.02	−0.06	0.09	1.0

Table 5
Results interval regression, consumption frequency of red and white meat and fish as dependent variables.

	(1)	(2)	(3)
	Red meat	White meat	Fish
Latent variable domestic food preferences	8.00**	1.48	−2.95
	(2.63)	(1.88)	(1.99)
Latent variable health concern	−3.05	5.26**	6.57***
	(2.55)	(1.89)	(1.9)
Latent variable environmental concern	−3.27	−6.5***	−0.22
	(2.79)	(1.9)	(2.13)
High meat consumption can be harmful to health	−3.6*	−1.57	3.34**
	(1.71)	(1.19)	(1.18)
Reducing meat consumption is an effective environmental measure	−3.41*	1.9	−0.27
	(1.6)	(0.99)	(1.09)
Norway is a grassland country best suited for livestock production	5.53**	2.62*	0.9
	(1.86)	(1.13)	(1.16)
I like to buy new types of food that come in the store	1.72	0.12	−1.9
	(1.69)	(1.16)	(1.18)
Female	−20.36***	2.88	0.45
	(4.36)	(2.82)	(3.086)
Age	0.32	0.55	−0.22
	(0.91)	(0.63)	(0.588)
Age squared	−0.01	−0.01	0.01
	(0.009)	(0.006)	(0.01)
University education	−1.93	−4.42	3.62
	(4.29)	(2.97)	(3.17)
Centrality index	−0.003	−0.002	−0.02*
	(0.02)	(0.01)	(0.01)
Constant	123.9***	66.42**	40.17
	(33.67)	(23.74)	(22.98)
Observations	899	899	899

Standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 6
Results logit regression. Consumption of ready-made plant-based dinners and self-identification as meat reducers as dependent variables.

	(1)	(2)
	Plant-based dinners	Vegan, vegetarian or flexitarian
Latent variable domestic food preferences	−0.28*	−0.47**
	(0.11)	(0.14)
Latent variable health concern	−0.084	0.12
	(0.115)	(0.14)
Latent variable environmental concern	0.58***	0.9***
	(0.13)	(0.15)
High meat consumption can be harmful to health	0.16*	0.34**
	(0.08)	(0.12)
Reducing meat consumption is an effective environmental measure	0.15*	0.45***
	(0.07)	(0.13)
Norway is a grassland country best suited for livestock production	−0.19**	−0.27**
	(0.07)	(0.1)
I like to buy new types of food that come in the store	0.35***	0.04
	(0.07)	(0.1)
Female	−0.12	0.46
	(0.19)	(0.24)
Age	−0.19***	−0.14**
	(0.04)	(0.04)
Age squared	0.002***	0.001**
	(0.0004)	(0.0004)
University education	−0.1	0.002
	(0.19)	(0.25)
Centrality index	0.001	−0.0001
	(0.001)	(0.001)
Constant	−9.44***	−9.29***
	(1.47)	(1.86)
Observations	899	899

Standard errors in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

consumption of plant-based dinners and identification as a meat reducer. Trying new foods has a positive impact on eating plant-based dinners.

In addition, we find that males eat more red meat than females. The consumption of plant-based ready-made dinners and identifying as a meat reducer first decreases with age and then increases with higher age, indicating that the youngest and the oldest respondents in our sample eat more plant-based products and less meat. We do not find any significant effect of the centrality index, although the pairwise correlation matrix shows that it is linearly correlated with red meat and plant-based consumption (more rurally located respondents eat more red meat and less plant-based food).

5. Discussion

The results of this study show that preferences for domestic food have an impact on the sustainability of food choices. Consumers with more positive attitudes towards Norwegian food products have a higher consumption frequency of red meat and are less prone to eat ready-made plant-based dinners and identify as meat reducers (vegan, vegetarian or flexitarian). We do not find any effect of preferences for domestic food on the consumption of white meat or fish.

The study also confirms previous results that plant-based food consumption is affected by environmental concern (Miki et al., 2020; Nie, Medina-Lara, Williams, & Smith, 2021; Vatn et al., 2022). We find that the more concerned people are with health, the higher their consumption of white meat and fish is. This result makes sense, as fish are considered to have health benefits (Clonan et al., 2012), and white meat can be considered a healthier alternative to red meat (Lippi, Mattiuzzi, & Cervellin, 2016; Zhang et al., 2022). On the other hand, although white meat and fish have a lower carbon footprint than meat from ruminants (Poore & Nemecek, 2018), in the regression analysis, environmental concern has a negative, not positive, effect on white meat consumption, and there is no significant effect on fish consumption. However, we find a positive pairwise linear correlation between fish consumption frequency and environmental concern. There is also a positive pairwise linear correlation between the consumption frequency of red meat and both fish and white meat; hence, we have no indication that white meat or fish are used as substitutes for red meat.

Although fish can be seen as a domestically produced, climate-friendly and healthier alternative to ruminant meat, our data do not indicate that it has taken this role. A possible explanation for why people with stronger preferences for domestic food do not seem to have a stronger preference for fish could be that the measure used in the variable for domestic food preferences includes a question about support for Norwegian agriculture, not fisheries. Furthermore, all fish not sold in Norway are exported, and the economy and employment in the fishing sector do not rely on support from Norwegian consumers the way the livestock sector does. In addition, the understanding of fish as an environmentally friendly alternative to meat is complicated in Norway, primarily due to pollution from aquaculture (Olesen et al., 2011).

Our results also show that the stronger the belief that meat reduction is an efficient environmental measure and that excess meat consumption is bad for health, the lower the consumption of red meat and the higher the likelihood of consuming plant-based products and identifying as a meat reducer. Given the strong scientific consensus regarding the negative impact of meat on the environment and health, it is puzzling to note that many still do not agree with these statements. It is, of course, possible that these facts have not reached the larger Norwegian population. Another explanation is avoidance or denial of this type of information to prevent cognitive dissonance (Bergmann et al., 2010). It is possible that consumers choose to believe in media content, which is often presented by supporters of the livestock sector, casting doubt on the scientific results regarding meat's negative impact (Clare et al., 2022; Sievert et al., 2022). Studies conducted in Norway show that parts of the livestock sector have low willingness to accept scientific facts regarding the environmental and health impact of meat and that they are searching to redefine "the problem of climate mitigation of red meat production/consumption towards food security and resource utilisation" (Farstad et al., 2021; Larsson & Vik, 2023).

In line with this, we note that agreement that Norway is a grassland country best suited for livestock is high and it has influence on the consumption of both red and white meat and plant-based food. Whether this statement is true or not is not easily determined. On the one hand, it is true that large parts of Norway's agricultural land are unsuitable for anything other than grass (Arnoldussen et al., 2014). On the other hand, in a country as far north as Norway, grass-based livestock production is more arduous than in many other countries as grass needs to be harvested, stored and fed to livestock during the winter months; consequently, Norwegian livestock production is highly dependent on imported feed and government subsidies (Vik, 2020). At the same time, Norway has a vibrant vegetable and cereal producer community, and a recent report estimated that the country has enough land resources to feed the population on a 100% plant-based diet (Bakken & Mittenzwei, 2023). Furthermore, Norway is far more important as a fishing nation than as a grassland and livestock nation. Despite these facts, most respondents agreed with the grassland claim. One reason could be that most of the meat sold in Norway, although reliant on imported feed, is produced by Norwegian farmers, while a large share of plant-based foods as well as pulses or products based on pulses are imported (OFG 2023; Gonera & Milford, 2018). In addition, it is likely that many consumers are unaware of the large import of feed needed to sustain livestock production. This could perhaps explain the influence of domestic food preferences on consumption patterns: if it is believed that Norway has the best natural preconditions to produce meat and much of Norway's plant-based food is currently imported, this may explain why people who care about Norwegian agriculture and believe in the superiority of Norwegian food products prefer meat over plant-based food.

On the one hand, an explanation for our results could be that many individuals feel a strong attachment to meat and are prone to moral disengagement, i.e., they are searching for justification to continue their present meat consumption level despite its negative impacts (Graça, Calheiros, & Oliveira, 2016). Supporting domestic agriculture and employment by avoiding imports may be exactly the justification they need, particularly if this is rationalised with the belief that Norway is best suited for livestock production. On the other hand, we cannot exclude the possibility that for many people, concern for the livestock sector and what will happen to it if people reduce their meat consumption level is real and heartfelt. After all, a sustainable food transition away from ruminant meat may cause large disruptions in the agricultural economy, particularly in the value chain for beef (Mason-Dcroz et al., 2022).

These results bring new aspects into the existing research and debate on sustainable diets and food transition, but we also acknowledge limitations. We used self-reported dietary frequency data, not actual consumption data with weights or volumes, which might have given different results. Furthermore, the case study was Norway, which may have special features and is not representative of many other countries in the world. The data were collected during the COVID-19 pandemic, and it is likely that valuation of both healthy food and the protection of domestic food producers may have been higher because of this (Kol, Zimand-Sheiner, & Levy, 2023)), although it is unclear how this may have affected the results of the regression analysis. This calls for a replication of the analysis with another dataset because the respondents in our dataset were, on average, older than the actual population that was sampled. Finally, in the questionnaire, we did not make a distinction between being vegetarian and being pescetarian (eating fish but not meat). This was intended to simplify the questionnaire, but we acknowledge that this was an inaccuracy that may have confused some respondents.

6. Conclusion

To find ways to make consumers shift away from their meat consumption levels, more attention should be given to consumers' preferences for domestic food. This aspect should also be investigated in other countries, particularly those where a sustainable food transition could imply more imports. More attention should also be paid to the role of white meat and fish in studies of sustainable food consumption.

Our study indicates that the supply of domestically produced, sustainable food options as alternatives to meat could be an important measure to make consumers with preferences for domestic food transition away from meat. One suggestion is to promote the "New Nordic Diet", which was developed as an alternative diet based on foods originating from the Nordic region that are healthy, palatable and less meat oriented (Mithril et al., 2012), as well as to develop a more convenient and cheaper version of this diet, which may have a higher practical acceptance level (Micheelsen, Havn, Poulsen, Larsen, & Holm, 2014).

However, although it is possible to increase national self-sufficiency with increased plant-based food consumption, lower demand for meat may still have negative implications for the livestock sector. In many other countries in addition to Norway, this sector is important for rural employment and the use of domestic grassland resources. These potential negative consequences can create resistance against climate policies affecting rural areas (Loeng & Korsnes, 2023; Mittenzwei, Gustavsen, Grimsrud, Lindhjem, & Bjørkhaug, 2023) and, as this study shows, can be used as justifications for consumers to continue their meat consumption habits. Furthermore, the livestock sector, in an attempt to protect itself against these consequences, will try to influence consumers with information that casts doubt on the negative environmental and health consequences of high meat consumption (Clare et al., 2022).

One solution to this is to implement policies that account for climate, health and agriculture and that seek to combine a transition towards less meat with the preservation of assets such as rural employment and food security. Such policies could, for instance, be directed towards local market opportunities and grants for environmentally friendly production methods (Lecole, Preget, & Thoyer, 2022; Loeng & Korsnes, 2023) and should consider the role of plant-based food producers, including those who operate on a small scale. Given the results of this study, it seems important to identify policy measures that can contribute to the creation of storylines where sustainable food transition implies positive changes, including improved livelihoods in farming communities.

Ethical statement

The survey data used in this work were collected by the market analysis company Kantar. Kantar follows the ethical guidelines of the Personal Data Act and the Data Inspectorate's guidelines, which also include Esomar's and the Norwegian Market Analysis Association's ethical rules and industry standards. NIBIO's ethics committee acknowledges that Kantar meets the ethical requirements for human participation.

CRediT authorship contribution statement

Anna Birgitte Milford: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Sarah Wangui Muiruri:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis.

Declaration of competing interest

None

Data availability

Data will be made available on request.

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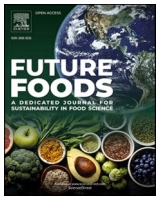

Norwegian consumers' willingness to try cultured meat

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ABSTRACT

Cultured meat (CM) is likely to reduce environmental footprints and health problems and improve animal welfare, but its success in the market will rely on consumer acceptance. A survey was used to investigate consumer acceptance of CM in Norway. The survey was conducted pre the COVID-19 pandemic and during the pandemic with a total of 4,683 usable responses. A partial proportional odds model was estimated, and identical coefficients were not rejected for the two periods. Social trust, trust in food authorities, and support to green parties were positively associated with the willingness to try CM but there was no association with trust in food retailers. Respondents who emphasized natural components and food safety were less willing, and respondents who emphasized health, novelty, environment, and price were more willing. Young, male, highly educated, urban, non-religious, non-vegetarian supporters of green parties were also more willing to try CM, and marketing activities should target these groups.

1. Introduction

The global population is expected to reach approximately 10 billion by 2050 (UNFPA, 2021), and the demand for meat may double (Revell, 2015). Meat production and processing contribute to several environmental problems. The livestock industry is responsible for 32 % of methane emissions within the agriculture sector and leads to deforestation, land degradation, and water-use (Kuylenstierna et al., 2021).

A transition towards more sustainable food consumption includes the need to substitute some meat with other protein sources, and cultured meat (CM) is an alternative (Sánchez et al., 2021). CM is artificially grown in a laboratory using tissue engineering and involves extracting stem cells from live animal tissues (Zhang et al., 2021). While CM is still in its early stages, it may be a promising meat substitute since existing plant-based meat alternatives appear to be preferred by people with lower or no beef consumption (Taylor et al., 2023; Tonsor et al., 2023). Furthermore, existing plant-based meat alternatives have also been found to be a supplement to white and a complement to red meats (Zhao et al., 2023).

CM is likely to reduce the environmental footprints from meat production, reduce health problems associated with intake of conventional meat, and improve animal welfare (Tuomisto and Teixeira de Mattos, 2011). Ongoing research and development within CM have focused on matching the nutritional profile, color, and texture of conventional meat (Deliza et al., 2023), and while advancements have been made, these concerns are yet to be fully overcome (Deliza et al., 2023; Zhang et al., 2021). Even though the price is high for the average consumer, the cost of CM production has been reduced over the last years, which increases the plausibility of CM as an alternative (Tsvakirai et al., 2024)

CM products are at various stages in the approval process for sales in various parts of the world with around 200 CM related companies globally (Ye et al., 2022; Yun et al., 2024). Cultivated chicken is for sale in Singapore (Eat Just, 2022). In the US, the Food and Drug Administration (FDA, 2022) has completed a pre-market consultation process for cultured chicken, which was submitted by UPSIDE Foods. However, the product is still not approved for sales. In September 2023, The Cultivated B applied to the European Food Safety Authority (EFSA) for the authorization of sales of a CM hotdog within the EU (The Cultivated B, 2023). Furthermore, the Dutch parliament approved tasting of CM in controlled environments in March 2022 (Lorenzo, 2022). However, conditional on approval the success of CM in the market will depend on consumers' acceptance in various parts of the world (Bryant and Barnett, 2020). North American consumers appear to be open to CM while consumers in developing countries are more averse towards CM (Tsvakirai, 2024). In Europe, opinions appear to differ, and East European consumers have different motivators than West Europeans (Tsvakirai, 2024).

There are many recent review studies on consumer acceptance of CM

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(e.g., Onwezen and Dagevos, 2024; Tsvakirai et al., 2024; Tsvakirai, 2024; Deliza et al., 2023; Kouarfaté and Durif, 2023; Siddiqui et al., 2022; Pakseresht et al., 2022; Zhang et al., 2021; and Bryant and Barnett. 2020). Many studies have also investigated factors affecting consumer acceptance of CM including food choice motives (e.g., Siegrist and Hartman, 2020a and 2020b), trust (e.g., Siegrist and Hartman, 2020b), price (e.g., Van Loo et al., 2020), socioeconomics (e.g., Bryant and Barnett, 2020), political inclination (e.g., Bryant et al., 2020), and being vegetarian (Bryant et al., 2020).

The objective of this study was to investigate the willingness to try (WTT) CM using data from a large Norwegian survey. Hypotheses related to the effects of different types of trust, food choice motives, and individual characteristics were developed and tested using a partial proportional odds model controlling for socioeconomic factors that usually are controlled for in similar models (e.g., Heijnk et al., 2023; Motoki et al., 2022).

This article adds to the literature in four ways. As reviewed by Monaco et al. (2024) and Kouarfaté & Durif (2023), trust is important in determining the consumer acceptance of novel foods including CM. Qualitative studies have found that trust in farmers, distrust in food companies and trust in food authorities were recurring concerns among consumers regarding their acceptance of CM (Ho et al., 2023; Shaw and Iomaire, 2019) and these results have, in some cases, been supported by other studies. Lin-Hi et al. (2023) constructed an index of organizational trustworthiness based on ten items and found that organizational trustworthiness influenced the willingness to buy CM while Siegrist and Hartmann (2020b) constructed an index of trust based on four items (trust in food industry, governmental controls in the food sector, food retailers, and food scientists) and found significant effects of this index on acceptance of CM in ten countries. Wilks et al. (2019), on the other hand, found no effects of distrust in science on the acceptance of CM. Trust in food retailers and trust in food control authorities may have different effects, and the specific effects of trust in food retailers and food authorities are investigated along with the effects of social trust. As far as we know, the effect of social trust has not been investigated in the context of consumer acceptance of CM.

Second, sustainability is an important topic in the policy debate, and people voting for green parties may be more likely to accept environmentally friendly food such as CM (Scoones, 2016). The effect of support to green parties on the acceptance of CM has been little investigated. One exception is Petersen et al. (2024), who investigated the effect of support to green parties on the consumption of already existing meat alternatives among German consumers and found a positive association.

Third, while consumer acceptance of CM in Norway has been previously studied (Engel et al., 2024; Klöckner et al., 2022; Rasmussen et al., 2024), we contribute to this literature through using data collected over several years from a large survey. The characteristics of the agricultural sector in Norway may result in emphasis on different food choice motives than in most other countries. Agriculture is based on highly subsidized small-scale farming (OECD, 2023) with beef and milk as main products. This ruminant production is important for rural areas and the cultural landscape (Ueland et al., 2022). Our results may be of particular interest for countries with similar types of agriculture, such as Iceland and Switzerland (OECD, 2023).

Fourth, the COVID-19 pandemic may have changed the importance of food choice motives and trust in the acceptance of CM. Reduced importance of health and increased importance of environmental impact, familiarity, and price have been found (Skalkos and Kalyva, 2023). Institutional and social trust have also been found to have increased from the implementation of lockdowns (Devine et al., 2020). To investigate such effects, two rounds of the survey were used. The first round was conducted before the pandemic and the second during the pandemic.

2. Determinants of willingness to try cultured meat

In this section, hypotheses concerning the determinants of WTT CM are developed based on current literature, and the hypotheses are summarized in the first column of Table 1.

2.1. Trust

Trust in food system actors and general social trust play an essential role when people choose what to eat and what not to eat (Ding et al., 2012; Muringai, 2017; Wu et al., 2021). Wu et al. (2021) conducted a review of determinants of consumers' trust in the food system and found that it relied on trust in product-specific assurances and trust in food system actors. The importance of social trust for food choices in general has been investigated in several studies. Ding et al. (2012) found that social trust positively affected consumers' acceptance of genetically modified food. Muringai (2017) found that individuals with low social trust and low trust in food actors were less likely to purchase processed meat products.[1] CM represents a new production technology, and trust may influence consumer acceptance in a similar way as trust has affected the acceptance of other novel food technologies such as genetically modified food (Ding et al., 2012; Siegrist and Hartmann, 2020a).

As mentioned above, Siegrist and Hartmann (2020b) investigated the importance of trust in the context of CM using an index constructed from trust in food industry, governmental controls in the food sector, food retailers, and food scientists while Lin-Hi et al. (2023) investigated the importance of organizational trustworthiness on willingness to buy CM in the context of a hypothetical restaurant. However, how trust is measured may have a significant impact on the acceptance of novel technologies such as CM (Earle, 2010), and trust in food authorities, trust in food retailers, and social trust may have different effects on the acceptance of CM. Different actors along the food value chain have distinct roles and consumers' trust in different actors may vary, for example, Macready et al. (2020) found that consumers had higher trust in farmers and retailers than in manufacturers and food authorities. Trust in retailers is likely to affect point of purchase decisions while trust in food authorities may affect CM safety assurances. Social trust, on the other hand, may affect the social acceptance of consuming CM.

H_1: Trust in retailers affects WTT CM.[2]

H_2: Trusts in food authorities affects WTT CM.

H_3: Social trust affects WTT CM.

2.2. Support to green parties

U.S. consumers with a left-wing or liberal political stand seem to be more open to CM than their conservative counterparts (Bryant et al., 2019; Wilks and Phillips, 2017; Wilks et al., 2019). Comparable results are reported for consumers in India (Bryant et al., 2019). However, political views were not found to be good predictors for CM acceptance in Germany and France (Bryant et al., 2020). For already existing meat alternatives, Petersen et al. (2024) found that German supporters of green parties had a significantly higher consumption of meat alternatives. The Liberal (center/right), the Socialist Left (left), and the Green Party (center) are the leading green parties in Norway (Farstad and Aasen, 2023; Kleven, 2022; Aardal, 1990), and these parties have strong

[1] The effect of social trust is important; however, social trust may also function as a control variable for the effects of trust in retailers or trust in public food authorities (Macready et al., 2020).

[2] As pointed out by a referee, several of the hypotheses could be framed as one sided. However, some would consider the use of one-sided hypotheses as gaming the significance, and we decided to use two-sided hypotheses consistently. However, the direction of the corresponding one-sided hypotheses follow from the text in Section 2. Any surprising directions of significant effects are also emphasized in the discussion of the results.

Table 1
Hypotheses, Survey Questions, Response Alternatives, and Constructed Variables.

Hypothesis	Survey Question [a]	Response Alternatives [a]	Constructed Variable
H_1: Trust in retailers affects WTT CM	How much trust do you have in the following institutions that exist in our society? One alternative was: The major grocery stores	Four alternatives: Very high, somewhat high, somewhat low, and no trust	TR = 1 if very high or somewhat high trust and = 0 otherwise
H_2: Trust in food authorities affects WTT CM	How much do you agree or disagree with the following statements about food and food safety? One alternative was: Norwegian authorities control the food so that only food that is safe to eat is sold in stores	Four alternatives: Totally agree, somewhat agree, somewhat disagree, and totally disagree	TFA = 1 if totally or somewhat agree and = 0 otherwise
H_3: Social trust affects WTT CM	Do you think that you can trust most people, or do you think that you cannot be careful enough in dealing with people?	Three alternatives: Can trust most people, cannot be careful enough, and in doubt	TS = 1 if can trust most people and = 0 otherwise
H_4: Support for green parties affects WTT CM	If there had been a parliamentary election next Monday, which party would you vote for?	Ten alternatives: Labour, Progress, Conservative, Christian Democratic, Green, Red, Centre, Socialist Left, Liberal, and other	Green = 1 if Socialist Left, Liberal, or Green and = 0 otherwise
H_5: Placing emphasis on natural components affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: The food is made from natural components	Tick if appropriate	Natural = 1 if natural components is ticked and = 0 otherwise
H_6: Healthiness assessment of food affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: The food is healthy	Tick if appropriate	Health = 1 if health is ticked and = 0 otherwise
H_7: Placing emphasis on the risk for illness from the food one eats affects WTT CM	People feel fear for different things in life. How much fear do you feel for each of the following things? One alternative was: Get sick from the food you eat.	Three alternatives: Great, moderate, and little or no fear	Safety = 1 if great or moderate and = 0 otherwise
H_8: Placing emphasis on novelty affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: The food is something new and exciting	Tick if appropriate	Novelty = 1 if something new and exciting is ticked and = 0 otherwise
H_9: Placing emphasis on familiarity affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: Eaten the food before	Tick if appropriate	Familiarity = 1 if eaten it before is ticked and = 0 otherwise
H_{10}: Price assessment of food affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: Low price	Tick if appropriate	Price = 1 if low price is ticked and = 0 otherwise
H_{11}: Placing emphasis on environmental effects affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: Environmental friendliness	Tick if appropriate	Environment = 1 if environmental friendliness is ticked and = 0 otherwise
H_{12}: Placing emphasis on animal welfare affects WTT CM	When purchasing food for yourself and your household, which factors do you consider to be particularly important? One alternative was: Animal welfare	Tick if appropriate	AW = 1 if animal welfare is ticked and = 0 otherwise
H_{13}: Being female affects WTT CM	What is your gender?	Two alternatives: Male and female	Female = 1 if female and = 0 otherwise
H_{14}: Being higher educated affects WTT CM	What is your highest completed education level?	Five alternatives: Primary school, secondary school, high school, bachelor's degree, graduate, and postgraduate studies	Education = 1 if bachelor's degree or more and = 0 otherwise
H_{15}: Age affects WTT CM	What is your age?	Age in years (continuous)	Age in years
H_{16}: Urban living affects WTT CM	How would you characterize the place where you live now?	Nine alternatives: Large city (central location), large city (outer districts), suburb of big city,	Urban = 1 if large city, suburb, medium-sized city and = 0 otherwise

(*continued on next page*)

Table 1 (*continued*)

Hypothesis	Survey Question [a]	Response Alternatives [a]	Constructed Variable
		medium-sized city (central location), medium-sized city (outer districts), suburb of medium sized city, smaller city, and village	
H_{17}: Income affects WTT CM	How large would you estimate your personal gross annual total income to be (all income before tax and deductions)?	Eleven groups (in 1000 NOK): < 100, 100 - 199, 200 – 299, 300 – 399, 400 – 499, 500 –599, 600 – 799, 800 - 999, 1000 - 1499, 1500 – 2000, and >2000	Income = 1 if in above median income and = 0 otherwise
H_{18}: Identifying with a religion affects WTT CM	What denomination or religion do you belong to?	Eight alternatives: Protestant, Catholic, other Christian, Jew, Muslim, humanist, other faith, and none of these	Religion = 1 if Protestant Catholic, other Christian, Jew, Muslim, other faith and = 0 otherwise
H_{19}: Being vegetarian affects WTT CM	How much do you agree or disagree with the following statements? One alternative was: I consider myself a vegetarian	Four alternatives: Totally agree, somewhat agree, somewhat disagree, and totally disagree	Vegetarian = 1 if totally or somewhat agree and = 0 otherwise

Note: [a] The survey was conducted in Norwegian, and the survey questions and response alternatives were translated to English by the authors.

environmental profiles. Climate related issues are among their top priorities, and voting for these parties may be associated with increased WTT CM.

H_4: Support for green parties affects WTT CM.

2.3. Other food choice motives

Naturalness is not a well-defined concept, and naturalness of food has been measured in different ways (Roman et al., 2017). A commonly used measure is the natural content framing, i.e., natural food contains no additives and only natural ingredients (Roman et al., 2017; Steptoe et al., 1995).[3] Most people seem to view CM as unnatural, which in turn lowers the level of consumers' acceptance (Bryant et al., 2019; Janat and Bryant, 2020; Lupton and Turner, 2018; Michel andSiegrist, 2019; Shaw and Iomaire, 2019; Siegrist and Hartmann, 2020a and 2020b; Siegrist et al., 2018).

H_5: Placing emphasis on natural components affects WTT CM.

[3] In our survey, the question was framed as "the food is made from natural components" without any definition of natural components. Natural components is not a well-defined concept and might have added some confusion among respondents. However, terms like "naturalness," "natural contents," or "natural components" are frequently used in surveys (e.g., Marty et al., 2021; Pieniak et al., 2009; Steptoe et al., 1995). Within the food value literature, naturalness has frequently been defined by the extent to which modern technologies were used in the production (Bazzani et al., 2018; Lusk & Briggeman, 2009). Another definition relates to whether the food is organically grown and/or the extent to which pesticides are used in the farming process (Roman et al., 2017).

Consumers base their healthiness assessment on how they expect the food to contribute to their health (Pinto et al., 2021), and this assessment is likely to influence their food choices. The content of nutrients like omega-3 and saturated fats can be controlled to make CM healthier than conventional meat (Bhat et al., 2015; Post, 2012). However, perceptions about CM may also be important, and Bryant et al. (2019) and Gómez-Luciano et al. (2019) found that perceived healthiness was a predictor for consumer acceptance for CM. Some consumers consider CM a risk while others acknowledge the potential health benefits (Bryant and Barnett, 2020; Shaw and Iomaire, 2019). Moreover, Bryant and Dillard (2019) found that the perceived healthiness of CM depended on the information consumers received, and whether it was framed as "clean meat" or "high-tech meat". In our survey, CM was framed as "lab-grown meat."

H_6: Healthiness assessment of food affects WTT CM.

Food safety may be defined in several ways. We followed Bazzani et al. (2018) and Lusk and Briggeman (2009) who defined food safety in terms of consumption not causing illness. These studies found that food safety was the most important food value. Consumers have expressed safety concerns towards CM in surveys. German respondents expressed uncertainty regarding the safety (Janat and Bryant, 2020), and Shaw and Iomaire (2019) concluded that safety of the technology was the biggest concern among Irish respondents. In a review study, Bryant and Barnett (2020) found that safety was seen as a risk by some consumers although some recognized potential benefits. CM is not commercially available in most countries, and safety concerns are not surprising. However, CM is expected to be produced in properly controlled lab environments thus reducing the risks of exposure to pathogens as compared to conventional meat (Chriki and Hocquette, 2020).

H_7: Placing emphasis on the risk for illness from the food one eats affects WTT CM.

Food neophobia and variety seeking behavior are two opposing forces that play essential roles in a consumer's WTT novel foods (Siegrist and Hartmann, 2020a; Tuorila and Hartmann, 2020). Variety seeking behavior is characterized by an intrinsic desire to explore new alternatives, i.e., novelty seeking (Van Trijp and Steenkamp, 1992), while food neophobia is characterized by resistance to try novel foods, i.e., a preference for familiar foods (Pliner and Hobden, 1992). Several studies evaluating the consumer acceptance of CM have found that food neophobia was a negative predictor for acceptance of CM (Bryant et al., 2019; Siegrist and Hartmann, 2020b; Faccio and Guiotto Nai Fovino, 2019; Rombach et al., 2022). Bryant and Sanctorum (2021) found that variety seeking was an important reason for choosing available alternatives to meat while Rombach et al. (2022) found food curiosity to be a driver for WTT CM.

H_8: Placing emphasis on novelty affects WTT CM.

H_9: Placing emphasis on familiarity affects WTT CM.

The anticipated price is likely to be a significant predictor for consumer acceptance of CM (Asioli et al., 2021; Valente et al., 2019). For most consumers, a high price is a barrier against consuming a food product, and studies suggest that consumers anticipate a high price of CM (Verbeke et al., 2015; Wilks and Phillips, 2017; Vermeir et al., 2020). Quite interestingly, Grasso et al. (2019) found that price-conscious older European consumers were more likely to accept CM, and Van Loo et. al. (2020) found that lower price did not influence consumer acceptance of CM among US consumers. Given, a relatively fair income distribution, price may be less important in Norway than in other countries (Bazzani et al., 2018).

H_{10}: Price assessment of food affects WTT CM.

Different food products have different environmental impact, and the degree of impact is likely to affect food choices (Hartmann et al., 2021; Lusk and Briggeman, 2009). One benefit of CM is environmental friendliness (Bryant and Barnett, 2020; Chriki and Hocquette, 2020), and consumers believe that CM is more environmentally friendly than conventional meat (Bryant and Sanctorum, 2021; Ruzgys and Pickering, 2020). Grasso et al. (2019) found that people, who considered

environmental friendliness attributes in their food choices, had a positive acceptance of CM. Correspondingly, Ruzgys and Pickering (2020) found that individuals with higher pro-environmental values had a higher acceptance and willingness to try CM.[4]

H_{11}: Placing emphasis on environmental effects affects WTT CM.

Animal welfare concerns affect consumers' food purchase decisions for animal products and their alternatives (Alonso et al., 2020), and these concerns have been found to be a significant driver for reduced meat consumption, especially among vegetarians (Mancini and Antonioli, 2019). Production of CM involves minimal animal welfare threats (Siegrist et al., 2018), and consumers seem to acknowledge these benefits (Bryant and Barnett, 2020; Franceković et al., 2021; Mancini and Antonioli, 2019). Asioli et al. (2021) found that individuals with high animal welfare concerns had a higher willingness to pay for CM, and Weinrich et al. (2020) found that animal welfare concerns were positively associated with the intention to consume CM.

H_{12}: Placing emphasis on animal welfare affects WTT CM.

2.4. Individual characteristics

Men have a higher acceptance of CM than women (Bryant and Sanctorum, 2021; Bryant et al., 2020; Engel et al., 2024; Klöckner et al., 2022; Mancini and Antonioli, 2019; Shaw and Iomaire, 2019; Slade, 2018; Wilks and Phillips, 2017). Higher education increases the acceptance of CM (Mancini and Antonioli, 2019; Slade, 2018; Zhang et al., 2020). Younger people have a higher acceptance for CM (Bryant and Sanctorum, 2021; Engel et al., 2024; Klöckner et al., 2022; Mancini and Antonioli, 2019; Shaw and Iomaire, 2019; Slade, 2018). Urban people have an increased acceptance of CM (Bryant et al., 2020; Shaw and Iomaire, 2019). The effects of income are mixed. Bryant et al. (2019) found that Indian consumers with higher income were more likely to purchase CM, and Gómez-Luciano et al. (2019) found that respondents from higher income countries had a higher acceptance of CM. Wilks et al. (2019), on the other hand, found that the perceived benefits of CM were lower among individuals with higher income in the U.S. and that income was not a significant predictor to willingness to eat CM.

H_{13}: Being female affects WTT CM.

H_{14}: Being higher educated affects WTT CM.

H_{15}: Age affects WTT CM.

H_{16}: Urban living affects WTT CM.

H_{17}: Income affects WTT CM.

Asioli et al. (2021) found that non-religious individuals in the U.S. had a higher mean willingness to pay for CM, while Marcu et al. (2015) found that religious people viewed production of CM as playing God. However, Bryant (2020) found that CM acceptance among religious people depended on the specific product and was guided by specific religious doctrines.

H_{18}: Identifying with a religion affects WTT CM.

Vegetarians acknowledge the potential benefits of CM but have been found to have a lower acceptance for CM (Bryant et al., 2020; Shaw and Iomaire, 2019).

H_{19}: Being vegetarian affects the WTT try CM.

3. Materials and methods

The Norwegian Monitor Survey (NMS) is a bi-annual survey run by IPSOS (2021). It is a nationally representative and repeated cross-sectional survey of adults aged 15–95 years, which has been conducted every second year since 1985. Ipsos Norway recruited respondents through a short telephone interview, and those who accepted to participate received a paper-based questionnaire of about 150 pages. The survey included 3710 respondents in the first round conducted between October 2019 and February 2020, i.e., before the COVID-19 pandemic, and 3537 respondents in the second round conducted between October 2021 and February 2022, i.e., during the pandemic. The survey covered a broad set of social, political, and economic questions including food preferences, food attitudes, food shopping behavior, political inclination, trust in different institutions, and socioeconomic variables (IPSOS, 2021). Data from the survey has been widely used in consumer research (e.g., Ardebili and Rickertsen, 2020).

The survey aimed at a nationally representative sample, however, respondents with a higher education were overrepresented. About 37 % of the Norwegian adult population (16+ years) had completed higher education (Statistics Norway, 2022) as compared with 65 % of the respondents. The average age of the respondents was 47 years as compared with a national average of 40.5 years (Haug, 2020). This high age was mainly due to the exclusion of respondents below 15 years in the survey, which constituted about 18 % of the population (Statistics Norway, 2023).

3.1. Variable measurement

Our dependent variable was constructed from the question: "Assume that the food will be approved by the health authorities, taste just as good, and be as healthy and nutritious as other foods. How willing or unwilling are you to try meat grown artificially (biologically) in a laboratory."[5] The response alternatives were unwilling, somewhat willing, totally willing, and do not know. The percentage distributions across these alternatives are shown in Fig. 1. In the first round, 3660 (99 %) responded to this WTT CM question. About 43 % were unwilling, 27 % somewhat willing, 25 % willing, and 5 % used the do not know option. In the second round, 3496 (99 %) responded to this question. About 42 % were unwilling, 29 % somewhat willing, 24 % willing, and 5 % used the do not know option.

The survey questions used to construct the variables associated with each hypothesis are shown in the second column of Table 1, the response alternatives are shown in the third column, and the associated constructed variables are shown in the last column. Some variables had missing values due to non-response, and "I do not know" responses were treated as missing values.[6]

3.2. Descriptive statistics

The mean values and standard deviations of the independent variables are shown in Table 2. The values are reported for the total sample and for each round. Respondents with missing values on any of the

[4] Even though the environmental benefits of CM are large, some research question these benefits. Lynch and Pierrehumbert (2019) claim that the sustainability of cultured as compared with conventional beef will depend on the energy system used to produce the cultured beef. Furthermore, there seems to be a knowledge gap related to the environmental impact of different foods among consumers (Abrahamse, 2020; Hartmann et al., 2021).

[5] The questions were asked in Norwegian and translated to English by the authors. The WTT CM question was asked conditional on approval of CM by health authorities and with assurances related to taste, health, and nutrition. These assurances may have reduced concerns related to health and safety.

[6] In the total sample (7,247 respondents), there were missing responses to the WTT CM question (91 respondents), and some respondents used the do not know option (387 respondents). After deleting these respondents, 6,769 respondents remained in the sample. Of these 6,769 respondents, 2,086 respondents did not answer one or several of the questions related to political affiliation (1,404 respondent), trust in authorities (329 respondents), income (251 respondents), trust in retailers (228 respondents), living in an urban area (133 respondents), vegetarian status (90 respondents), food safety (56 respondents), and social trust (48 respondents) leaving 4,683 respondents. Any potential bias from deleting respondents is unknown, however, the distribution between willing, somewhat willing, and unwilling in the final sample (4.683 respondents) is similar to the distribution in the total sample (7.247 respondents).

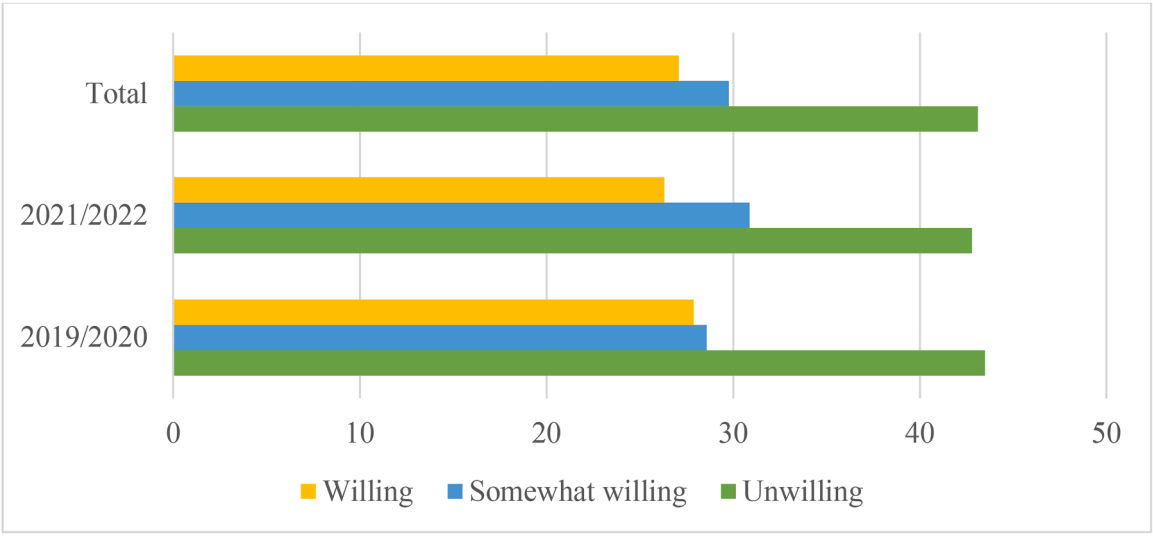

Fig. 1. WTT Cultured Meat Group, Percentage Distributions across Alternatives
Note: Percentage distribution willing, somewhat willing, and unwilling in the total sample and each survey round.

Table 2
Descriptive Statistics.

Variable	Mean Total [a]	SD Total [b]	Mean 19/20 [c]	Mean 21/22 [d]	Mean Willing [e]	Mean Unwilling [f]	p-value [g]
TR	27.38	0.45	28.38	26.45	32.33	23.91	0.000
TFA	78.13	0.41	76.78	79.38	82.33	74.16	0.000
TS	77.79	0.42	76.51	78.97	77.68	76.34	0.374
Green	22.19	0.41	22.33	22.05	33.51	15.50	0.000
Natural	46.87	0.50	45.60	48.05	33.83	58.20	0.000
Health	54.32	0.50	54.67	54.00	55.68	53.32	0.186
Safety	26.67	0.44	27.62	25.79	22.63	31.19	0.000
Novelty	18.81	0.39	18.51	19.10	25.24	14.01	0.000
Familiarity	46.19	0.50	46.22	46.16	46.77	46.04	0.684
Price	54.35	0.50	55.16	53.59	66.48	46.44	0.000
Environment	22.70	0.42	23.84	21.64	25.32	22.43	0.057
AW	31.63	0.47	30.60	32.57	31.15	33.66	0.135
Female	47.96	0.50	47.78	48.13	35.65	56.53	0.000
Education	65.17	0.48	60.94	69.08	62.15	65.20	0.076
Age	46.75	18.12	45.58	47.83	36.84	53.07	0.000
Urban	53.30	0.50	52.85	53.72	65.06	43.32	0.000
Income	45.74	0.50	47.95	43.70	42.27	45.45	0.075
Religion	67.70	0.47	74.06	61.81	51.89	77.23	0.000
Vegetarian	6.13	0.24	6.49	5.79	8.12	5.54	0.004

Notes: [a] For 4,683 respondents in the total sample. [b] Standard deviations for the total sample. [c] For 2,248 respondents in 2019/2020. [d] For 2,435 respondents in 2021/2022. [e] For 1,268 respondents who responded that they were WTT CM. [f] For 2,020 respondents who responded that they were unwilling to try CM. [g] The *p*-value for a *t*-test of identical mean values for respondents who were willing and who were unwilling to try CM.

variables were excluded, which resulted in a sample of 4683 respondents (2248 respondents in 2019/2020 and 2435 respondents in 2021/2022). There are differences between respondents who are willing and unwilling to try CM. The mean values and *p*-values for identical mean values of the variables for these two groups are reported in the last column of the table. The willing group consists of 1268 respondents (27 %), the somewhat willing consisted of 1395 respondents (30 %), and the unwilling group consists of 2020 respondents (43 %).

Fig. 2 illustrates the determinants of willingness to try cultured meat in the total sample and each round. In the total sample, trust in food authorities (78 %) and social trust (77 %) were high and trust in retailers was low (27 %). About 22 % supported green parties. The motives emphasized by most respondents when purchasing food were price (54 %) and health (54 %). Almost half the respondents found natural components (47 %) and familiarity (46 %) to be particularly important. Fewer found animal welfare (32 %), safety (27 %), and the environment (23 %) to be important. About half the sample was female or urban, about two-thirds had completed a bachelor's degree, and less than half (46 %) had above median income. About two thirds identified themselves with a religion, and few were vegetarian (6 %).

The mean values of most variables were similar in the two rounds. Two notable exceptions were education and religion. The number of respondents who had completed a bachelor's degree increased from 61 % to 69 %, and the number of respondents who identified with a religion decreased from 74 % to 62 %. Trust in food authorities and social trust increased slightly during the period while trust in retailers was slightly reduced. The support to green parties remained stable. The respondents in 2021/2022 were on average two years older, and more respondents had below median income.

There were significant differences in many variables between respondents who were willing and unwilling to try CM as shown in the three last columns of Table 2 and illustrated in Fig. 3. Respondents who were WTT CM trusted retailers more than those who were unwilling (32% vs 24 %), trusted food authorities more (82% vs 74 %), and indicated more support to green parties (34% vs 16 %). However, the difference for social trust was small (78% vs 76 %). Respondents who

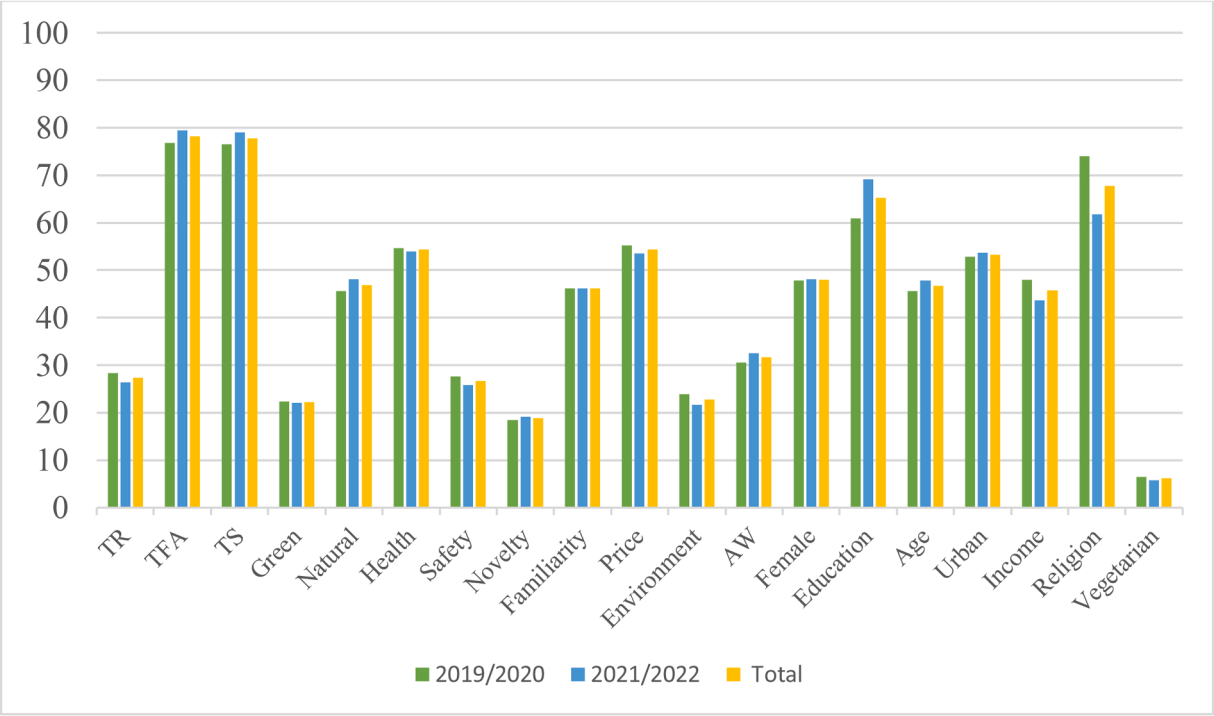

Fig. 2. Determinants of WTT Cultured Meat in the Total Sample and in Each Round
Note: The variables are dummy variables, as defined in the last column of Table 1, except for age in years. Each bar shows the percentage distribution of the alternative coded as one except for age, which shows the average age of respondents in the sample.

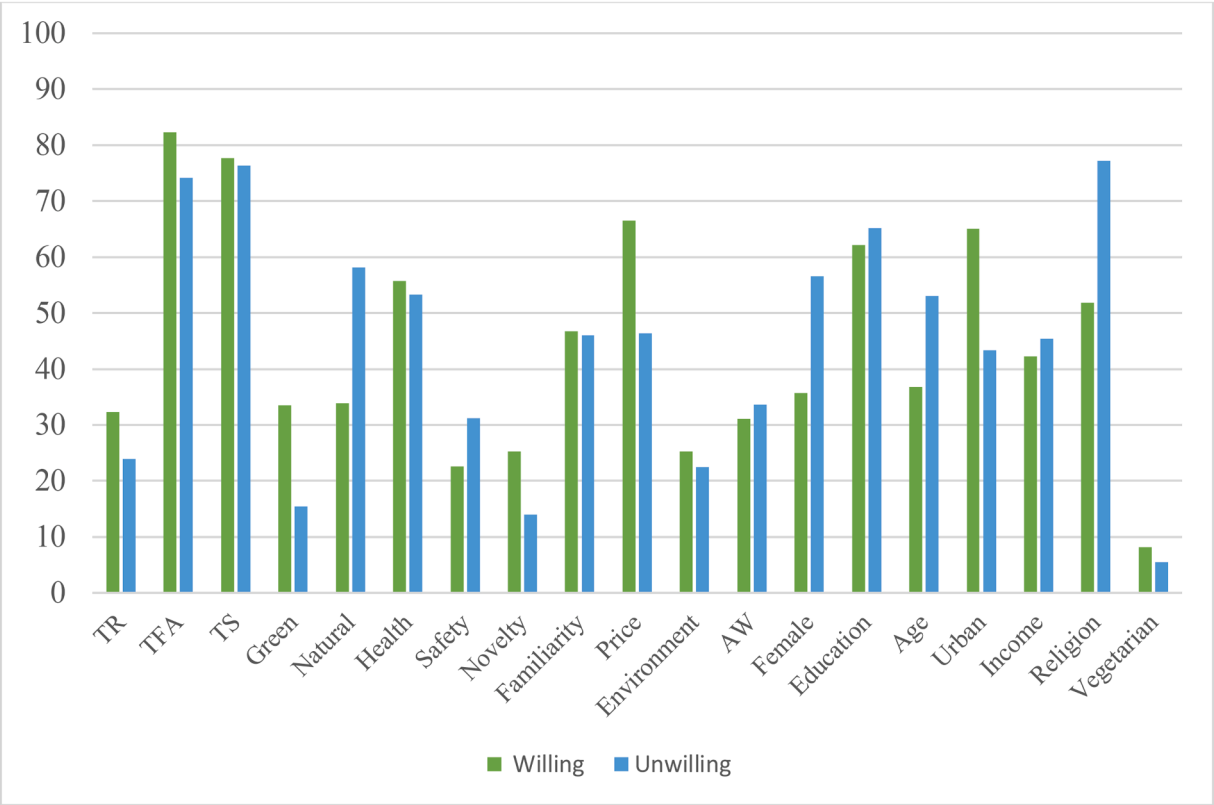

Fig. 3. Determinants of WTT Cultured Meat among Willing and Unwilling Respondents in the Total Sample
Note: The variables are dummy variables, as defined in the last column of Table 1, except for age in years. Each bar shows the percentage distribution of the alternative coded as one except for age, which shows the average age of respondents in the sample.

were WTT CM also emphasized novelty and price more and natural components and safety less than those who were unwilling.

3.3. Statistical model

There are three response alternatives: unwilling to try CM ($WTT = 1$), somewhat willing to try CM ($WTT = 2$), and willing to try CM ($WTT = 3$), and an ordinal logit model was specified:

$$WTT_i^* = X_i\beta + e_i \quad (1)$$

where WTT_i^* is the unobserved WTT, X is a vector of the variables in Table 2, β is the vector of coefficients associated with these variables, and e is an error term that is assumed to follow a logistic distribution. The probability of each alternative is:

$$P(WTT_i > j) = \frac{\exp(\alpha_j + X_i\beta)}{1 + [\exp(\alpha_j + X_i\beta)]} \text{ for } j = 1, 2 \quad (2)$$

and $P(WTT_i = 1) = 1 - P(WTT_i = 2) - P(WTT_i = 3)$ where α_j are the cut-off points.

In Eq. (2), a constant effect of each independent variable for each level of the WTT is assumed, i.e., the proportional odds (PO) assumption. This assumption was tested for each variable by a Wald test, and the assumption was rejected for *Natural* ($p = 0.02$), *TFA* ($p = 0.04$), *Urban* ($p = 0.04$), and *Age* ($p = 0.00$).[7]

In our partial proportional odds (PPO) model, the PO assumption was imposed on the variables for which it was not rejected, X_1, but not on the other variables, X_2. In the resulting PPO model, the probability of each alternative is (Williams, 2006; 2016):

$$P(WTT_i > j) = \frac{\exp(\alpha_j + X_{1i}\beta_1 + X_{2i}\beta_{2j})}{1 + [\exp(\alpha_j + X_{1i}\beta_1 + X_{2i}\beta_{2j})]} \text{ for } j = 1,\ 2 \quad (3)$$

The PPO model was estimated by maximum likelihood estimation using the gologit2 command in Stata version 17 (StataCorp, 2021).

4. Results

The PPO model (3) including a year dummy variable and year interaction terms was estimated to test for identical estimated coefficients in the two rounds. Identical coefficients were not rejected by a likelihood-ratio test ($p = 0.78$), and the results of the model using the total sample are presented. The pseudo R-square value of the model was 0.12, and the cut-off points were significant ($p = 0.00$) implying that our outcome variable is ordinal and the thresholds relevant (Soon, 2010).

The marginal effects (ME) and the associated p-values for the three WTT levels are shown in Table 3. The ME can be interpreted as the effects on the probability of belonging to the associated WTT class of a one unit change in a continuous variable or the effect of not belonging to the reference group for a dummy variable. The reference respondent was a male with low income and education who lived in a rural area, had low trust, did not identify with green parties or any religion, was not a vegetarian, and did not emphasize any of the specified motives when purchasing food. Almost three quarters of the ME were significant at the 5 % level.

The conclusion regarding rejection of each hypothesis is shown in the last column of Table 3. A hypothesis was not rejected when the p-value of the marginal effects for being unwilling ($WTT = 1$) and willing ($WTT = 3$) both were significant at the 5 % level. As expected, the signs of the marginal effects are consistently different for respondents who are willing and unwilling.[8]

The conclusions regarding our hypotheses are in many cases different from the conclusions suggested by the p-values for the test for identical mean values for respondents who were willing and unwilling to try CM as reported in the last column of Table 2. This is the case for trust in retailers, social trust, health, environment, and education. Both the results in Table 2 and Table 3 suggest an effect of being vegetarian. However, the estimation results indicate that vegetarians were less WTT CM, while the p-value in Table 2 suggested that they were more willing. These differences demonstrate the importance of controlling for other factors.

4.1. Trust

Siegrist and Hartmann (2020b) found that their trust index based on trust in food industry, government, retailers, and food scientists was associated with higher acceptance of CM. Our results demonstrates that trust in different actors have different effects on the WTT CM. It was rejected that high trust in retailers is associated with the WTT CM (H_1), which may be an effect of the low level of trust in retailers as shown in Table 2. The results concerning trust in food authorities were mixed, and our hypothesis (H_2) was partly rejected. Higher trust in food authorities reduced the probability of being unwilling by 5.1 percentage points (pp), while the probability of being willing was unaffected. Food authorities have a critical role in ensuring trust in the different CM processes including testing, approval, production, and distribution (Kouarfaté and Durif, 2023; Monaco et al., 2024; Zhang et al., 2021). Respondents with higher social trust were significantly less unwilling (4.7 pp) and more willing (3.3 pp) to try CM, and our hypothesis was not rejected (H_3). Given that consumers view CM to be similar to other novel food technologies, the effect of social trust is in line with Ding et al. (2012) and Muringai (2017) who found that social trust is a determinant of consumers' acceptance for novel foods. The effects of social trust also corroborates with Engel et al. (2024), who found that acceptance of CM among an individual's social network positively influenced the acceptance of CM products in Norway.

4.2. Support to green parties

Our hypothesis about support to green parties (H_4) was not rejected. Respondents who would vote for a green party were significantly less unwilling (11.7 pp) and more willing (9.4 pp) to try CM. These results corroborate with Petersen et al. (2024) who found a positive association of consumption of meat alternatives and support for green parties. Individuals supporting liberal parties have also been found to be more open to CM (Bryant et al., 2019; Wilks and Phillips, 2017; Wilks et al., 2019). However, our green parties included parties on the center/right (The Liberal Party), the center (The Green Party), and the left (The Socialist Left Party), and the green party effect is likely to be associated with green rather than left-wing policies.

4.3. Other food choice motives

Our hypotheses concerning food choice motives were not rejected for natural components (H_5), health (H_6), safety (H_7), novelty (H_8), price (H_{10}), and the environment (H_{11}), and these results mostly correspond well with previous results as discussed in Section 2.3. For respondents

[7] The PO assumption was tested by an iterative procedure as described in Williams (2006) and using the autofit command in Stata version 17 (StataCorp, 2021). First, the ordinal logit model (2) was estimated. Second, a Wald test was conducted for each variable to test whether the associated coefficients were identical across the equations. Third, identical coefficients of the least significant variable were imposed. Fourth, this procedure was repeated until no more variables were found to meet the PO assumption.

[8] The effects of being somewhat willing ($WTT = 2$) were not considered because this category is in the middle position. However, except for *Age* and *Vegetarian*, the conclusions regarding significance are identical. Moreover, the signs of the marginal effects are identical for the categories somewhat willing and willing.

Table 3
Marginal Effects (ME) on the Willingness to Try Cultured Meat.

	WTT = 1 [a]		WTT = 2		WTT = 3		
Variable	ME	p-value	ME	p-value	ME	p-value	Conclusion [b]
TR	0.022	0.185	−0.006	0.203	−0.016	0.179	Rejected
TFA	−0.051	0.008	0.046	0.012	0.005	0.747	Partly rejected
TS	−0.047	0.008	0.014	0.015	0.033	0.006	Not rejected
Green	−0.117	0.000	0.023	0.000	0.094	0.000	Not rejected
Natural	0.139	0.000	−0.069	0.000	−0.070	0.000	Not rejected
Health	−0.053	0.000	0.015	0.001	0.038	0.000	Not rejected
Safety	0.058	0.000	−0.018	0.002	−0.040	0.000	Not rejected
Novelty	−0.087	0.000	0.018	0.000	0.068	0.000	Not rejected
Familiarity	0.020	0.162	−0.006	0.167	−0.014	0.162	Rejected
Price	−0.041	0.008	0.011	0.009	0.029	0.007	Not Rejected
Environment	−0.049	0.010	0.012	0.004	0.037	0.014	Not rejected
AW	0.006	0.738	−0.002	0.740	−0.004	0.737	Rejected
Female	0.190	0.000	−0.052	0.000	−0.137	0.000	Not rejected
Education	−0.060	0.000	0.018	0.001	0.042	0.000	Not rejected
Age	0.007	0.000	−0.000	0.478	−0.007	0.000	Not rejected
Urban	−0.113	0.000	0.059	0.000	0.054	0.000	Not rejected
Income	0.023	0.123	−0.006	0.126	−0.017	0.123	Rejected
Religion	0.105	0.000	−0.025	0.000	−0.081	0.000	Not rejected
Vegetarian	0.064	0.045	−0.021	0.083	−0.043	0.030	Not rejected

Notes: For 4,683 respondents in the total sample, and the log likelihood of the model was −4434.82. [a] $WTT = 1$ is unwilling, $WTT = 2$ is somewhat willing, and $WTT = 3$ is willing to try CM [b] Each null hypothesis was tested at the 5 % level. A hypothesis was not rejected when the *p*-value of the marginal effects for being unwilling ($WTT = 1$) and willing ($WTT = 3$) both indicated significance at the 5 % level.

who emphasized the importance of food being made from natural components, the probability of being unwilling increased (13.9 pp), and the probability of being willing decreased (7.0 pp). For respondents who emphasized the fear of getting sick from the food, the probability of being unwilling increased (5.8 pp), and the probability of being willing decreased (4.0 pp). Respondents who emphasized health, novelty, price, and the environment were more willing and less unwilling to try CM. The probabilities for being unwilling were reduced (4.1 to 8.7 pp), and the probabilities for being willing increased (2.9 to 6.8 pp).

The positive effects of price on WTT CM are somewhat surprising. Consumers anticipate CM to be expensive, which would function as a barrier against acceptance (Bryant and Sanctorum, 2021; Wilks and Phillips, 2017). The effects of price may be due to a wealthy population in a country with an equal income distribution (Bazzani et al., 2018). Given the progress within CM development and production costs (Tsvakirai, 2024; Tsvakirai et al., 2024), consumers may also expect that future CM products will be offered at competitive prices in comparison to conventional meat.

Our hypotheses regarding familiarity (H_9), and animal welfare (H_{12}) were rejected. Familiarity had no significant effects, which contrasts with the findings in Bryant et al. (2019) and Mancini and Antonioli (2019) who found familiarity to be a significant predictor for intent to purchase CM. This result suggests that food neophobia is less important for WTT CM in Norway than in some other countries. Furthermore, animal welfare concerns did not significantly affect the willingness, which corroborates with the findings from Engel et al. (2024) but also contrasts with the results in Asioli et al. (2021) and Weinrich et al. (2020) who found that high animal welfare concerns were associated with openness towards CM. Given the unavailability of CM in the Norwegian market, consumers may be unaware of animal welfare benefits of CM or unable to perceive them given that CM still depends on the use of live animal tissues. Furthermore, as the familiarity of CM increases, consumers may better understand the animal welfare related benefits. It is also further interesting to note that animal welfare concerns have been found to be low among Norwegians (Kjærnes et al., 2022).

4.4. Individual characteristics

Our hypotheses concerning individual characteristics were not rejected for females (H_{13}), education (H_{14}), age (H_{15}), urban living (H_{16}), religious identification (H_{18}), and being vegetarian (H_{19}). Females were more likely to be unwilling (19.0 pp) and less likely to be willing (13.7 pp). For higher educated and urban respondents, the probability of being unwilling decreased (6.0 and 11.3 pp), and the probability of being willing increased (4.2 and 5.4 pp). A one-year increase in age, increased the probability of being unwilling (0.7 pp) and reduced the probability of being willing (0.7 pp). For respondents who identified with a religion, the probability of being unwilling increased (10.5 pp), and the probability of being willing decreased (8.1 pp). Finally, for vegetarians, the probability of being unwilling increased (6.4 pp), and the probability of being willing decreased (4.3 pp).

These results correspond well with previous results as discussed in Section 2.4. Respondents who identified with a religion were significantly more unwilling and less willing to try CM, which corresponds with Asioli et al. (2021) who found that non-religious individuals had a lower willingness to pay for CM. Vegetarians were significantly more unwilling and less willing to try CM. This finding is in line with Bryant et al. (2020) and Shaw and Iomaire (2019) who found that vegetarians had a lower acceptance for CM.[9] Corroborating with recent reviews (Deliza et al., 2023; Onwezen and Dagevos, 2024), our results indicate that CM will be more attractive for consumers interested in reducing their meat consumption suggesting that CM will receive higher acceptance among flexitarian meat eaters

It was rejected that income affected the WTT CM (H_{17}). The reported effects of income have been mixed. However, our result is in line with Wilks et al. (2019), who did not find income to be a predictor of willingness to eat CM in the US, and Engel et al. (2024) who did not find income to be associated with the intention to consume cultured proteins in the Nordic countries. This lack of association may be the effect of a wealthy population in a country with an equal income distribution (Bazzani et al., 2018). Klöckner et al. (2022) also found that there were very small differences between how higher income Nordic consumers perceived the benefits of CM compared to lower income consumers.

4.5. Before and during COVID-19

As described above, identical coefficients before and during the pandemic were not rejected, which suggests that COVID-19 overall had

[9] Quite interestingly, Oven et al. (2022) found that even though vegetarians were less willing to eat CM, they were more willing to feed it as pet food.

minor effects on the factors determining the WTT CM. When the model was estimated on the before and during pandemic samples separately, the signs of the coefficients in both these models were identical to the signs of the coefficients that are significant at the 5 % level in Table 3.

In both the sub samples, the effects of being vegetarian were insignificant while they were significant in the total sample. Furthermore, several significant coefficients in the total sample were insignificant in the before pandemic sample. Trust in food authorities and social trust had insignificant effects on being unwilling to try CM and trust in food authorities had an insignificant effect on being willing to try CM. These results are in line with Devine et al. (2020) who found that institutional and social trust increased from the implementation of lockdowns.

Emphasizing health, price, and the environment had insignificant effects on being both unwilling and willing to try CM in the before pandemic sample but significant effects in the during pandemic sample. These results are partly in line with the results in Skalkos and Kalyva (2023), who found reduced importance of health and increased importance in price, familiarity, and environmental concern due to the pandemic in their multi-country review study.

5. Conclusions

The associations between WTT CM and trust, support to green parties, food choice motives, and individual characteristics were investigated using a large survey. The survey was conducted before and during the COVID-19 pandemic with a total of 4683 usable responses. About 27 % were WTT CM, 30 % were somewhat willing, and 43 % were unwilling.

A partial proportional odds model was estimated, and identical coefficients before and during the pandemic were not rejected. Trust in food authorities and social trust were important but no effects were found for trust in retailers. High trust in food control authorities reduced the unwillingness to try CM. Furthermore, respondents with high social trust were less unwilling and more willing to try CM. Respondents voting for green parties were less unwilling and more willing to try CM. Respondents who emphasized natural components and food safety were less willing to try CM, while respondents who emphasized health, novelty, the environment, and price were more willing. Respondents who identified themself as religious or vegetarian were less willing to try CM.

This study has some limitations. First, we use data from a national survey covering many subjects, and the survey questions did not specifically focus on WTT CM. A survey with a specific focus on WTT CM could have included other and more detailed questions. However, the advantage of this survey is that it included a large sample over two years with many relevant questions. Second, as described above the sample was more educated than the population. Given that more educated respondents were more WTT CM, this may give an upward bias in the WTT CM. Third, in a survey reported intent to consume rather than actual behavior is reported, and there could be a disparity between real life choices and intent (e.g., Vermeir and Verbeke, 2006).

There are several marketing implications of our results. First, trust in food authorities reduced the unwillingness to try CM, which offers an opportunity to provide information focusing on the similarities rather than the differences with conventional meat. Specifically, terms like clean meat based on natural ingredients and terms highlighting CM benefits should be used in the information rather than high-tech meat or other technical words with a negative connotation as also discussed in Deliza et al. (2023) and Siddiqui et al. (2023). Concerns over getting sick from food reduced the WTT CM indicating. Information should therefore emphasize CM as an alternative with less risk for exposure to pathogens and emphasize personal nutritional and health benefits that may be accrued. Second, given the importance of social trust, CM could be introduced and promoted in social settings allowing consumers to eat CM among their social networks and observe others consuming it. This could promote the social acceptability of CM given the cultural influences and aspects related to meat consumption as discussed in Engel et al. (2024) and Onwezen and Dagevos (2024). Third, our results suggest that early adopters of CM are likely to be male, highly educated, young, living in an urban area, non-religious, and non-vegetarian. The stability in determinants of the WTT CM during a major event such as the COVID-19 pandemic emphasize that marketing activities and information should target these groups who already are willing to try CM. Finally, it is important that CM products are produced in environmentally friendly ways focusing on sustainability and reducing the environmental impacts of meat and that consumers are informed of this.

Ethical statement

Norwegian Monitor Survey is a syndicated Ipsos study. Ipsos complies with the Data Protection Act and is obliged to comply with the European Data Protection Regulation (GDPR) regarding the processing of personally identifiable information. Ipsos AS is a member of the Norwegian Market Analysis Association (NMF) and is Quality Management System (ISO 9001) and Market, Opinion and Social Services (ISO 20252) certified. Ipsos is also a member of European Society for Opinion and Marketing Research (ESOMAR) and follows the guidelines set by ESOMAR. These guidelines regulate issues of ethics and confidentiality in market research. Further Ipsos AS has their own data protection officer (DPO). Consent from participants were obtained according to GDPR and ISO 20252 guidelines.

Ethical statement

The data used in this study is from the Norwegian Monitor conducted by Ipsos. Ipsos is a market and social research company and follows the EU General Data Protection Regulation (GDPR). It is also a member of ESOMAR, bound by the ICC/ESOMAR Code on Market and Social Research.

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CRediT authorship contribution statement

Sarah Wangui Muiruri: Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Kyrre Rickertsen:** Writing – review & editing, Supervision, Methodology, Data curation, Conceptualization.

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

The authors do not have permission to share data.

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Norwegian consumers' willingness to try food made from insects: The role of trust, food choice motives and OCEAN personality traits

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ABSTRACT

Entomophagy, the consumption of insects, may reduce the negative health and environmental impacts of meat. As one of the novel protein alternatives expected to replace conventional meat consumption, its success will depend on consumer acceptance. To investigate the consumer acceptance of entomophagy, three rounds of a Norwegian survey with 8633 useable responses conducted in 2019/2020, 2021/2022, and 2023/2024 were used. Generalized structural equation modelling was used to test the developed hypotheses. The direct effects of trust, food choice motives, and OCEAN personality traits were investigated. The mediating effects of food safety concerns on the relationship between trust and willingness to try (WTT) food made from insects were also investigated. Social trust and trust in food authorities were positively associated with WTT. No association was found for trust in retailers. Negative associations were found between the effects of social trust and trust in food authorities on food safety concerns, and food safety concern was also a significant mediator. Respondents who emphasized environmental friendliness, health, and novelty were more willing to try, and those who emphasized natural ingredients and familiarity were less willing. Openness was positively associated with WTT, while conscientiousness, extraversion, and agreeableness had a negative association. Gender, education, age and urban living were also found as significant moderators in some paths. The findings of the study imply the need to foster trust among consumers and to emphasize the environmental and health benefits of entomophagy while focusing on increasing consumer familiarity and use of natural ingredients. Personality-focused marketing strategies may also be implored to target consumers high in openness and low in conscientiousness, extraversion, and agreeableness.

1. Introduction

The need for sustainable food production and sustainable food consumption is a growing global need given the environmental, health, and economic impacts of food. Current food systems are estimated to account for 21–37 % of global anthropogenic greenhouse gas (GHG) emissions [1], and diet-related risk factors have been identified as a leading cause for the rising prevalence of non-communicable diseases (NCDs) [2]. Furthermore, the current global food systems have been identified as economically disadvantageous. It is estimated that the unaccounted annual costs of the present global food systems are approximately 15 trillion USD (20 % of global GDP) and that transforming these food systems would generate 5–10 trillion USD a year [3].

While sustainable food consumption is desirable, it is a wide thematic area, and efforts to identify efficient, appropriate measures are continuously been assessed. The need for a dietary shift is among the measures that have been widely highlighted, with the call to reduce meat consumption among the identified action points [4,5].

Meat consumption and production are associated with negative health, environmental, and animal welfare implications. Meat production is responsible for 19 % of the global greenhouse gas (GHG) emissions and is the highest contributor to methane emissions [6,7]. On the health impact of meat, the consumption of red meat is associated with NCDs such as cardiovascular diseases [8], and the consumption of both red and highly processed meat products is acknowledged to be probably carcinogenic [9]. The negative animal welfare implications of meat production including overcrowding, poor nutrition, and production intensification resulting to production diseases, also raise concern about the ethical stand of meat production and consumption [10,11].

The consumption of insects, known as entomophagy, is proposed as a sustainable alternative to meat consumption with the potential to combat food insecurity and transform the present food systems by

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offering a healthy and environmentally sustainable meat alternative [12–14]. Compared to conventional meat production, insect rearing has less negative environmental impacts. It is less resource-intensive requiring minimal land water, and insects can be fed with food waste and other agricultural waste products, thus promoting circularity [15,16]. Insects also have a higher feed conversion rate compared to livestock and poultry [14,17]. On the healthiness of insects, insects vary in their protein content based on their growth and species, but generally have higher protein content than fish, poultry, and beef [12,18]. They are also rich in fatty acids, fiber, amino acids, and vitamins, among other nutritional components [13,19].

While entomophagy is common in some Asian and African societies [15] with about two billion people worldwide regularly consuming insects [14], it is novel and almost non-existent in Western societies [13,15,20]. Recent market developments show that, investments in the insects' industry have been growing, and that they are expected to reach 3 billion euro by 2030 [13]. Advancement within the regulation of the sale of insects for human consumption has evolved over the years [21,22]. Within the EU, since 2018, insects were recognized as novel food, and their marketing and sale are regulated under the EU novel foods regulations, which require thorough safety assessments and approvals [22]. While Norway is not an EU member, it is part of the European Economic Area (EEA) and upholds the EU novel foods regulation [23]. The US and Canada also recognize insects as a novel food, and sales and marketing approvals must be sought from The US Food and Drug Administration (FDA) and Health Canada, respectively [22].

Understanding consumer acceptance and potential drivers and barriers of entomophagy is important, and research in this area has been growing, with several recent review studies focusing on this subject [12,13,15,16,24–27]. Some recurring factors that seem to affect the consumer acceptance of entomophagy include food neophobia, disgust, taste and environmental and health concern. Furthermore, the type of insect species and the extent of food processing, including the visibility of the insects, also appear to affect the acceptance of entomophagy [28]. This study adds to the existing literature by investigating the consumer acceptance of entomophagy among Norwegian consumers. The study used data from three rounds of a large survey conducted bi-annually with 8633 useable responses.

The study contributes to the literature in four ways. First, this is the first study to investigate the effects of social trust and trust in retailers on the willingness to try (WTT) food made from insects. Previous studies have investigated the effect of trust in regulators and media. Trust in regulators and trust in media were found to positively affect the intention to purchase insects [29,30]. Moreover, trust in food safety public authorities was also found to be positively associated with willingness to buy and willingness to pay for insect-fed food products [31,32]. Given the novelty of entomophagy, trust is expected to play a key role in encouraging consumers by providing safety and health assurances and promoting social acceptability [24,25].

While trust in different actors may be important, possible mediation effects between trust and food safety perceptions may exist. In this study, the possible mediation effects of food safety perceptions on the effect of trust on the WTT food made from insects were tested. The fear of falling sick from food, referred to as safety within the food value literature [33,34], may affect food choices and understanding its association with trust and WTT food made from insects may provide useful insights. Previous research found that risk perceptions mediated the effect of trust in regulators on the intention to purchase insects [29].

Thirdly the effects of personality traits on the WTT food made from insects were investigated. The effects of personality traits on the consumer acceptance of entomophagy have been little investigated, and in this paper the OCEAN personality traits framework consisting of five personality traits groups: openness, conscientiousness, extraversion, agreeableness and neuroticism (OCEAN) was used. An earlier study that investigated the effect of OCEAN personality traits on disgust and interest on entomophagy among Japanese consumers found that conscientiousness and neuroticism were positively associated with disgust while openness had a negative association [35].

Fourthly, while the consumer acceptance of entomophagy among Norwegian consumers has been earlier investigated [36], this study contributes to this literature by using data from three rounds of a large nationally representative survey. The results from the study provide a more comprehensive overview of the consumer acceptance of entomophagy among Norwegian consumer, including how it has evolved over time.

2. Conceptual framework and hypotheses development

In this section, the potential determinants of WTT food made from insects are discussed. The discussion includes trust and safety, environment, health, natural ingredients, novelty, familiarity, and personality traits. Table 1 summarizes the survey questions, response choices, and the variable constructs used in the analyses, and Fig. 1 shows the conceptual framework of the study.

2.1. Determinants of willingness to try food made from insects

2.1.1. Trust and safety

Often, consumers are faced with incomplete information and left to rely on heuristics, such as trust, when making decisions including food choices [37–39]. Trust becomes even more useful when decisions involve the consumption of novel foods [38]. Broadly, trust has been grouped into two categories; social trust (generalized trust) and institutional trust [40–42], and both categories of trust have been found to be important in the consumer acceptance of novel foods such as genetically modified foods and cultured meat [40,42–44].[1]

For entomophagy, trust in regulators and the media have been found to be significant drivers of the intention to purchase insects [29,30] and insect-fed food products [31,32]. Additionally, some qualitative studies have highlighted that public health institutions may play a convincing role in the consumer acceptance of entomophagy [45].

Several diseases can be potentially transmitted to humans through the consumption of insects [12], but the harmfulness of these disease pathogens greatly reduces through proper processing [13]. Proper safety assessment frameworks are expected to ensure that insects on sale are safe to consume which also fosters trust among consumers. Generally, consumers appear to have safety concerns about entomophagy which negatively affects their acceptance [15,24,25]. Consumers expect that mandated authorities conduct proper safety assessments before insects are marketed [15] and providing information on the safety of the insects was found to increase the acceptance of entomophagy [25,46].

H1. Social trust positively affects WTT food made from insects.

H2. Trust in food authorities positively affects WTT food made from insects.

H3. Trust in retailers positively affects WTT food made from insects.

H4. Food safety concerns negatively affect WTT food made from insects.

H5. Social trust positively affects food safety concerns.

H6. Trust in food authorities positively affects food safety concerns.

H7. Trust in retailers positively affects food safety concerns.

[1] Social trust implies overall trust in people while institutional trust implies trust in food value players such as farmers, manufacturers, retailers, food authorities and the media [41].

Table 1
Survey question, response choices and variable constructs[a].

Survey Question	Survey Response Choices	Variable Constructs
Trust and safety		
How much trust do you have in the following institutions that exist in our society? One alternative was: The large grocery stores	4 choices: Very high trust, somewhat high trust, somewhat low trust and no trust	Trust in food retailers = 4 if very high trust = 3 if somewhat high trust, = 2 is somewhat low trust and = 1 if no trust
How much do you agree or disagree with the following statements about food and food safety?[b] One alternative was: Norwegian authorities control the food so that only food that is safe to eat is sold in stores	4 choices: Totally agree, somewhat agree, somewhat disagree and totally disagree	Trust in food authorities = 4 if totally agree, = 3 if somewhat agree, = 2 is somewhat disagree and = 1 if disagree
Do you think at all that you can trust most people, or do you think that you cannot be careful enough in dealing with people?	3 alternatives: Can trust most people, cannot be careful enough and in doubt	Social trust = 3 if can trust most people, = 2 if cannot be careful enough and = 1 if in doubt
People feel fear for different things in life. How much fear do you feel for each of the following things? One alternative was: Get sick from the food you eat	3 alternatives: great fear, moderate and little or no fear.	Safety = 3 if great fear, = 2 if moderate fear and = 1 little or no fear
Other food choice motives		
When purchasing food for yourself and your household, which of the factors below do you consider to be particularly important? Five of the alternatives were:	Tick if appropriate	Food choice motives variables
The food is healthy		Health = 1 if health is selected and = 0 otherwise
The food is made from natural components		Naturalness = 1 if made from natural components is selected and = 0 otherwise
The food is environmentally friendly		Environmentally friendly = 1 if environmentally friendly is selected and = 0 otherwise
The food is something new and exciting		Novelty = 1 if something new and exciting is selected and = 0 otherwise
Eaten the food before		Familiarity = 1 eaten the food before is selected and = 0 otherwise
Personality traits		
Below are descriptions that suit different people more or less well. How good do the descriptions fit you? Tick the box that best suits you as you usually are.	7 choices: 1 = does not fit to 7 = totally fits	Personality traits latent variables
Is original, comes up with new ideas		Openness latent variable
Has a lively imagination		
Likes to speculate, play with ideas		
Has few artistic interests[c]		
Does a thorough job		Conscientiousness latent variable
Tends to have little order in life[c]		
Make plans and follows them		
Can be careless[c]		
Is talkative		Extraversion latent variable
Tends to be quite[c]		
Is outgoing and social		
Can be shy and inhibited[c]		
Can be cold and distant.[c]		Agreeableness latent variable
Is helpful and unselfish in relation to others		
Can sometimes be rude[c]		
Is considerate and friendly towards most people		
Is depressed[c]		Neuroticism latent variable
Is relaxed, copes well with stress		
Worries a lot[c]		
Gets easily nervous[c]		
Demographics		
What is your gender?	2 alternatives: Male or female	Female = 1 if female, 0 otherwise
What is your age?	Age in years (continuous)	Older = 1 if age >48 (median age)
What is your highest completed education?	Five alternatives: Primary school, secondary school, high school, bachelor's degree, graduate, and postgraduate studies	Higher educated = 1 if education is bachelor's degree or more, 0 otherwise
How would you characterize where you live now?	Nine alternatives: Large city (central location), large city (outer districts), suburb of big city, medium-sized city (central location), medium-sized city (outer districts), suburb of medium sized city, smaller city, and village	Urban = 1 if large city, suburb, medium-sized city, 0 otherwise

[a] The survey was administered in Norwegian, and the survey questions are translations from the author.
[b] Totally agree is assumed to be similar to very high trust and disagree, no trust.
[c] The scales of these items were reversed when constructing the personality trait constructs.

2.1.2. Other food choice motives

2.1.2.1. Environment. The environmental impact of a food product largely depends on its production process [33,34]. Insects have a lower environmental impact that requires less land and water, depends on organic waste as feed, and emits lower GHG emissions [14–16,25,47]. Moreover, their high feed conversion rate implies lower feed demand [14]. Review studies show that consumers with pro-environmental attitudes have a higher acceptance of entomophagy and providing information on the environmental benefits of entomophagy increases consumer acceptance [13,15,24–26,46].

H8. Placing emphasis on environmental friendliness when purchasing food positively affects WTT food made from insects.

2.1.2.2. Health. Consumers are increasingly gaining health consciousness in their food intake, and this seems to affect their food choices [48]. Insects have been proposed as a healthy meat substitute rich in protein, fatty acids, amino acids, minerals, vitamins, and antioxidants [12,14,18,

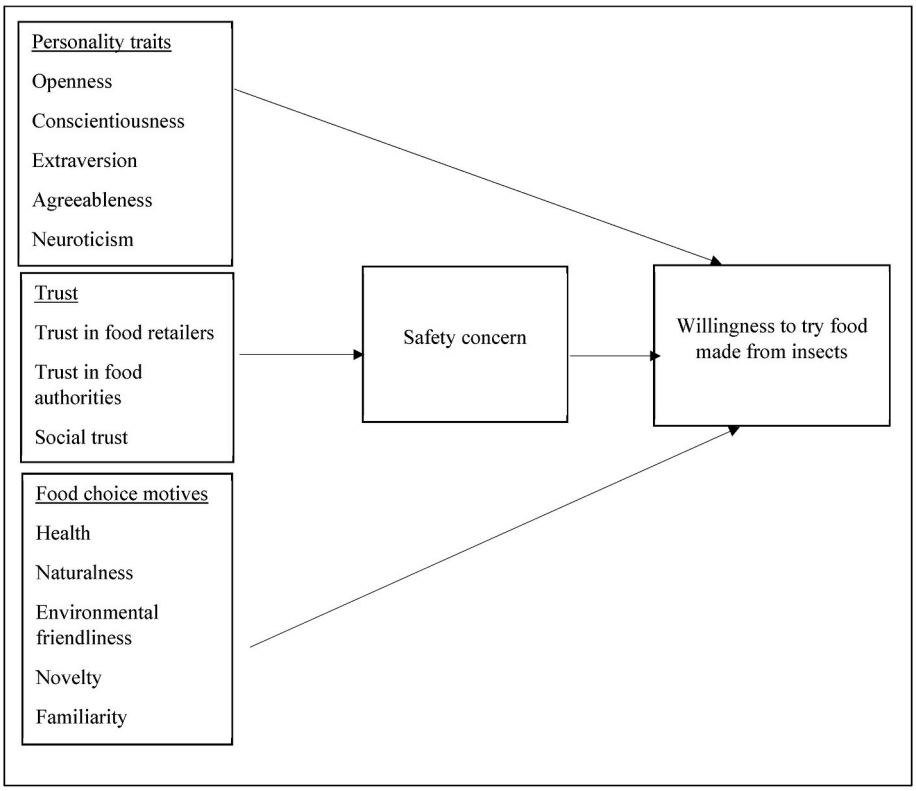

Fig. 1. Conceptual framework.

19]. Findings from recent review studies show that consumers with higher health consciousness have a higher acceptance of entomophagy and offering health benefits information also increases consumer acceptance [15,24–26]. Among consumers that perceive conventional meat as healthy the acceptance for entomophagy is lower [49,50].

H9. Placing emphasis on health when purchasing food positively affects WTT food made from insects.

2.1.2.3. Natural ingredients. The natural-is-better heuristic makes it less mentally exhaustive when making food choices, with "natural" products being generally viewed with a sense of authenticity [38,51,52]. Naturalness is a vague descriptive attribute, and the extent of food processing, additives levels, natural ingredients, and application of modern technology are among the ways food naturalness has been assessed [33,34,53,54]. In the context of entomophagy, previous studies found that insects were perceived as natural among Dutch and Australian consumers [55,56]. Moreover, perceived naturalness positively affected the willingness to pay for food made from insects [57] and consumers who perceived entomophagy as unnatural had a lower acceptance [58].

H10. Placing emphasis on natural ingredients when purchasing food positively affects WTT food made from insects.

2.1.2.4. Novelty and familiarity. With modern technology and intensive product differentiation, the food market is continually expanding giving room to many novel products [33]. Food neophobia and food neophilia are important factors in consumers' food choices [59,60]. Food neophobia is characterized by a resistance towards unfamiliar foods [61] and often results from disgust, risk perceptions, or sensory appeal [59] while food neophilia is an appeal towards new food products often resulting from variety seeking, curiosity and sensational seeking [62,63]. Among consumers, food neophobia has been found to be a recurring barrier and unfamiliarity with eating insects results in lower acceptance of entomophagy [24,25,27]. Curiosity and sensational seeking have also been found to be motivators of entomophagy [24,64].

H11. Placing emphasis on something new and exciting when purchasing food positively affects WTT food made from insects.

H12. Placing emphasis on having eaten the food before when purchasing food negatively affects WTT food made from insects.

2.1.3. Personality traits

McCrae and Costa (2003, p. 25) [65] described personality traits as "dimensions of individual differences in tendencies to show consistent patterns of thoughts, feelings and actions". The five-factor model (FFM) of personality includes five personality traits groupings namely openness, conscientiousness, extraversion, agreeableness and neuroticism, and commonly referred to as The Big Five or OCEAN personality traits [65]. Openness is characterized by the excitement and willingness to try out new things, conscientiousness by being goal oriented with the need to achieve highly, extraversion by interactions and being sociable and friendly, agreeableness by being harmonious, kind and willing to conform and neuroticism by emotional instability involving sadness and being irritable [65].

Several studies have found associations between OCEAN personality traits and food choice behaviors. Higher conscientiousness and neuroticism,among Japanese consumers, were positively associated with disgust towards entomophagy, while openness had a negative association [35]. Among UK consumers, higher extraversion and openness were associated with a higher willingness to consume insects [66]. Norwegian consumers with higher conscientiousness had a higher acceptance of genetically modified salmon while those with higher agreeableness resisted genetically modified (GM) salmon [67]. Lastly, consumers higher in openness had a higher willingness to pay (WTP) for GM pork in The US, China, and Italy, while those high in conscientiousness had a lower WTP in The US and Italy [68].

H13. Openness positively affects WTT food made from insects.

H14. Conscientiousness negatively affects WTT food made from insects.

H15. Extraversion positively affects WTT food made from insects.

H16. Agreeableness negatively affects WTT food made from insects.

H17. Neuroticism negatively affects WTT food made from insects.

3. Data and methods

3.1. Survey and variable measurements

The data needs of the study were met using the 2019/2020, 2021/2022, and 2023/2024 rounds of the Norwegian Monitor Survey (NMS) [69]. The survey targeted a nationally representative Norwegian sample and has been conducted bi-annually since 1985, broadly covering social, political, and economic subjects including food preferences. The survey rounds ran from October to February and involved an initial telephone interview to obtain consent and socio-demographic information. Upon consenting, participants received a detailed questionnaire by mail. Several earlier studies have used the NMS [43,67].

There were 3710, 3537, and 3471 respondents in the three rounds, respectively, leading to a total of 10,718 respondents. Some of the respondents had missing responses to one or more questions, and listwise deletion was employed. I don't know, or impossible to answer responses were also treated as missing, and after deletion, 8633 useable responses were left. The variables missing most responses were trust in food authorities (5 % of respondents) and trust in retailers (3 % of respondents).

To measure the willingness to try insects, the respondents were asked, *"Assume that the food will be approved by the health authorities and taste just as good and be as healthy and nutritious as other foods. How willing or unwilling are you then to try food made from insects."* The response choices were 1(unwilling), 2 (somewhat willing) and 3 (willing).

The OCEAN personality traits were measured using the Norwegian version, BFI-20, included in the NMS and developed by Engvik and Clausen [70]. This version follows the five-factor model, and the personality traits are measured using 20 items, with each of the five personality trait measures consisting of four items [70]. This shorter version is useful given time constraints and was developed from BFI-44, an earlier version consisting of 44 items [71]. The BFI-20 was adequately validated by measures of structural validity, factor divergence, maximal representation, test-retest reliability, and criterion validity [70].

3.2. Statistical analyses

3.2.1. Measurement model

Measurement models estimate latent variables from a set of observed item responses, while linear regression models estimate the relationship between continuous responses and latent or observed covariates [72]. A confirmatory factor analysis (CFA) was performed to measure the latent personality traits. All the personality traits items were measured on a 7-point Likert scale, 1 = does not fit and 7 = totally fits. Subsequently, factor scores were predicted and used as predictors in the main model.

The reliability and validity of the of the BFI-20 were evaluated using several measures. The indicator reliability was assessed using the standardized factor loadings and values ≥ 0.5 were deemed reliable [73]. The internal consistency reliability was assessed using the Cronbach's alpha test and Composite Reliability (CR) test. For both, values greater than 0.6 were deemed reliable [72]. The convergent validity was assessed using the Average Variance Extracted (AVE) test and values greater than 0.5 deemed reliable [72].

3.2.2. Structural equation modelling

Structural equation modelling (SEM) estimates complex relationships and is often a two-part process combining measurement models and linear regression [72]. SEM allows the estimation of various models within the same framework, and path diagrams are used to illustrate the conceptual framework of the models [74]. Mediation models can also be included within SEM frameworks, and both direct and indirect effects estimated [72]. Since SEM assumes multivariate normality, it is only applicable when this is met, thus restricting binary, ordinal, and multinomial measures [74].

Generalized structural equation modelling (GSEM) provides a broader use of structural equation modelling by combining SEM and generalized linear modelling [75,76]. It is, therefore, applicable when dealing with generalized linear responses with binary, ordinal, categorical, or count outcomes [75,76].

To model the structural component, GSEM was used. Both the main model and the mediation model followed an ordinal logit distribution, given that WTT and safety were measured using ordinal scales. To assess the GSEM model goodness of fit, a second GSEM model following an ordinal probit distribution was estimated, and the Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) statistics compared.[2] The model using ordinal logit was retained given almost identical AIC and BIC values.

Given possible sub-group variations, to complement the GSEM model, the effects of sociodemographic factors were evaluated by performing multigroup analyses (MGA) [77]. The MGA involved estimating multiple GSEM models on sub-samples based on gender, education, age and urban living.[3] Afterwards, the Wald test was used to test whether significant differences, related to gender, education, age and urban living, existed, in the main structural model path relationships. All the analyses were computed using Stata 18 [78].

4. Results

4.1. Demographic profile of respondents

About half of the respondents were female and lived in urban areas. Two-thirds of the respondents had at least a bachelor's degree and the average age was about 47 years.[4]

4.2. Descriptive analysis

4.2.1. Willingness to try

About 40 % of the respondents were unwilling, 31 % were somewhat willing, and 29 % were willing to try food made from insects. The willingness to try food made from insects over the three rounds also appeared stable, as shown in Fig. 2. Results from the Pearson Chi-Square test of association ($p = 0.081$) also suggested that there was no association between WTT and year.

[2] Most of the goodness of fit assessment measures used in sem such as the chi-square (χ^2) test, root mean squared error of approximation (RMSEA), standardized root mean squared residual (SRMR), comparative fit index (CFI) and the Tucker-Lewis index (TLI) are based on the joint-normality of observed variables assumption, and they are therefore not available after gsem estimation [76]. Primarily, Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) statistics are used to assess model's goodness of fit after GSEM.

[3] Since age was measured as a continuous variable, for the multi-group analyses, a dummy variable representing older respondents (respondents above the median age of 48 years) was created and used for comparison.

[4] The sample was nationally representative in terms of gender [79]. In addition, the difference between the sample mean age and population mean age (47 versus 40) [80] was small. This difference may be because the population below 15 years makes up 18 % of the total population and these do not participate in the survey [81]. For education, the higher educated were over-represented in the sample. The population proportion of higher educated individuals was 36.9 % [82].

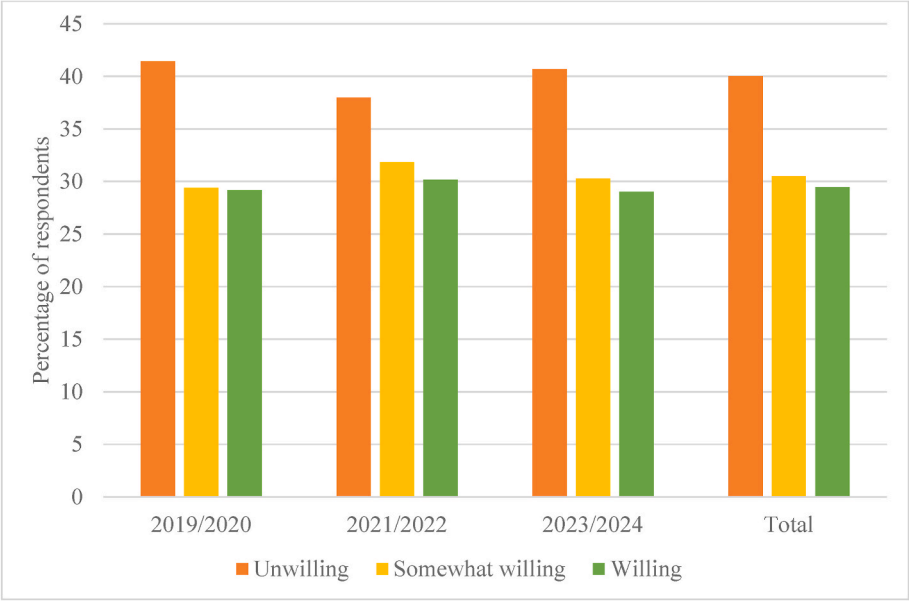

Fig. 2. Willingness to try food made from insects: Total sample and by survey rounds.

4.2.2. Trust, safety, and other food choice motives

Table 2 shows the mean values and standard deviations for the total sample, the mean values for the three survey rounds, the p-values for the Pearson Chi-square test of association between survey rounds and food choice motives, the mean values for those who were willing to try food made from insects and those who were unwilling and the p-values for the *t*-test of no mean differences between those who were unwilling to try and those who were willing.

Table 2
Summary statistics of food choice motives.

Variable	Mean (Total)[a]	Std. Dev.[b]	Mean (19/20)[c]	Mean (21/22)[d]	Mean (23/24)[e]	*p*-value (Chi^2)[f]	Mean (WTT = 1)[g]	Mean (WTT = 3)[h]	*p*-value (*t*-test)[i]
Social trust						0.000			0.000
In doubt	11.502	0.319	10.638	9.941	13.983		12.731	9.870	
Cannot be careful enough	13.472	0.341	14.894	13.786	11.688		16.959	10.381	
Most people can be trusted	75.026	0.433	74.468	76.273	74.329		70.313	79.748	
Trust in food authorities						0.001			0.000
No trust	5.027	0.219	0.4.976	4.053	6.073		6.134	5.151	
Low trust	17.642	0.381	18.463	16.834	17.620		18.634	15.140	
Somewhat high trust	52.821	0.499	53.706	54.105	50.600		54.311	49.430	
High trust	24.511	0.430	22.855	25.009	25.706		20.920	30.279	
Trust in food retailers						0.000			0.050
No trust	23.642	0.425	19.286	22.203	29.590		23.987	23.869	
Low trust	50.515	0.500	52.334	50.606	48.552		51.042	48.447	
Somewhat high trust	22.611	0.418	24.949	23.762	19.032		22.049	23.634	
High trust	3.232	0.177	3.432	3.429	2.825		2.922	4.050	
Safety						0.003			0.000
Little or no fear	71.702	0.450	71.860	73.571	69.633		70.226	75.501	
Moderate fear	24.325	0.429	23.747	23.346	25.918		25.637	21.195	
Great fear	3.973	0.195	4.393	03.083	4.449		4.138	3.303	
Other food choice motives									
Environment	20.711	0.405	23.576	20.852	17.620	0.000	15.683	27.409	0.000
Healthy	55.033	0.497	54.701	53.966	56.462	0.150	53.009	56.469	0.008
Natural ingredients	47.179	0.499	46.294	47.454	47.811	0.482	48.553	44.593	0.002
Novelty	18.371	0.387	19.149	19.328	16.596	0.012	15.075	23.280	0.000
Familiarity	46.345	0.499	46.706	46.657	45.657	0.669	50.579	40.543	0.000

Notes.
[a] For 8633 respondents in the total sample.
[b] Total sample standard deviation.
[c] For 2914 respondents in the 2019/2020 survey round.
[d] For 2887 respondents in the 2021/2022 survey round.
[e] For 2832 respondents in the 2023/2024 survey round.
[f] *p*-value for Pearson Chi-square test of association between food choice motives and survey round.
[g] For 3456 respondents that were unwilling to try food made from insects.
[h] For 2543 respondents that were willing to try food made from insects.
[i] *p*-value for *t*-test to check mean differences between respondents that were willing to try and those who were unwilling.

Social trust and trust in food authorities appeared high, with about 75 % of the respondents responding that most people could be trusted and at least 77 % having somewhat high trust in food authorities. For retailers, trust in retailers appeared low, with at least 74 % having low trust. Safety concerns appeared to be generally low, with about 72 % of the respondents stating little or no fear of getting sick from food. Health was the most considered food choice motive (54 % of the respondents), and about 47 % considered naturalness and familiarity. Environmental friendliness and novelty were considered by 21 % and 19 % of the respondents, respectively.

For whether there were mean differences in the importance of the different food choice motives between those that were willing to try food made from insects and those that were not, *t*-test results show significant differences at a 5 % significance level for all food choice motives. Those willing to try food made from insects had higher social trust, higher trust in food authorities, and less food safety concerns. They also emphasized more on the environment, health, and novelty and less on familiarity and natural ingredients.

For whether there were differences in the importance of the food choice motives across the survey rounds, the Pearson Chi-Square test for association results showed significant associations, at a 5 % significance level, for all food choice motives except health, natural ingredients, and familiarity. In 2021/2022, social trust appeared to have slightly increased, while trust in food authorities slightly dropped in 2023/2024. Mistrust in food retailers appeared to have risen in 2023/2024, while those with little or no fear of getting sick from food had reduced. Lastly, there was a drop in emphasis on the environment and novelty across the years.

4.2.3. OCEAN personality traits

The items used to measure the personality traits, their means and standard deviations, standardized factor loadings, Satorra-Bentler corrected standard errors, Cronbach's alphas, composite reliability, and average variance extracted values (AVE) are shown in Table 3. Items associated with agreeableness had the highest mean scores, while those associated with openness had the lowest. Fig. 3 shows the personality traits distribution from the predicted factor scores.

The reliability and validity of the measurement model were evaluated using several measures. For indicator reliability, 15 out of 20 items met the suggested 0.5 threshold [73]. Additionally, all standardized factor loadings were significant at the 1 % significance level. For internal consistency, assessed using the composite reliability and Cronbach's alpha values, 3 out of the 5 constructs met the 0.6 suggested acceptable threshold level [72]. The convergent validity of the constructs appeared limited, with only two of the constructs meeting the 0.5 convergent validity threshold [72]. To ensure consistency with the BFI-20, all items in the measurement model were retained in the analyses.

4.3. Main structural model

The results for the main structural model are summarized in Table 4 below. The coefficients and their respective standard errors and *p*-values are presented.[5]

Social trust ($\beta = 0.208$, $p = 0.000$) and trust in food authorities ($\beta = 0.175$, $p = 0.000$) were positively associated with WTT food made from insects, supporting H_1 and H_2. Being concerned over food safety ($\beta = -0.128$, $p = 0.001$) had a negative association with WTT, supporting H_4. For the effect of trust on food safety, social trust ($\beta = -0.407$, $p = 0.001$) and trust in food authorities ($\beta = -0.345$, $p = 0.000$) had a negative association with food safety concerns supporting H_5, and H_6.

For the other food choice motives, emphasizing environmental friendliness ($\beta = 0.511$, $p = 0.000$), health ($\beta = 0.143$, $p = 0.001$), and novelty ($\beta = 0.292$, $p = 0.000$), when purchasing food, had a positive association with WTT supporting H_8, H_9 and H_{11} while emphasizing natural ingredients ($\beta = -0.259$, $p = 0.000$) and familiarity ($\beta = -0.307$, $p = 0.000$) had a negative association, rejecting H_{10} and supporting H_{12}, respectively.

For personality traits, higher levels of openness ($\beta = 0.343$, $p = 0.000$) were positively associated with WTT food made from insects, supporting H_{13}. In contrast, higher levels of conscientiousness ($\beta = -0.452$, $p = 0.000$), agreeableness ($\beta = -0.142$, $p = 0.001$) and extraversion ($\beta = -0.038$, $p = 0.048$) had a negative association, supporting H_{14} and H_{16} and rejecting H_{15}, respectively.

4.4. Mediation model

Food safety concerns were a significant mediator. The results in Table 5 show that food safety concern was a significant mediator in the path between social trust ($\beta = 0.052$, $p = 0.001$) and WTT food made from insects and in the path between trust in food authorities ($\beta = 0.044$, $p = 0.014$) and WTT food made from insects.

4.5. Multigroup analyses

The results for the MGA for the paths associated with WTT food made from insects are shown in Table A1. in the appendix. There were significant gender differences for the associations related to emphasizing natural ingredients, emphasizing novelty, emphasizing familiarity and extraversion. The negative effects of emphasizing natural ingredients ($p = 0.031$) and familiarity ($p = 0.023$) and the positive effect of emphasizing novelty ($p = 0.003$) were stronger among male respondents than female respondents. Moreover, among female respondents, extraversion ($p = 0.003$) was positively associated with WTT food made from insects.

For education related differences, the negative effect of emphasizing natural ingredients ($p = 0.002$) and the positive effect of openness ($p = 0.001$) were stronger among the non-higher educated respondents. For age related differences, the positive effects of trust in food authorities ($p = 0.000$) and emphasizing health ($p = 0.044$) were stronger among younger respondents while the positive effect of openness ($p = 0.006$) was stronger among older respondents. Lastly, for urban living related differences, the negative effect of conscientiousness ($p = 0.008$) was stronger among urban respondents compared to their rural counterparts.

5. Discussion, implications, strengths and limitations

5.1. Discussion

This study aimed to assess the consumer acceptance of entomophagy by investigating the WTT food made from insects and the significant factors associated with it. Specifically, the effects of trust, food choice motives, and personality traits were investigated. The mediation effects of food safety concerns on the relationship between trust and WTT food made from insects were also tested. Moreover, the moderating role of gender, education, age and urban living were also assessed.

The willingness to try food made from insects appeared low and stable over the survey rounds, with about 40 % of the respondents being unwilling to try and 29 % being willing.

5.1.1. Determinants of willingness to try food made from insects

Social trust and trust in food authorities were positively associated with WTT. While the effects of social trust on entomophagy have not been previously investigated, these results align with an earlier study

[5] The results presented in Table 4 are from the pooled total sample. Separate analyses, available upon request, were performed for each survey round. Very small differences were found between the total sample results and the survey rounds. Compared to the total sample, in 2019/2020, agreeableness was not a significant predictor of WTT (p = 0.071). In 2021/2022, safety (p = 0.180), health (p = 0.261), extraversion (p = 0.884) and agreeableness (p = 0.112) were not significant predictors of WTT. Lastly, in 2023/2024, extraversion was not a significant predictor of WTT.

Table 3
Summary statistics and assessment of OCEAN personality traits items.

Items	Mean	Std. Dev.	Factor loadings[a]	*SE* (SB)[b]	Cron. Alpha[c]	CR[d]	AVE[e]
Openness					0.670 (0.63)	0.707	0.399
Is original, comes up with new ideas	4.158	1.616	0.717	0.009			
Has a lively imagination	4.401	1.746	0.675	0.009			
Likes to speculate, play with ideas	4.509	1.720	0.739	0.009			
Has few artistic interests[e]	4.411	2.020	0.280	0.011			
Conscientiousness					0.564 (0.57)	0.581	0.266
Does a thorough job	5.721	1.132	0.466	0.012			
Tends to have little order in life[f]	5.450	1.598	0.611	0.013			
Make plans and follows them	4.966	1.393	0.348	0.013			
Can be careless[f]	4.578	1.616	0.593	0.012			
Extraversion					0.809 (0.78)	0.812	0.524
Is talkative	4.534	1.655	0.779	0.006			
Tends to be quiet[f]	4.415	1.792	0.698	0.007			
Is outgoing and social	4.825	1.608	0.820	0.006			
Can be shy and inhibited[f]	5.279	1.632	0.574	0.008			
Agreeableness					0.556 (0.63)	0.576	0.259
Can be cold and distant.[f]	5.176	1.562	0.422	0.011			
Is helpful and unselfish in relation to others	5.322	1.252	0.501	0.014			
Can sometimes be rude[f]	5.048	1.630	0.445	0.011			
Is considerate and friendly towards most people	6.048	1.016	0.638	0.016			
Neuroticism					0.786 (0.73)	0.789	0.488
Is depressed[f]	5.635	1.580	0.640	0.008			
Is relaxed, copes well with stress	4.656	1.641	0.575	0.008			
Worries a lot[f]	4.617	1.852	0.851	0.006			
Gets easily nervous[f]	4.913	1.759	0.698	0.008			

Notes.

[a] Standardized factor loading values. All the factor loadings were significant at the 1 % significance level.

[b] Satorra Bentler corrected standard errors were used since they are more robust to non-normality [93].

[c] Cronbach's alphas values for the standardized items. They are a measure of internal consistency reliability and values ≥ 0.6 are deemed reliable. The values in parentheses are the values obtained by the developers of the BFI-20 [67].

[d] Composite reliability value for the standardized items. It is also a measure of internal consistency reliability calculated as $CR = \frac{(\Sigma\ Standardized\ Loadings)^2}{(\Sigma\ Standardized\ Loadings)^2 + \Sigma\left(1 - (Standardized\ Loadings)^2\right)}$. Values ≥ 0.6 are deemed reliable.

[e] Average Variance Extracted values. It is a measure of convergent validity and values > 0.5 are deemed as successful convergent validity.

[f] The scales of these items were reversed during construct formation.

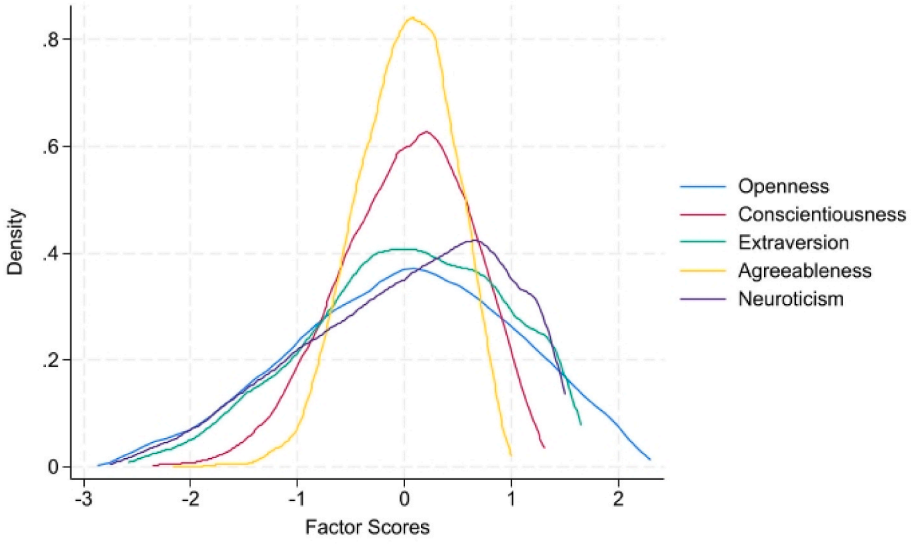

Fig. 3. Personality traits distribution.

that found that social trust was positively associated with the willingness to try cultured meat [43]. The positive effects of trust in food authorities also corroborate with other previous studies [29,31,32]. Trust in food retailers did not significantly affect WTT food made from insects. This result may be due to the low trust levels for food retailers and the low availability of insect-based food products in retail stores. Food safety concerns were negatively associated with WTT food made from insects, and these findings are in line with results from previous review studies that identify safety concerns as a potential barrier to entomophagy [15,24,25].

Table 4
Generalized structural equation model results.

Paths	Coefficient	*SE*	*p*-value	Hypotheses conclusion
H_1: Social trust → WTT	0.208	0.031	0.000	Supported
H_2: Trust in food authorities → WTT	0.175	0.028	0.000	Supported
H_3: Trust in food retailers → WTT	0.045	0.028	0.105	Not Supported
H_4: Safety → WTT	−0.128	0.038	0.001	Supported
H_5: Social trust → Safety	−0.407	0.032	0.000	Supported
H_6: Trust in food authorities → Safety	−0.345	0.032	0.000	Supported
H_7: Trust in food retailers → Safety	0.015	0.033	0.654	Not Supported
H_8: Environment → WTT	0.511	0.054	0.000	Supported
H_9: Health → WTT	0.143	0.043	0.001	Supported
H_{10}: Natural ingredients → WTT	−0.259	0.045	0.000	Not Supported
H_{11}: Novelty → WTT	0.292	0.053	0.000	Supported
H_{12}: Familiarity → WTT	−0.307	0.041	0.000	Supported
H_{13}: Openness → WTT	0.343	0.022	0.000	Supported
H_{14}: Conscientiousness → WTT	−0.452	0.054	0.000	Supported
H_{15}: Extraversion → WTT	−0.038	0.019	0.048	Not Supported
H_{16}: Agreeablesness → WTT	−0.142	0.044	0.001	Supported
H_{17}: Neuroticism → WTT	0.044	0.024	0.070	Not Supported

Table 5
Mediation analysis results.

Specific Indirect Effects	Coefficient	*SE*	*p*-value
Social trust → Safety → WTT	0.052	0.016	0.001
Trust in food authorities → Safety → WTT	0.044	0.014	0.001
Trust in food retailers → Safety → WTT	−0.002	0.004	0.658

Emphasizing environmental friendliness and health was positively associated with WTT food made from insects. The positive effects of environmental friendliness and health corroborate with several review studies [15,24–26]. Emphasizing natural ingredients was found to be negatively associated with WTT food made from insects, different from other studies that found consumers perceived insects as natural [55,56]. A possible explanation of this finding may be because the survey did not describe how the food made from insect would be produced and consumers may have perceived that food made from insects may include additives or be ultra-processed to make it tasty. Moreover, information on the level of processing and the visibility of the insects in the food, among the important factors affecting entomophagy [28], had not been provided. Novelty was positively associated with WTT, and familiarity negatively associated, and these findings are in line with previous review studies [24,25,27].

Similar to a study conducted among Japanese consumers, openness and conscientiousness were positively associated with WTT food made from insects [35]. Extraversion was negatively associated with WTT food made from insects, different from the findings of another study conducted among UK consumers [66]. This finding is surprising given that individuals high in extraversion appear more open to novel foods [83]. Our finding, however, corroborates with another study conducted in Norway, that found that Norwegian consumers higher in extraversion had a lower acceptance of organic food [84]. Compared to other countries, Norway ranks lower in extraversion [85] and given the low extraversion levels in the Norwegian society, people higher in extraversion may be less willing to try novel foods as a way of maintaining social conformity. Agreeableness was negatively associated with WTT food made from insects, and this finding is in line with a previous study that found similar results for genetically modified foods [67]. No significant association was found for neuroticism which is somewhat in line with another study that found that neuroticism was not associated with interest in entomophagy but only had an effect on disgust in entomophagy [35].

5.1.2. Mediating role of safety

The study results show that food safety concerns mediate the relationship between social trust and WTT food made from insects and between trust in food authorities and WTT food made from insects. Both social trust and trust in food authorities also had a direct negative effect on food safety concerns. These results are similar to a meta-analysis that found that higher social trust and trust in food actors, including the government and value-chain companies, were associated with lower food safety risk perception [86]. These results suggest the need to foster higher social trust and trust in food authorities, which in turn could support reduced food safety concerns and, in turn, support higher acceptance of entomophagy.

5.1.3. Moderating role of sociodemographic factors

The results of the multigroup analyses show that the sociodemographic characteristics of consumers may moderate the effect of food choice motives and personality traits on the consumer acceptance of entomophagy. These results are similar to other studies that found moderating effects of gender, education, age and/or urban living on the effect of consumer acceptance of entomophagy [24,87–89]. These results suggest the importance of offering nuanced entomophagy interventions based on consumers' sociodemographic profile.

5.2. Implications

The results of this study have important implications on policymakers, food marketers, and other relevant stakeholders. Given the importance of social trust and trust in food authorities, food authorities can be important in informing, educating, and encouraging consumers on entomophagy. These authorities should work on fostering trust among consumers, which could, in turn, reduce entomophagy-related safety concerns. Given the significance of social trust, insect-based food marketers and retailers may focus on advertising and serving insect-based foods in social settings. Norwegians with higher social trust are more likely to have extensive social networks [90] thus being more susceptible to social and peer influences. By seeing others consume insects in social settings, entomophagy may be affirmed as acceptable and not socially awkard thus encouraging trying out.

Marketers of insect-based foods should focus on the environmental and health advantages of entomophagy, given the expected positive influence. They should also promote entomophagy as new and exciting, thus capturing consumers who are novelty-seeking. Given the possibility of emphasizing familiarity acting as a barrier to entomophagy, it is important that insect-based food marketers increase the availability and visibility of these food products to help consumers gain more exposure to entomophagy. Insect-based food producers should also consider the ingredients and production processes used, to mitigate the potential aversion caused by the preference for natural ingredients. They should aim to use natural ingredients, which should be communicated to consumers.

Given the possibility of predicting personality traits from online patterns [91,92], marketing strategies may also target consumers higher in openness and lower in conscientiousness, extraversion, and agreeableness. As entomophagy gains familiarity it may be expected that agreeableness may cease being a potential barrier.

While targeting consumers based on food choice motives and personality traits is important, marketers should also consider the sociodemographic profile of respondents in their targeted campaigns. Nuanced marketing strategies and communication targeting specific sociodemographic consumer profiles may be adopted for interventions targeting food choice motives and/or personality traits where sub-group variations may be expected.

5.3. Strengths and limitations

This study contributes to the literature on consumer acceptance of entomophagy. To the author's knowledge, this is the first study to investigate the effect of social trust and trust in retailers on entomophagy. It also contributes to the limited literature on the effects of personality traits on entomophagy. The study used data from a large national survey, and one of its strengths is the large sample size it provides. Another of its strengths is that the data on the willingness to try food made from insects was available from several survey rounds covering 2019–2024, allowing the evaluation of consumer acceptance of entomophagy over time.

Since the data used in the study was part of a larger survey, not focusing on entomophagy, one of its limitations is that it does not cover some important factors such as disgust and food neophobia since questions covering these dimensions were not present in the survey. The questions on novelty and familiarity while purchasing food could, however, reflect respondents' disgust and food neophobia. Secondly, the question on WTT food made from insects was not elaborate enough and respondents may not have understood, among other factors, types of edible insects, possible types of foods that could be made from insects and whether the insects would be visible in the foods. Furthermore, the role of the insects in the food including whether the insects would be eaten whole or whether they would be used to fortify other existing foods was not captured. Providing such additional information may have helped respondents assess their willingness to try in a more informed way. Thirdly, in a survey focusing on entomophagy the questions covering the food choice motives may have been worded or measured differently to obtain more information. Lastly, the BFI-20 containing 20 items was used to measure the personality traits. Using a version containing more items may have provided more information on personality traits but given the length of the survey, the BFI-20 provided a simpler and reliable way to assess personality traits.

6. Conclusion

Entomophagy is anticipated to facilitate a reduction in meat consumption, but its success will largely depend on consumer acceptance. While the market for insect-based foods is expected to grow, understanding the consumer acceptance of entomophagy is necessary. The findings of this study show that social trust, trust in food authorities, and emphasis on the environment, health and novelty are expected to be potential drivers of entomophagy. Safety concerns and emphasizing familiarity are expected to act as potential barriers. The study's results also show that personality traits are expected to affect entomophagy, with individuals higher in openness being more open to entomophagy and those higher in conscientiousness, extraversion, and agreeableness being more averse.

Food authorities, marketers, and other relevant stakeholders should aim to foster trust among consumers as this may reduce safety concerns and, in turn, increase consumer acceptance of entomophagy. The environmental and health benefits of entomophagy should also be communicated, and the production of insect-based foods should be done in a way that focuses on using natural ingredients. The relevant stakeholders should also aim to increase familiarity. Targeted marketing should also aim at individuals higher in openness and lower in conscientiousness, extraversion, and agreeableness. Lastly, the sociodemographic profiles of consumers should be considered to tailor more targeted and effective interventions.

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Ethical statement

The data used is from the Norwegian Monitor Survey conducted by Ipsos. Ipsos is a market and social research company and follows the EU General Data Protection Regulation (GDPR). It is also a member of ESOMAR, bound by the ICC/ESOMAR Code on Market and Social Research. The respondents consented to the survey after being guaranteed that, their responses were confidential, and no identifiable personal information would be included.

CRediT authorship contribution statement

Sarah Wangui Muiruri: Writing – original draft, Software, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

None.

Data availability

The authors do not have permission to share data.

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Appendix

Table A1
Multi-group analyses

	Male[a]	Female[b]	*p*-value[c]	Non higher-educated[d]	Higher educated[e]	*p*-value[f]	Non older[g]	Older[h]	*p*-value[i]	Non urban[j]	Urban[k]	*p*-value[l]
Social trust → WTT	0.228***	0.189***	0.537	0.161**	0.226***	0.311	0.203***	0.329***	0.052	0.248***	0.165***	0.189
	(0.044)	(0.045)		(0.049)	(0.041)		(0.041)	(0.051)		(0.046)	(0.042)	
Trust in food authorities → WTT	0.170***	0.161***	0.860	0.162***	0.188***	0.643	0.226***	0.034	0.000	0.132**	0.193***	0.267
	(0.036)	(0.041)		(0.045)	(0.034)		(0.038)	(0.039)		(0.040)	(0.037)	
Trust in food retailers → WTT	0.084*	0.094*	0.851	0.092*	0.018	0.188	−0.048	−0.129**	0.162	0.023	0.052	0.606
	(0.038)	(0.041)		(0.044)	(0.036)		(0.036)	(0.045)		(0.041)	(0.037)	
Safety → WTT	−0.117*	−0.070	0.552	−0.116	−0.130**	0.867	−0.084	−0.227***	0.069	−0.088	−0.153**	0.404

(*continued on next page*)

Table A1 (*continued*)

	Male[a]	Female[b]	*p*-value[c]	Non higher-educated[d]	Higher educated[e]	*p*-value[f]	Non older[g]	Older[h]	*p*-value[i]	Non urban[j]	Urban[k]	*p*-value[l]
	(0.059)	(0.051)		(0.062)	(0.049)		(0.050)	(0.061)		(0.057)	(0.052)	
Environment → WTT	0.500***	0.586***	0.424	0.560***	0.474***	0.467	0.540***	0.433***	0.324	0.512***	0.480***	0.766
	(0.080)	(0.073)		(0.098)	(0.064)		(0.075)	(0.078)		(0.082)	(0.071)	
Health → WTT	0.178**	0.123	0.525	0.180*	0.116*	0.484	0.211***	0.035	0.044	0.053	0.170**	0.180
	(0.059)	(0.063)		(0.074)	(0.053)		(0.060)	(0.063)		(0.064)	(0.059)	
Natural ingredients → WTT	−0.312***	−0.118	0.031	−0.458***	−0.165**	0.002	−0.158*	−0.026	0.149	−0.276***	−0.213***	0.486
	(0.062)	(0.065)		(0.078)	(0.054)		(0.064)	(0.066)		(0.066)	(0.060)	
Novel → WTT	0.443***	0.126	0.003	0.276**	0.304***	0.797	0.209**	0.277**	0.535	0.292***	0.274***	0.869
	(0.074)	(0.077)		(0.087)	(0.067)		(0.069)	(0.085)		(0.082)	(0.070)	
Familiarity → WTT	−0.446***	−0.256***	0.023	−0.255***	−0.332***	0.375	−0.390***	−0.241***	0.073	−0.347***	−0.277***	0.393
	(0.057)	(0.061)		(0.069)	(0.051)		(0.057)	(0.060)		(0.061)	(0.056)	
Openness → WTT	0.340***	0.262***	0.073	0.431***	0.287***	0.001	0.230***	0.350***	0.006	0.353***	0.321***	0.455
	(0.032)	(0.030)		(0.035)	(0.027)		(0.031)	(0.031)		(0.031)	(0.029)	
Conscientiousness → WTT	−0.424***	−0.290***	0.216	−0.433***	−0.504***	0.520	−0.446***	−0.347***	0.363	−0.315***	−0.599***	0.008
	(0.074)	(0.079)		(0.088)	(0.068)		(0.073)	(0.080)		(0.078)	(0.074)	
Extraversion → WTT	−0.050	0.065*	0.003	−0.017	−0.052*	0.378	−0.034	−0.074*	0.298	−0.071*	−0.030	0.271
	(0.027)	(0.028)		(0.032)	(0.023)		(0.025)	(0.029)		(0.028)	(0.026)	
Agreeableness → WTT	−0.024	−0.192***	0.055	−0.171*	−0.107	0.473	−0.126*	−0.102	0.789	−0.193**	−0.062	0.132
	(0.059)	(0.064)		(0.070)	(0.055)		(0.060)	(0.064)		(0.064)	(0.059)	
Neuroticism → WTT	−0.027	−0.042	0.773	0.032	0.053	0.670	0.111**	0.157***	0.356	0.088*	0.024	0.184
	(0.037)	(0.034)		(0.040)	(0.030)		(0.032)	(0.038)		(0.036)	(0.032)	

Notes.
[a]For 4463 male respondents.
[b]For 4170 female respondents.
[c] *p*-value for Wald test of gender differences.
[d]For 3039 non higher educated respondents in the sample.
[e]For 5597 higher educated respondents.
[f] *p*-value for Wald test of education related differences.
[g]For 4420 respondents aged 48 years or less.
[h]For 4213 respondents more than 48 years old.
[i] *p*-value for Wald test of age related differences.
[j]For 3981 non-urban respondents.
[k]For 4652 urban respondents.
[l] *p*-value for Wald test of urban living related differences.***$p < 0.001$ **$p < 0.01$ **$p \leq 0.05$.

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Paper IV

Norwegian consumption of plant-based meat analogues

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Abstract

Plant-based meat analogues (PBMA) are expected to reduce environmental, health, and animal welfare challenges from the production and consumption of meat. This paper investigates PBMA consumption using three rounds of a survey. PBMA consumption in Norway increased from 2017 to 2019 but stagnated in 2022. Several food choice motives and socioeconomic factors affected consumption consistently across the survey rounds. Emphasizing the environment, animal welfare, and novelty were positively associated with PBMA consumption, while emphasizing familiarity and Norwegian origin were negatively associated. Younger, higher educated, urban, and vegetarian respondents were more likely to consume PBMA. Use of social media had a positive effect on the consumption for the total sample, but it was not stable across the survey rounds. Producers, marketers, and other policy makers could promote the environmental and animal welfare benefits along with the novelty aspects of PBMA. The use of domestic ingredients could also appeal to older and rural individuals who emphasize food familiarity.

Keywords: Consumer acceptance, food choice motives, plant-based meat analogues, social media.

1. Introduction

There is a call to reduce meat production and consumption due to their negative effects on the environment, health, and animal welfare (Machovina et al., 2015; Poore & Nemecek, 2018; Willett et al., 2019). Meat production constitutes the largest global share of methane emissions from food production (Kuylenstierna et al., 2021), and livestock grazing is globally the second highest contributor of deforestation (FAO, 2022). Moreover, consumption of red and processed meat has been identified as probably carcinogenic and linked to cardiovascular illnesses (Bouvard et al., 2015).

As a substitute for meat, plant-based meat analogues (PBMA) have been developed. The Intergovernmental Panel on Climate Change (IPCC) identified consumption of PBMA as a potential mitigation option for food related greenhouse gas (GHG) emissions (Pathak et al., 2022). Usually, these meat analogues are produced from plant proteins such as soybean and peas that have a positive health impact and whose production is more environmentally sustainable than meat (Santo et al., 2020). They often mimic meat products such as burgers, nuggets, and sausages. By mimicking meat, they are meant to attract both meat eaters and non-meat eaters, providing them with the sensory experience of meat eating while staying away from actual meat (Hu et al., 2019). They can also be prepared in the same way as meat, and do not require a change of preparation habits (Graça et al., 2019; Stoll-Kleemann & Schmidt, 2017).

To achieve the potential benefits of PBMA, consumer acceptance is important. However, during the last years the consumption has stagnated. The sales in 13 European countries grew by 16% from 2020 to 2021, but only by 3% from 2021 to 2022 (GFI Europe, 2023). In the US, unit sales declined by 8% from 2021 to 2022 (GFI, 2023). It is therefore important to increase knowledge on consumer preferences.

Many PBMA studies have focused on purchase or consumption intentions as measured through surveys or stated preferences studies (Bryant et al., 2019; Hwang et al., 2020; Slade, 2018; Szejda et al., 2021; van Dijk et al., 2023). Other studies have assessed consumer spending using sales scanner data (Cuffey et al., 2023; Neuhofer & Lusk, 2022). Typically, studies focusing on purchase or consumer intentions find consumers to be moderately willing to consume, while studies using scanner data find the sales to be quite low.

Our study has three objectives. First, changes in the importance of food choice motives and socioeconomic factors over time are studied. Changes over time are highly relevant given the rapid changes in the PBMA market but have not been much investigated. Two notable exceptions are Cuffey et al. (2023) and Zhao et al. (2023). Cuffey et al. (2023) studied socioeconomic determinants and changes in consumer spending in the US over the period 2014 – 2019. They found that spendings on meat analogues were generally low and dropped after initial purchases and that households with higher education, higher income, and living in urban areas had higher consumption. Zhao et al. (2023) estimated the demand relative to other meats in the US over the period 2017 – 2020 and found that PBMA was a complement for red meat and substitute for white meat. To our knowledge no study has investigated the importance of choice motives over time. We add to the literature by investigating changes in motives and socioeconomic factors using three rounds of a biannual survey with at least 3,000 respondents in each round and covering the 2017-2021 period.

Second, the effect of social media on novel food consumption, including consumption of PBMA, has been little investigated (Fischer & Reinders, 2022). An exception is Rini et al., (2024) who found that social media mediated the relationship between meat reduction beliefs and the intention to consume PBMA. Information about healthy and sustainable food choices need to be communicated in a relatable and practical way and social media could act as a knowledge exchange platform for policy makers to promote increased consumption.

Third, this is the first Norwegian consumer study on PBMA. Both the recently released Norwegian dietary guidelines released in August 2024 by The Norwegian Directorate of Health (2024) and The Nordic Nutritional Recommendations (NNR) released in June 2023 (Blomhoff et al., 2023) recommended a shift towards increased consumption of plant-based diets and reduced consumption of red and processed meats . Knowledge about Norwegians as a consumer group has therefore some practical importance in the implementation of these guidelines to alter domestic consumption.

2. Determinants of consumption of PBMA

Several review studies suggest that health, environment, and animal welfare concerns are main drivers for the consumption of meat analogues (He et al., 2020; Ishaq et al., 2022; Ismail et al., 2020; Singh et al., 2021), while taste appears to be the leading barrier among consumers (Fiorentini et al., 2020; Lee et al., 2020; Szenderák et al., 2022). We include these food choice motives, and some other motives as described below. The survey questions, response alternatives, and constructed variables used in the statistical model are shown in Table 1.

Health

Reduced intake of red and processed meat is associated with reduced mortality (Blomhoff et al., 2023; European Commission, 2021; Norwegian Directorate of Health, 2023; Willett et al., 2019). PBMA are generally healthier than their meat-based counterparts, but there is variation among the products in the market (Alessandrini et al., 2021; Bryant, 2022; Bryngelsson et al., 2022). Health may act as a driver for purchasing PBMA (Bryant et al., 2019; Eckl et al., 2021; Weinrich, 2019). However, these products have received criticism of being ultra processed and containing relatively high amounts of sodium (Hu et al., 2019). Such perceptions reduce the attractiveness of these products (Kerslake et al., 2022; Varela et al., 2022), and studies have also found that consumers consider PBMA as highly processed and less natural foods (Michel et al., 2021; Pointke et al., 2022).

Environment

Meat production is associated with several negative environmental impacts (Machovina et al., 2015; Poore & Nemecek, 2018), while PBMA has been associated with pro-environmental effects, and have a lower carbon footprint than meat from ruminants (Mejia et al., 2020; Santo et al., 2020; Shanmugam et al., 2023). Morach et al. (2021) projected that if alternative proteins replaced 10% of the global consumption of egg, dairy, and meat by 2035, it would cause a reduction in carbon emissions almost equivalent to Japan's annual emissions. In line with these results, studies have found that consumers seem to rate PBMA as more environmentally friendly (Szenderák et al., 2022), and environmental concern has been found to be a good predictor for the intent to purchase or consume these products (Bryant et al., 2019; Davitt et al., 2021).

Animal welfare (AW)

There is a growing concern of animal welfare in Western countries (Hopwood et al., 2020), and this concern has been a driver for vegetarianism (Hopwood et al., 2020; Ruby, 2012). van Loo et al. (2020) found that providing consumers with information about animal welfare would potentially draw them towards PBMA. In a Belgian study, animal welfare benefits was selected as the second top reason for choosing PBMA (Bryant & Sanctorum, 2021).

Taste

Taste has been found to be a major criterion affecting consumer acceptance of PBMA (He et al., 2020; Ishaq et al., 2022; Szenderák et al., 2022).[1] Vegetarian consumers do not appear to place a strong focus on mimicking the taste of conventional meat but for non-vegetarian consumers this is important, and not achieving the meat-like texture and taste is presently a major barrier among non-vegetarian consumers (Fiorentini et al., 2020; He et al., 2020). To attract more consumers, developments within the industry continuously aim at making PBMA products that taste and appear like conventional meat (Ishaq et al., 2022; Zahari et al., 2022).

Additives

Different additives are applied to achieve the meaty taste and texture in PBMA. Some brands use genetically modified (GM) additives while other brands have adopted non-GM additives (Ishaq et al., 2022). Additives in food can influence consumers' food choices (Bazzani et al., 2018; Lusk & Briggeman, 2009; Roman et al., 2017). How consumer perceptions of these products in terms of additives are divided. Some consumers negatively perceive the presence of additives in PBMA (Weinrich, 2018), while others are drawn to the plant ingredients component and find it more appealing, which may result in increased purchase intentions (Szenderák et al., 2022).

Novelty

Variety seeking behavior affects food choices (Lähteenmäki & Arvola, 2001). Due to the globalization of the food system, consumers are now exposed to many novel foods, and Bazzani et al. (2018) identified novelty as a food value with importance for some consumers. Food curiosity, driven by variety seeking behavior, was found to be one motivation for consumption of PBMA among consumers in Australia, Germany, and Korea (Bryant & Sanctorum, 2021; Estell et al., 2021; Hwang et al., 2020).

[1] We use data from a large survey covering multi-faceted topics within the Norwegian society and not specifically aimed at studying consumption of PBMA. Our survey question asked to what extent consumers perceive healthy foods to be tasty. Though it does not directly ask consumers to what extent they consider taste when purchasing food, it is used as a proxy for how consumers perceive healthy foods in terms of taste.

Familiarity

Dependence on dietary habits may motivate a preference for familiar foods (Aldridge et al., 2009; Daunfeldt et al., 2011). Furthermore, consumers may stay away from unfamiliar foods based on food neophobia (Pliner & Hobden, 1992). On a general scale, PBMA appear to be moderately unfamiliar (Bryant et al., 2019; He et al., 2020; Szejda et al., 2021; van Dijk et al., 2023). In review studies, Ishaq et al. (2022) and Onwezen et al. (2021) found that food neophobia was a barrier against acceptance of these products among some consumers. Moreover, consumers who were already familiar with PBMA had a significantly higher acceptance for it (Onwezen et al., 2021; Szenderák et al., 2022; van Dijk et al., 2023).

Price

Price is an important factor for consumers when making their food consumption decisions (e.g., Lusk & Briggeman, 2009). Compared to conventional meat, PBMA are generally highly priced despite the ingredients being cheaper to produce (Lusk et al., 2022; Smart Protein, 2021). Acceptance of these products relies on reducing their price (Boukid, 2021; Lusk et al., 2022). In the US, Slade (2018), found that individuals preferring PBMA were less conscious about price. Similar results were found in ten European countries where only 25% of flexitarians said they were very likely to pay a higher price (Smart Protein, 2021).

Origin

A preference for products that are produced domestically is widespread in many countries (Balabanis & Siamagka, 2022; Yeh & Hirsch, 2023). This preference can be explained by a perception of domestic food as being healthier and safer than imported food (Gineikiene et al., 2016), or by motives such as a wish to protect the domestic agriculture (Casado-Aranda et al., 2020). Lower willingness to pay for imported products and higher willingness to pay for local or domestically produced PBMA products have been reported among UK consumers (Apostolidis & McLeay, 2016), and a preference for Norwegian origin was found to be associated with higher consumption of red meat and lower consumption of plant-based food (Milford & Muiruri, 2024).

Media

Use of social media has grown exponentially, and food recipes are commonly shared by social networks on social media platforms (Simeone & Scarpato, 2020). Many studies have investigated the effect of social media on food choices. In a review, Kucharczuk et al. (2022) found that social media increased the consumption of unhealthy foods among adolescents. Simeone and Scarpato (2020) found that use of social media for obtaining food information was negatively associated with consumption of local fish or with a moderate consumption of meat among Italian consumers. However, the effect of social media on the acceptance of novel foods remains under explored (Fischer & Reinders, 2022). Given the novelty of PBMA, social media may play a role in the diffusion of this product. Rini et al. (2024) found that social media use affected the intention to consume PBMA and significantly mediated the relationship between meat reduction beliefs and the intention to consume such products.

Socioeconomic factors

Previous studies have found that older people have a lower acceptance for PBMA (Carlsson et al., 2022; Gómez-Luciano et al., 2019; Neuhofer & Lusk, 2022; Slade, 2018; van Dijk et al., 2023; Van Loo et al., 2020), while females have a higher acceptance (Bryant et al., 2019; Carlsson et al., 2022; Gómez-Luciano et al., 2019; Siegrist & Hartmann, 2019; van Dijk et al., 2023). Studies have also found that higher

education is associated with a higher acceptance (Carlsson et al., 2022; Cuffey et al., 2023; Gómez-Luciano et al., 2019; Neuhofer & Lusk, 2022; Slade, 2018), and individuals living in urban areas have a higher acceptance for PBMA (Carlsson et al., 2022; Cuffey et al., 2023). The effect of the presence of children on acceptance is inconclusive with some finding a positive effect (van Loo et al., 2020) and others a negative effect (Cuffey et al., 2023). Married individuals seem to have a lower acceptance (Cuffey et al., 2023), and vegetarians seem to have a higher acceptance (Apostolidis & McLeay, 2016; Davitt et al., 2021). Lastly, individuals with higher income have been found to have a higher acceptance for PBMA (Bryant et al., 2019; Cuffey et al., 2023; Neuhofer & Lusk, 2022).

Table 1. Variable, Survey Questions, Response Alternatives, and Constructed Variables

Variable	Survey Questions [a]	Response Alternatives [a]	Constructed Variable
Health	How interested are you in the following things? One alternative was: Healthy diets	4 alternatives: Very interested, pretty interested, a little bit interested, not interested	= 1 if totally agree and = 0 otherwise
Environment	How well do you think the statements below agree with what you think or do yourself? One alternative was: I am concerned with what I can personally do to protect environment and natural resources.	4 alternatives: Totally agree, somewhat agree, somewhat disagree, and totally disagree	= 1 if either totally agreed and/or worried a lot was ticked and = 0 otherwise
	How concerned are you about the following environmental problems? One alternative was: Greenhouse effects and climate change	4 alternatives: Worried a lot, pretty worried, a little worried, not worried	
AW	When purchasing food for yourself and your household, which of the factors below do you consider to be particularly important? One alternative was: Animal welfare	Tick if appropriate	= 1 if animal welfare was ticked and = 0 otherwise
Taste	How much do you agree or disagree with the following statements? One alternative was: Healthy food can be tasty.	4 alternatives: Totally agree, somewhat agree, somewhat disagree, and totally disagree	= 1 if totally agree and = 0 otherwise
Additives	When purchasing food for yourself and your household, which of the factors below do you consider to be particularly important? Two alternatives were: Few or no additives	Tick if appropriate	= 1 if at least one of the alternatives was ticked

	The food is made from natural components		
Novelty	When purchasing food for yourself and your household, which of the factors below do you consider to be particularly important? One alternative was: The food is something new and exciting	Tick if appropriate	= 1 if something new and exciting was ticked and = 0 otherwise
Familiarity	When purchasing food for yourself and your household, which of the factors below do you consider to be particularly important? One alternative was: Eaten the food before	Tick if appropriate	= 1 if eaten it before was ticked and = 0 otherwise
Price	When purchasing food for yourself and your household, which of the factors below do you consider to be particularly important? One alternative was: Low price	Tick if appropriate	= 1 if low price was ticked and = 0 otherwise
Origin	How important is it to you that the agricultural products you use or eat are Norwegian?	5 alternatives: Very important, pretty important, somewhat important, does not matter, prefer foreign	= 1 if very important and = 0 otherwise
Media	How often do you use these sources to acquire knowledge and tips about cooking? Two alternatives were: Watch foodstuff on Facebook and other social media Watch foodstuff on YouTube	4 alternatives: Often, sometimes, seldom, never	= 1 if often is ticked for at least one of the alternatives and = 0 otherwise
Age	What is your age?	Age in years	Age in years
Female	What is your gender?	2 alternatives: Male, female	= 1 if female and = 0 otherwise
Education	What is your highest completed education level?	5 alternatives: Primary school, secondary school, high school, bachelor's degree, graduate, or postgraduate studies	= 1 if bachelor's degree or more and = 0 otherwise
Urban	How would you characterize the place where you live now?	9 alternatives: Large city (central location), large city (outer districts), suburb of big city, medium-sized city (central location), medium-sized city (outer districts), suburb of	= 1 if large city, suburb, medium-sized city and = 0 otherwise

		medium sized city, smaller city, town village	
Children[b]	How many live-at-home sons or daughters are there in the household?	5 alternatives: zero, one, two, three, four, five or more	= 1 if number of children ≥ 1 and = 0 otherwise
Partner	Are you married: in a partnership, unmarried/never married, earlier married/divorced/separated or widow/widower?	5 alternatives: married, in a partnership, unmarried/never married, earlier married/divorced/separated, widow/widower	= 1 if married or in a partnership and = 0 otherwise
Vegetarian	How much do you agree or disagree with the following statements? One alternative was: I consider myself a vegetarian	4 alternatives: Totally agree, somewhat agree, somewhat disagree, and totally disagree	= 1 if totally agree and =0 otherwise
Income	What would you estimate your personal total gross income to be per year? In other words, all total income before tax and deductions.	11 groups (in 1000 NOK): < 100, 100 - 199, 200 – 299, 300 – 399, 400 – 499, 500 -599, 600 – 799, 800 - 999, 1000 - 1499, 1500 – 2000, >2000	=1 if income higher than median income and =0 otherwise

Notes: [a] The survey was conducted in Norwegian, and the survey questions and response alternatives were translated to English by the authors. [b] Only children 20 years and below are considered

3. Materials and methods

The 2017/2018, 2019/2020, and 2021/2022 rounds of the Norwegian Monitor Survey (NMS) with respectively 3,778, 3,710, and 3,537 respondents were used. The NMS is a nationally representative survey, which has been carried out every second year since 1985 (IPSOS, 2021). Each round included two stages. The first stage was a telephone interview mostly covering socioeconomic questions, and the second stage was a self-administered questionnaire covering multi-faceted topics within the Norwegian society including food consumption patterns and food choice motives. Many studies have used the NMS including Gustavsen (2021), Gustavsen and Hegnes (2020), Ardebili and Rickertsen (2020), Gustavsen and Rickertsen (2018, 2019, 2020), and Øvrum et al. (2014).

3.1. Variable measurement

The frequency of PBMA consumption was our dependent variable and was derived from the question: "How often do you eat or use vegetarian dishes with protein substitute, for example hamburger or sausages made from tofu." The response alternatives were: daily, 3-5 times a week, 1-2 times a week, 2-3 times a month, once a month, 3-11 times a year, seldom, and never. Out of the 10,802 respondents who answered to the PBMA consumption frequency question, 1,299 respondents had missing responses to one or several of our questions related to health (186 respondents), environment (98 respondents), taste (403 respondents), origin (142 respondents), media (188 respondents), urban (266 respondents), vegetarian (278 respondents), and income (398 respondents). The missing observations were deleted from the statistical analysis and our final sample of 9,503 respondents included 3,141, 3,218, and 3,144 respondents in 2017/2018, 2019/2020, and 2021/2022 surveys respectively.

Table 2. presents the frequencies of consumption of PBMA for the total sample and for each round. Close to two-thirds of the respondents did not consume PBMA. The main changes in consumption frequencies were due to respondents who moved from the "never" group to the two groups consuming

PBMA, but less than monthly. The "never" group decreased by almost 10 percentage points from 2017 to 2019 but remained quite stable from 2019 to 2021. About 18% of the respondents consumed PBMA seldom, almost 8% of the respondents reported to have eaten PBMA 3-11 times a year, and this group increased by about 3 percentage points from 2017 to 2021. About 10% consumed PBMA once a month or more, and this group increased from about 8% to 12% from 2017 to 2019 but stagnated in 2021.

Table 2. Consumption Frequencies of PBMA: Percentage of Sample

Frequencies	Total	2017	2019	2021
Never	63.44	69.88	60.04	60.50
Seldom	18.28	16.52	19.45	18.83
3-11 times a year	7.81	5.89	8.45	9.06
Once a month	3.76	2.80	3.98	4.48
2-3 times a month	3.24	2.26	3.79	3.66
1-2 times a week	2.35	1.66	2.98	2.39
3-5 times a week	0.96	0.76	1.15	0.95
Daily	0.17	0.22	0.16	0.13

3.2. Descriptive statistics

Table 3 shows the mean values of the independent variables for the total sample and each round, and the standard deviations for the total sample. Significant differences in mean values across the three rounds were tested by using a one-way ANOVA test for the age variable and Chi-square test of independence for the other variables, and the *p*-values for no difference are reported in column 7 of the table.

In the total sample, the top three motives were taste (83%), presence of additives (55%), and price (53%). Environment and familiarity were emphasized by 40% and 46%, while the other motives were less important. About 10% of the respondents often used social media for cooking tips. The mean age of the respondents was 47 years, and about half the sample were female or lived in urban areas. Close to two thirds were higher educated and either married or living with a partner. About a third had children living in the household, 3% highly identified themselves as vegetarian and 36% had a higher income.[2]

There were significant differences across the rounds for all variables except for origin, female, presence of children, and vegetarian status. The share of respondents who prioritized animal welfare, taste, novelty, familiarity, and used social media increased, while the share who prioritized health decreased over the rounds. The share that emphasized environment increased between 2017/2018 and 2019/2020 but then stabilized.

The total sample included 3,474 respondents with positive consumption and 6,029 respondents with zero consumption and the mean values are shown in Table 3. Differences in the mean values of the independent variables between the two groups were tested, and the *p*-values for no difference between the two groups are also reported. Between respondents who consumed and those that did not consume PBMA, there were significant differences in all variables except emphasis on no additives. Respondents who consumed PBMA put more emphasize on health, environment, animal welfare, taste, novelty, and

[2] The mean age of the respondents was higher than the national average of about 40 years (Haug, 2020). The higher age in the sample was mainly due to the exclusion of respondents below 15 years in the survey. About 18% of the population was below 15 years (Statistics Norway, 2023a). Our sample is overrepresented with respondents with higher education. The national average for persons with higher education is 36% (Statistics Norway, 2023b).

price, used social media more actively, but emphasized familiarity and country of origin less. PBMA consumers were more likely to be young, female, higher educated, urban, with children, and vegetarian, and less likely to live with a partner.

Table 3. Descriptive Statistics

Variable	Mean Total[a]	SD Total[b]	Mean 2017/18[c]	Mean 2019/20[d]	Mean 2021/22[e]	p-value[f]	Mean Zero[g]	Mean Non-Zero[h]	p-value[i]
Health	18.23	0.39	20.06	17.34	17.30	0.01	15.57	22.83	0.00
Environment	39.68	0.49	37.00	41.17	40.84	0.00	32.86	51.55	0.00
AW	29.59	0.46	26.97	29.52	32.28	0.00	25.19	37.22	0.00
Taste	82.71	0.38	74.66	86.89	86.48	0.00	80.31	86.87	0.00
Additives	55.49	0.50	58.77	53.45	54.29	0.00	55.85	54.86	0.35
Novelty	17.67	0.38	14.55	19.14	19.27	0.00	14.50	23.17	0.00
Familiarity	45.58	0.50	42.50	46.65	47.55	0.00	48.08	41.22	0.00
Price	53.20	0.50	50.30	55.07	54.20	0.00	51.12	56.82	0.00
Origin	21.27	0.41	21.62	20.79	21.41	0.70	23.75	16.95	0.00
Media	9.69	0.30	6.49	10.16	12.40	0.00	07.35	13.76	0.00
Age	47.08	18.24	48.29	45.54	47.44	0.00	51.01	40.25	0.00
Female	49.85	0.50	50.02	50.09	49.43	0.85	48.75	51.76	0.00
Education	62.39	0.48	61.25	59.14	66.86	0.00	61.04	64.74	0.00
Urban	51.51	0.50	48.55	52.95	52.99	0.00	46.11	60.88	0.00
Children	36.49	0.48	36.26	35.86	37.37	0.43	35.54	38.14	0.01
Partner	62.94	0.48	64.09	60.91	63.87	0.01	66.66	56.48	0.00
Vegetarian	3.04	0.17	2.93	3.11	3.09	0.90	0.93	6.71	0.00
Income	36.10	0.48	30.12	36.51	41.67	0.00	34.86	38.26	0.00

Notes: [a] For the 9,503 respondents in the total sample. [b] Standard deviations for the total sample. [c] For the 3,141 respondents in 2017/2018 sample. [d] For the 3,218 respondents in 2019/2020 sample. [e] For the 3,144 respondents in 2021/2022 sample. [f] The *p*-value for ANOVA test for the age variable and Chi-square test of independence for the other variables for mean differences across the three rounds. [g] For the 6,029 respondents who reported to never have eaten PBMA. [h] For the 3,474 respondents who reported to have eaten PBMA. [i] The *p*-value for a *t*-test of identical mean values for respondents who had consumed PBMA and those who had not consumed PBMA.

3.3. Logistic regression model

As discussed above, almost two-thirds of the respondents had never consumed PBMA and only about 10% consumed PBMA once a month or more. Skewed distributions is a common problem among other studies dealing with novel foods (e.g., Denver et al., 2023; and Van der Stricht et al., 2024), and the dependent variable is specified as a binary variable. A binary logistic regression model was specified as:

$$y_i^* = x_i\beta + e_i \quad \text{where } y_i = 1 \text{ if } y_i^* > 0 \text{ and } y_i = 0 \text{ otherwise.} \tag{1}$$

In Equation (1), y_i^* is a latent continuous variable, y_i is the observed dummy variable representing whether the respondents consumed PBMA or not, x and β represent the vectors of the variables and coefficients, and e_i is an error term assumed to be logistically distributed. The probability of positive PBMA consumption is:

$$\mathrm{E}[y_i^*|x_i] = \Pr(y_i = 1|x_i) = \frac{\exp(x_i\beta)}{1 + \exp(x_i\beta)}. \tag{2}$$

The logit model was estimated by maximum likelihood estimation using the logit command in Stata 18 (StataCorp, 2023).

4. Results

An unrestricted model with survey round dummy variables and interaction terms was estimated. To test for changing importance of food choice motives, a restricted model without interaction terms was also estimated. A likelihood ratio test rejected identical coefficients (p = 0.001), and the results from the unrestricted model are presented. Marginal effects (ME) and associated p-values for the total sample and each survey round are presented in Table 4. For a continuous variable, the marginal effect gives the change in the probability of a positive PBMA consumption when the variable increases by one unit. For a dummy variable, the ME gives the change in the probability of a positive consumption when the respondent changes from belonging to the reference to the other group. The reference respondent was a male non-vegetarian with low education who lived in a rural area without children or partner, earning below median income, and not emphasizing any of the food choice motives.

In the total sample, many variables were associated with the probability of PBMA consumption. However, taste, price, living with children, and income had no effects. The consumption probability increased with emphasis on health (4.1 percentage points (pp)), environment (11.2 pp), animal welfare (8.7 pp), no additives (2.7 pp), novelty (7.6 pp), and with use of social media (3.4 pp). Conversely, the probability was reduced with an emphasis on familiarity (5.4 pp) and Norwegian origin (7.7 pp).

Several socioeconomic factors were associated with the consumption probability. It decreased with age (0.7 pp per year), being female (2.4 pp), and living with a partner (2.8 pp) and increased with higher education (7.6 pp), urban living (5.5 pp), and being vegetarian (32.9 pp).

Compared to the 2017/2018 round, the consumption probability increased in 2019/2021 (7.5 pp) and 2021/2022 (7.3 pp). For about 60% of the variables, the conclusions regarding significance were identical in each round and for the total sample. None of the significant effects changed sign. However, health, use of social media, and living with children were only significant in the 2019/2020 round and being female and living with a partner were only significant in the 2017/2018 round. Placing emphasis on additives was insignificant in each survey round.

Table 4. Estimated Marginal Effects

	Total		2017/2018		2019/2020		2021/2022	
	ME[a]	p-value	ME[b]	p-value	ME[c]	p-value	ME[d]	p-value
Health	0.041	0.001	0.021	0.307	0.081	0.000	0.020	0.359
Environment	0.112	0.000	0.105	0.000	0.113	0.000	0.117	0.000
AW	0.087	0.000	0.111	0.000	0.053	0.004	0.098	0.000
Taste	0.011	0.417	-0.019	0.334	0.006	0.803	0.044	0.066
Additives	0.027	0.007	0.031	0.078	0.020	0.254	0.031	0.075
Novelty	0.076	0.000	0.058	0.010	0.109	0.000	0.059	0.003
Familiarity	-0.054	0.000	-0.065	0.000	-0.048	0.003	-0.050	0.001
Price	-0.007	0.465	0.007	0.674	-0.025	0.135	-0.002	0.891
Origin	-0.077	0.000	-0.070	0.000	-0.054	0.007	-0.107	0.000
Media	0.034	0.034	-0.004	0.887	0.075	0.007	0.029	0.225
Age	-0.007	0.000	-0.005	0.000	-0.007	0.000	-0.008	0.000
Female	-0.024	0.011	-0.050	0.002	-0.011	0.512	-0.012	0.460
Education	0.076	0.000	0.042	0.013	0.091	0.000	0.094	0.000

Urban	0.055	0.000	0.047	0.004	0.038	0.019	0.081	0.000
Children	-0.019	0.065	-0.006	0.744	-0.045	0.009	-0.004	0.825
Partner	-0.031	0.004	-0.045	0.017	-0.023	0.221	-0.026	0.169
Vegetarian	0.329	0.000	0.313	0.000	0.348	0.000	0.328	0.000
Income	0.013	0.208	-0.008	0.654	0.026	0.151	0.021	0.246
2019/2020	0.075	0.000						
2021/2022	0.073	0.000						

Notes: [a] For the 9,503 respondents in the total sample. [b] For the 3,141 respondents in 2017/2018 sample. [c] For the 3,218 respondents in 2019/2020 sample. [d] For the 3,144 respondents in 2021/2022 sample.

The contrast of a marginal effect (CME) of a variable is the difference between the marginal effects of the variable in two periods. The 2017/2018 and 2019/2020, the 2017/2018 and 2021/2022, and the 2019/2020 and 2021/2022 rounds were compared. The CMEs and their associated *p*-values are shown in Table 5. Most of the CMEs were insignificant, however, there are some exceptions. Comparing the 2017/2018 and the 2019/2020 rounds, the effects of health (6.0 pp), and education (4.8 pp) increased and the effect of animal welfare (6.0 pp) and age (0.3 pp per year) decreased. Between the 2017/2018 and the 2021/2022 rounds, the effects of taste (6.2 pp) and education (5.2 pp) increased while that of age was reduced (0.3 pp per year). Lastly, between the 2019/2020 and the 2021/2022 rounds, the effect of health (6.1 pp) was reduced.

Table 5. Marginal Effects across Survey Rounds

	2017/2018 and 2019/2020		2017/2018 and 2021/2022		2019/2020 and 2021/2022	
	CME[a]	p-value	CME[a]	p-value	CME[a]	p-value
Health	0.060	0.049	-0.001	0.968	-0.061	0.050
Environment	0.008	0.740	0.012	0.630	0.004	0.880
AW	-0.058	0.033	-0.013	0.626	0.045	0.087
Taste	0.025	0.427	0.062	0.042	0.038	0.270
Additives	-0.011	0.659	-0.000	0.995	0.011	0.660
Novelty	0.051	0.096	0.001	0.986	-0.050	0.080
Familiarity	0.017	0.457	0.015	0.518	-0.002	0.919
Price	-0.033	0.175	-0.009	0.692	0.023	0.333
Origin	0.016	0.562	-0.038	0.170	-0.054	0.053
Media	0.079	0.057	0.034	0.391	-0.045	0.218
Age	-0.003	0.000	-0.003	0.000	-0.001	0.412
Female	0.039	0.086	0.038	0.095	-0.001	0.957
Education	0.048	0.046	0.052	0.034	0.004	0.877
Urban	-0.009	0.699	0.033	0.151	0.042	0.067
Children	-0.040	0.110	0.002	0.938	0.041	0.092
Partner	0.022	0.399	0.019	0.482	-0.003	0.896
Vegetarian	0.035	0.641	0.016	0.839	-0.020	0.798
Income	0.035	0.184	0.030	0.257	-0.005	0.846

Note: [a] CME shows the difference between the marginal effects of the variable between two periods.

5. Discussion, implications, and limitations

PBMA consumption appears to be novel and in its infancy with more than two-thirds of the respondents reporting to have never consumed it. Furthermore, while there was an increased consumption between the 2017/2018 and 2019/2020 rounds, the consumption stagnated between the 2019/2020 and 2021/2022 rounds. Similar stagnation is also reported for other regions (GFI, 2023; GFI Europe, 2023).

The associations between PBMA consumption and the explanatory variables were stable across the rounds for more than half of the variables. Emphasizing the environment, animal welfare, and novelty increased PBMA consumption, which is in line with previous review studies (He et al., 2020; Ishaq et al., 2022; Ismail et al., 2020; Singh et al., 2021). Conversely and corroborating with van Dijk et al. (2023), placing emphasis on familiarity had a negative association with PBMA consumption. A stated preference for Norwegian origin was negatively associated with PBMA consumption and in line with Milford and Muiruri (2024).

Older respondents were more averse to PBMA consumption as reported in for example Carlsson et al. (2022) and Gómez-Luciano et al. (2019). Higher educated and urban respondents were more likely to consume PBMA, which corroborates with for example Carlsson et al. (2022) and Cuffey et al. (2023). Being vegetarian had a positive association with PBMA consumption, as previously reported in, for example, Apostolidis & McLeay (2016) and Davitt et al. (2021).

We are not aware of any studies that have looked at the effect of social media on consumer acceptance of PBMA over time, and we found a declining effect over time. There was a positive association in the total sample and in the 2019/2020 survey round, however, the effect became insignificant in the other rounds. The reduced association may be explained by several factors. First, although PBMA remains relatively novel, but it has been around long enough that consumers who have been exposed to it in social media already may have formed their opinions. As a result, the influence of social media may have been reduced. Second, given that many PBMA are ultra processed, the debate on the healthiness of PBMA on social media (Lee et al., 2024) may reduce the influence of social media. Third, the visibility of PBMA on social media is competing for consumer attention with other new food products, for example, cultured meat that has increased visibility traction on social media (Pilařová et al., 2022).

Studies have found that PBMA frequently do not have a meaty taste, and this has been identified as one leading barrier especially among non-vegetarians (Fiorentini et al., 2020; Lee et al., 2020; Szenderák et al., 2022). One plausible explanation for the insignificant effect of taste may be the framing of our survey question. As discussed above, it was framed with a general focus on healthy foods rather than PBMA.

Several variables also changed in importance over time. Compared to the 2017/2018 round, the effect of higher education was stronger in the later rounds implying the consistent growth in the importance of higher education. An opposite trend was observed for age, older respondents in the later rounds were more open towards PBMA consumption as compared to those in the 2017/2018 round. This declining effect in age may imply that older people may have received more information or gained more exposure to PBMA products over time. The fluctuating effect of health may be due to the debates on the healthiness of meat analogues products. The initial increased effect suggesting that consumers may have embraced these products as healthy while the subsequent decline may imply a change in consumer perception. Interestingly, the declined effect was experienced during the COVID-19 pandemic when consumers' health consciousness was high. The declining effect of animal welfare (2017/2018-2019/2020) may suggest that the early adopters may have been strongly motivated by animal welfare concerns while the increasing effect of taste (2017/2018-2021/2022) may imply a positive change towards perceiving healthy food as tasty.

Plant-based meat analogues, cultured meat (CM), and insects are alternatives to meat. The willingness to try CM have been analysed in Muiruri & Rickertsen (2024) and the willingness to try insects have been analysed in Muiruri (2024). Some factors affect the consumer acceptance of these alternatives in similar ways and other not among Norwegian consumers. Emphasising the environment, novelty, and familiarity affect the consumer acceptance of the three alternatives in similar ways. However, emphasizing animal welfare is positively associated with consumer acceptance of PBMA but not with CM. This difference may be since, unlike PBMA that is already on sale and depends on plant ingredients, cultured meat is still not on sale and consumers may be unaware or question the animal welfare benefits of CM given that CM would depend on live animal tissue. Emphasizing no additives appears to positively affect consumer acceptance of PBMA while the oppositive was found for CM and insects. Quite interestingly, being vegetarian was positively associated with acceptance of PBMA but negatively associated with CM. This finding is in line with review studies showing that vegetarians embrace PBMA more while CM is likely to be embraced by people with high meat attachments and flexitarians (Onwezen et al., 2021) Lasty, age, education, and urban living have similar effects for cultured meat and PBMA with a higher acceptance among younger, higher educated, and urban living respondents.

Our results have some marketing and policy implications. First, marketers and public health authorities should emphasize the environmental and animal welfare benefits of PBMA. Dietary recommendations aimed at increased plant-based foods consumption should be formulated to highlight the environmental and animal welfare benefits. The Norwegian dietary guidelines newly released by the Norwegian Directorate of Health (2024) were based exclusively on the connection between diet and health. That the guidelines ignored the environmental effect of food consumption and only highlighted the health effects may be seen as a weakness (Mittenzwei et al., 2024). Second, our results suggest that PBMA producers should aim to produce with minimal use of additives and using domestically produced ingredients, which also should be highlighted in the marketing of these product. Third, given the strong effect among vegetarians, marketing efforts should be placed on this group. PBMA marketers may use vegetarian-targeted communication channels. Fourth, targeted marketing should focus on younger, higher-educated, and urban consumers as early adopters of PBMA. Marketing and policy-based efforts including educational interventions and information campaigns should be adopted to also encourage older, lower educated, and rural consumers to consume these products.

There are four main limitations in our study. First, the data are not panel data, and it is impossible to investigate respondent specific differences over time. Second, the study used self-reported consumption frequency data as opposed to actual consumption. Consumers are subject to misreporting and may not be aware of their own consumption frequencies of different food products. Third, the data was extracted from a large survey covering many topics, and some questions would have been worded different in a survey focusing solely on PBMA. For example, a proxy question was used to assess the importance of taste. Fourth, the response alternatives varied across the questions, and any biases resulting from difference in response alternatives are not controlled for.

6. Conclusions

This study investigated PBMA consumption and its evolution over time. The consumption appears to have stagnated in Norway, in line with the development in many other countries. Being younger, higher educated, vegetarian, and living in an urban area were positively associated with PBMA consumption, while emphasizing familiarity and Norwegian origin had a negative association. Most of the food choice motives and socioeconomic effects appear to be stable over time. Stable effects include the effects of an emphasis on the environment, animal welfare, and novelty.

To encourage PBMA consumption, marketers and policy makers should, beyond health, focus on promoting the environmental and animal welfare benefits. It is important that these benefits are included in different communication strategies including dietary guidelines. Targeted marketing based on socioeconomic factors may be adopted and marketers may expect their products to be more appealing to younger, higher educated, and urban consumers. Our findings show a declining effect of social media over time, which raises questions regarding how promising this is as a marketing platform for PBMA. Further research on social media and PBMA is needed to validate our results and to uncover underlying explanatory factors. The changing importance of some factors over time highlights the complexity associated with consumption behaviour and signals a need to investigate changing consumer preferences over time and how these preferences relate to other societal trends.

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Ethical statement

The data used is from the Norwegian Monitor Survey conducted by Ipsos. Ipsos is a market and social research company and follows the EU General Data Protection Regulation (GDPR). It is also a member of ESOMAR, bound by the ICC/ESOMAR Code on Market and Social Research. The respondents consented to the survey after being guaranteed that, their responses were confidential, and no identifiable personal information would be included.

Declaration of competing interests

None

Data availability

The authors do not have permission to share the data.

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