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► To cite this version:

Florence Akinmeye, Sghaier Chriki, Changqi Liu, Jing Zhao, Sami Ghnimi. What factors influence consumer attitudes towards alternative proteins?. *Food and Humanity*, 2024, 3, pp.100349. 10.1016/j.foohum.2024.100349 . hal-04749499

HAL Id: hal-04749499

<https://hal.science/hal-04749499v1>

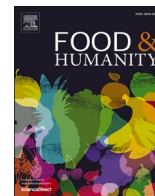
Submitted on 23 Oct 2024

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What factors influence consumer attitudes towards alternative proteins?

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ARTICLE INFO

Keywords:

Meat consumption
Cultured meat
Insects
Plant-based products
Fermentation-based proteins
Consumer behaviour
Willingness to purchase
Sustainability
Food security

ABSTRACT

Achieving the sustainability of protein is central to creating a sustainable food system. Current meat consumption patterns require a paradigm shift, as the status quo is unsustainable. However, at present, consumer participation in this shift is limited necessitating a change in consumer behaviour. This review seeks to understand consumer willingness to consume alternative proteins (cultured meat, edible insects, plant and fermentation-based proteins) and the factors influencing their decisions, considering variations across protein categories and cultural backgrounds. Understanding these factors is vital for designing interventions that effectively enhance acceptance levels. Consumer behaviour is complex, influenced by a spectrum of personal and societal factors, which must be interpreted within the specific context of the target society or demographic segment.

1. Introduction

The Sustainable Development Goals (SDGs), adopted by the United Nations in 2015, aim to end poverty, protect the planet, and ensure peace and prosperity by 2030. They encompass 17 interconnected goals that focus on balancing social, economic, and environmental sustainability (UNDP, 2015). Building a sustainable food systems has been identified as a key action required to achieve the Paris Agreement and SDGs due to the significant role food systems play in meeting several of these goals simultaneously (Chen, Chaudhary, & Mathys, 2022; Hundscheid, Wurzing, Gühne, Melcher, & Stern, 2022; IPCC, 2019; UN, 2019).

A sustainable system is one that meets the needs of present generation without compromising future generation's ability to do same. Currently, our food systems are inefficient and major contributors to issues such as GHG emissions, eutrophication, land degradation, biodiversity and freshwater loss (Ahmed and Byker Shanks, 2020). In 2010, it was estimated that global food systems were responsible for approximately 5.2 billion tons of CO₂ equivalent emissions (methane and nitrous oxide), 12.6 million km² of cropland use, 1810 km³ of freshwater use, and significant fertilizer applications (104 teragrams of nitrogen and 18 teragrams of phosphorus) (Springmann et al., 2018). Recent analysis has demonstrated that, even if all fossil fuel emissions were

eliminated, global food system emissions alone could still push us beyond the 1.5 °C and possibly the 2.0 °C targets outlined in the Paris Agreement (Clark et al., 2020).

The rising global population, expected to reach 9.3 billion by 2050, and environmental changes will further intensify the strain on food systems, necessitating a more than 50 % increase in food production from current levels to meet 2050 demands (Ahmed and Byker Shanks, 2020; FAO, 2009). Researchers agree that a transition to a sustainable diet is essential to combat these challenges and achieve sustainable development (Aiking and de Boer, 2020; Bryant and van der Weele, 2021; Chen et al., 2022; Hundscheid et al., 2022; Katz-Rosene, Hefernan, & Arora, 2023).

The Food and Agriculture Organization (FAO) defines sustainable diets as "diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations". These diets protect biodiversity and ecosystems, are culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy, while optimizing natural and human resources (FAO, 2010).

Protein production and consumption is a major area for change within food systems due to its inefficiency and large environmental footprint. It significantly impacts the top three planetary boundaries: biodiversity loss, nitrogen cycle disruption, and carbon cycle disruption,

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<https://doi.org/10.1016/j.foohum.2024.100349>

Received 2 April 2024; Received in revised form 18 June 2024; Accepted 4 July 2024

Available online 6 July 2024

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leading to climate change and therefore pivotal to achieving sustainability (Aiking, 2014; Aiking and de Boer, 2020; Chen et al., 2022; Hundscheid et al., 2022).

Western diets rely heavily on animal-based proteins which dominate dietary protein sources (FAO, 2018; Hundscheid et al., 2022; Neacsu, McBey, & Johnstone, 2017). Over a decade ago, it was recommended for health and sustainability to reduce the consumption of protein by a third in many western countries as they were 150 % over the recommended levels (Aiking and de Boer, 2020; de Boer and Aiking, 2018). The Dasgupta (2021) Review also highlighted reducing meat consumption as essential to preserving the planet's biodiversity and other researchers are in agreement (Bryant and van der Weele, 2021; European Commission, 2020; Hundscheid et al., 2022; IPCC, 2019).

Livestock production, while providing essential nutrients and economic benefits, also accounts for 14.5 % of greenhouse gas emissions, has a large water footprint, causes water pollution, and contributes to biodiversity loss (Pulina et al., 2022; Murphy et al., 2018; Ward et al., 2005; Godfray et al., 2018). Additionally, it raises ethical concerns due to poor animal welfare and intensive antibiotic use, which leads to antibiotic resistance and disease outbreaks like avian influenza and bovine spongiform encephalopathy (Duluins and Baret, 2024).

Excessive consumption of processed meat like sausages and ham is linked to several health problems, including cardiovascular disease, type 2 diabetes, obesity and colorectal cancer (IARC, 2018). However, evidence regarding health risks of unprocessed red meat is limited and inconclusive (Lescinsky et al., 2022). World Health Organisation (WHO) recommends consuming no more than 500 g (cooked weight) of red meat per week to reduce cancer risk as numerous studies have associated increased consumption of red and processed meat with various health challenges (Godfray et al., 2018).

The protein challenge is twofold: developed countries need to reduce overconsumption of animal protein, while developing and underdeveloped countries need to increase animal protein intake to ensure adequate nutrition for their citizens. Therefore, the conversation of protein transition is only suitable for developed/emerging economies with high level of protein consumption (Duluins and Baret, 2024; Parlasca and Qaim, 2022). Bryant and van der Weele (2021), highlighted some of the policy shifts in these societies supporting the protein transition. The EU's Farm to Fork strategy, part of the EU Green Deal, promotes a more plant-based diet and meat alternatives. The UK's Path to Sustainable Farming aims to enhance animal welfare and sustainability by phasing out the CAP's Basic Payment Scheme and subsidizing nature-supporting farming activities. In 2019, Canada revised its food guidelines, reducing emphasis on the dairy consumption. The healthy China 2030 plan to reduce meat consumption by 50 % by 2030 and Brazil's National Plan for Agroecology and Organic Production (PNAPO, 2018).

While the recommendation is a shift towards a more plant-based diet and reduced meat consumption, complete meat elimination or adopting a fully plant-based diet is impractical for many due to social, cultural, personal preferences and nutritional needs (Lang, 2020; pp, 1015, 5201; Leroy and Barnard, 2020; Tso and Forde, 2021). Instead, a flexitarian lifestyle, which incorporates meat-free days, more plant proteins and alternative proteins is proposed as a better option for more sustainable consumer behaviour (Duluins and Baret, 2024; Tso, Lim, & Forde, 2021). However, flexitarians remain a minority, often practicing limited meat moderation rather than making the significant reductions required to depart from meat overconsumption (Dagevos, 2021). A report from Euromonitor estimated that about 40 % of global consumers identify as flexitarians (Euromonitor, 2020), despite the lack of consensus about the definition of flexitarianism (Henchion, 2022).

The alternative protein sector, driven by technological advances, offers novel solutions such as cultured meat, fermentation-derived proteins, and edible insects (Chriki and Hocquette, 2020; Lee, Yong, Kim, Choi, & Jo, 2020). The sector has witnessed significant growth in recent years. In 2016, Euromonitor reported annual growth rates of

15–20 % in Denmark and Germany, 5–10 % in the Netherlands, Sweden, and the UK saw growth rates of 5–10 % in 2016 (Tziva, Negro, Kalfagianni, & Hekkert, 2020). The global market was valued at about USD \$4.4 billion in 2022 and projected to increase by 24.9 % by 2030. However, recent reports have noted a decline in plant-based sales since 2021, with volume sales dropping by nearly 21 % over a 52-week period (Ford et al., 2024).

Therefore, the aim of this review is to understand consumer willingness to consume alternative proteins (cultured meat, edible insects, plant and fermentation-based proteins) and the factors that influence their decisions, considering variations across protein categories and cultural backgrounds. The objective is to aid the development of more effective interventions to promote responsible and sustainable protein consumption among consumers.

A preliminary search was performed in Google Scholar for studies on alternative proteins, consumer acceptance, protein transition, meat consumption & meat reduction in combination with consumer perspectives to identify keywords to use in the literature search. From this preliminary review, it became clear that 'acceptance' and 'perception' were often mentioned so the final string used is the following: "consumer perception" AND ("meat reduction*" OR "plant-based proteins" OR "cultured meat*" OR "insects") AND (willingness to buy* OR acceptance*). The literature search was conducted on Google Scholar in October 2023. Based on title screening, and due to the limited timeframe of the research, 75 articles were selected in the first stage. After a more rigorous screening of the abstract and methodology section of the studies, 20 articles were discarded for not focusing on consumer perception of alternative proteins specifically. A total of 55 studies were then used to perform the literature review.

2. Alternative proteins sector

Alternative proteins sector encompasses proteins from conventional plant sources and non-conventional sources, including edible insects (Tso et al., 2021).

Plant-based alternatives are made from vegetable proteins such as pulses, cereals, and nuts and have been on the market for several decades (Hoek et al., 2011a). Plant-based dairy (e.g., almond milk, oat milk), meat (Impossible Burger, Beyond Meat, etc.), seafood, and egg (Just Eat) products are commercially available.

Fermentation-enabled protein alternatives are made using microorganisms such as yeast, algae bacteria or fungi. Fermentation has been used in food production for millennia with foods such as beers, wine and tempeh, but more recently the application has expanded to a much broader range of alternative protein applications. Fermentation-derived products currently available on the market include products fermented by fungi (Quorn, Nature's Fynd, Promyc) and algae (Too Good To Be).

Cultured meat is grown in a laboratory or factory environment from animal stem cells. The industry is in its early stages and faces many technological, regulatory and ethical challenges (Chriki and Hocquette, 2020). Despite being promoted by its proponents as a sustainable and cruelty-free alternative, concerns remain about the use of foetal bovine serum and lack of comprehensive life cycle assessments and affordability (Chriki, Ellies-Oury, & Hocquette, Chap. 18, 2022; Chriki et al., 2023). In a significant milestone, Singapore became the first country to approve the sale of the world's first cultured chicken product in 2020. In 2023, Upside Foods and Good Meat received the go-ahead from the US Department of Agriculture and Food and Drug Administration to introduce cultured meat to the US market. Though the industry is still a long way from producing cultured meat on industrial scale and competitive price, there are already several studies on how consumers perceive it.

Eating insects as food is common in Asian, African and South American cultures but relatively uncommon in western cultures including Europe and North America (Ordoñez López, Ghnimi, & Liu, 2023). There are an estimated 5.5 million insect species worldwide with over 2000 identified as edible (Jongema, 2017). They have been

identified as a sustainable protein option due to their high feed conversion efficiency, low environmental impact and high nutritional value (Onwezen, van den Puttelaar, Verain, & Veldkamp, 2019).

Edible insects as a novel status in the European union (food that was not consumed “significantly” prior to May 1997) (EFSA, 2023) and as of January 2023, four edible insects have been approved for marketing by the European Food Safety Authority (EFSA); yellow mealworm (*Tenebrio molitor*), European migratory locust (*Locusta migratoria*) house cricket (*Acheta domestica*), and lesser mealworm (*Alphitobius diaperinus*) (European Commission, 2023).

3. Factors influencing consumer perception of alternative proteins

A summary of the different factors influencing the acceptance of each category of alternative protein is presented in Table 1.

3.1. Animal welfare

In recent years, consumers have increasingly considered animal welfare issues in their food choices, leading many to view alternative proteins as a more ethical option (Adamczyk, Jaworska, Affeltowicz, & Maison, 2022; Laila et al., 2021; Specht, Rumble, & Buck, 2020; pp, 1015, 5201). Studies comparing meat substitutes with conventional meat consistently show that meat substitutes score higher in terms of being perceived as more animal and environmentally friendly (Hoek et al., 2011a). Consumer dietary patterns are often consistent with their concern for animal welfare, with vegetarians showing the highest level of concern, heavy meat eaters expressing the least concern, and flexitarians closely matching with heavy meat eaters in their level of concern (Tso et al., 2021).

3.2. Environmental impact

Existing literature highlights the low level of consumer knowledge about the environmental impacts of animal proteins and the environmental benefits of alternative proteins (Szenderák, Fróna, & Rákos, 2022). However, in studies where consumers are aware of such benefits, it plays an important role in their acceptance (Onwezen, Bouwman, Reinders, & Dagevos, 2021). For example, consumers’ positive perceptions of the environmental benefits of cultured meat have motivated its consumption (Bryant and Barnett, 2020; pp, 1015, 5201; Weinrich, Strack, & Neugebauer, 2020). Similarly, insects and plant-based meat alternatives have been positively perceived for their environmental benefits (Adamczyk et al., 2022; Ordoñez López et al., 2023; Woolf et al., 2021). Consumer perceptions of environmental friendliness are also influenced by lifestyle choices, as shown in a German study. Heavy meat eaters rated meat as more environmentally friendly than meat alternatives while non-meat eaters and flexitarians did not (Michel, Hartmann, & Siegrist, 2021).

3.3. Health and Nutrition

Numerous reports highlight the health benefits of plant-based protein diets, such as improved indices in type 2 diabetes, management of cardiovascular disease and obesity, and support for weight loss (Kyriakopoulou, Dekkers, & van der Goot, Chap. 6, 2019). These health benefits serve as relevant drivers for consumer acceptance of all alternative proteins. For example, in a study of plant-based dairy alternatives, consumers indicated that they chose these products because of health concerns or a desire to include healthier options in their diet (Adamczyk et al., 2022). Other studies have also identified health as a driver for consumer acceptance of algae, insects, and plant-based alternatives and cultured meat (Liu, Hocquette, Ellies-Oury, Chriki, & Hocquette, 2021; Ordoñez López et al., 2023; Profeta et al., 2021; Woolf et al., 2021).

Table 1

Summary of the factors influencing the acceptance of each category of alternative protein.

Alternative	Factors	Impact on the consumer acceptance	References
Plant-based	Familiarity	+ -	(Hoek et al., 2013; Hoek et al., 2011b)
	Sensory quality	+ -	(Elzerman et al., 2011; Hoek et al., 2011a)
	Animal welfare	+ +	(Adamczyk et al., 2022; Haggmann, Siegrist, & Hartmann, 2019; Laila et al., 2021; Tso et al., 2021)
	Environmental impact	+ +	(Bryant, 2019)
	Health and nutrition	+ -	(Adamczyk et al., 2022; Clark et al., 2022; Hwang et al., 2020; pp, 1015, 5201; Ismail et al., 2020; Kyriakopoulou et al., 2019; Chap. 6; Sogari, Caputo, Joshua Petterson, Mora, & Boukid, 2023)
	Consumer lifestyle	+ -	(Graça et al., 2015)
	Unnaturalness	-	(Giacalone et al., 2022; Hartmann et al., 2022)
	Price	-	(Onwezen et al., 2021)
	Framing and labelling	+ -	(Siegrist and Sütterlin, 2017)
	Familiarity	-	(Birch et al., 2019; Birch, Skallerud, & Paul, 2018)
Fermentation-derived	Consumer lifestyle	+ -	(Weinrich and Elshiewy, 2019)
	Food neophobia	-	(Birch et al., 2019; Moons, Barbarossa, & De Pelsmacker, 2018)
	Animal welfare	+ +	(Bryant and Barnett, 2018; Specht et al., 2020; pp, 1015, 5201)
Cultured meat	Environmental impact	+ +	(Bryant and Barnett, 2020; pp, 1015, 5201; Weinrich et al., 2020)
	Health and nutrition	+ -	(Chriki and Hocquette, 2020; Liu et al., 2021)
	Familiarity	-	(Hocquette et al., 2022)
	Consumer lifestyle	+ -	(Gousset et al., 2022)
	Unnaturalness	-	(Bryant and Barnett, 2018; Circus and Robison, 2018; Liu et al., 2021)
	Food neophobia	-	(Boereboom et al., 2022; Wilks, Phillips, Fielding, & Hornsey, 2019)
	Food technology phobia	-	(Giacalone and Jaeger, 2023)
	Price	-	(Sghaier Chriki et al., 2022; Chap. 18; S. Chriki et al., 2022; Chap. 18)
	Trust	-	(Wilks et al., 2019)
	Framing and labelling	+ -	(C. Bryant and Dillard, 2019; C.J. Bryant and Barnett, 2019; Mancini and Antonioli, 2019)
Insects	Environmental impact	+ +	(Circus and Robison, 2018; Menozzi, Sogari, Veneziani, Simoni, & Mora, 2017)
	Health and nutrition	+ -	(Profeta et al., 2021; Sogari et al., 2017)
	Familiarity	+ -	(Woolf et al., 2019)

(continued on next page)

Table 1 (continued)

Alternative	Factors	Impact on the consumer acceptance	References
	Cultural appropriateness	-	(Onwezen et al., 2019; Ordoñez López et al., 2023)
	Social norms	+ -	(Jensen and Lieberoth, 2019; Sogari et al., 2017)
	Food neophobia	-	(Barton et al., 2020; Orkusz et al., 2020)

(+ +) means positive influence on consumer behaviour, (+ -) means both negative and positive influence on consumer behaviour, (-) means a negative influence on consumer behaviour.

On the other hand, ensuring a high nutritional value comparable to animal proteins is challenging for alternative proteins, especially plant-based alternatives, due to limitations in essential amino acids, minerals, and trace elements compared to meat or dairy. The absence or low levels of essential nutrients such as calcium, potassium, iron, vitamin D, and B12 in plant-based dairy alternatives has led healthcare professionals to emphasize the superior nutritional value of animal dairy products, despite efforts to fortify plant-based dairy alternatives with these nutrients (Adamczyk et al., 2022; Clark, Pope, & Belarmino, 2022).

Perceptions of over-processing and the use of additives, preservatives, flavour enhancers, high sodium, and added sugars in some alternative protein products also raise concerns about their nutritional quality and healthiness (Ismail, Hwang, & Joo, 2020; Tso et al., 2021). Presenting alternative proteins especially the plant based ones in fast-food style meals also affects their acceptance, as it often leads to simply replacing animal-based fast foods with plant based version, rather than promoting a healthier, nutrient dense diet. Additionally, questions remains on the long-term impact of some of the novel ingredients, such soybean haem been used to improve the functionality and palatability of plant based meat alternatives (Tso et al., 2021).

3.4. Sensory quality

Sensory quality plays an important role in consumer food choices, and for alternative proteins to successfully replace animal proteins, they must be widely accepted in terms of overall palatability and perceived as viable meat substitutes (Maya, Shertukde, & Liu, 2023). Alternative proteins often struggle to achieve the meat-like textures and do not deliver the same eating experiences as animal products. Even hybrid products containing both plant and animal proteins are unable to replicate the complex sensory profile of meat products. This has led consumers to perceive alternative proteins as inferior in sensory appeal compared with conventional meat products (Tso et al., 2021).

Sensory evaluation is influenced not only by the product's sensory characteristics of the product, but also by personal factors, which can be a potential driver or barrier depending on the consumer's lifestyle (Fiorentini, Kinchla, & Nolden, 2020). A survey done by Hoek et al. (2011), which investigated the sensory acceptability of alternative proteins among consumers with different lifestyles (non-users, light-/medium users, and heavy users of meat substitutes) revealed that the level of sensory appeal varied depending on the consumer's meat substitute use. For non-users and light/medium users a key barrier was sensory unattractiveness (Hoek et al., 2011a).

Certain sensory attributes may hold particular importance than others to certain consumers. For example, taste and texture are of particular importance to meat eaters, and play a critical role in product acceptance (Hoek et al., 2011a). Therefore, identifying the product attributes that drive liking, taking into account person-related factors, is essential to promote acceptance (Fiorentini et al., 2020). In addition, the sensory quality acceptance of alternative proteins is influenced by the

meal context, as alternative proteins are often consumed as part of a dish. Elzerman, Hoek, van Boekel, and Luning (2011) reported, based on a focus group, that ensuring the form and use of meat substitutes closely resemble with those of meat is crucial for consumer acceptance, as it enhances their ability to blend well with other components of a dish and provide a satisfactory sensory experience (Elzerman et al., 2011). Therefore, the sensory quality of individual products alone is not enough to drive consumption.

3.5. Familiarity

Consumer acceptance of alternative proteins is significantly influenced by familiarity, previous experience, and integration into familiar products. Resemblance to more familiar food increases liking for novel foods due to consumers' positive bias toward the familiar (Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994). Several research has reported the relevance of familiarity in the acceptance of alternative proteins; algae (Birch, Skallerud, & Paul, 2019), insects (Ordoñez López et al., 2023; Woolf, Zhu, Emory, Zhao, & Liu, 2019), plant-based meat alternatives (Hoek et al., 2013; Hoek, van Boekel, Voordouw, & Luning, 2011b), cultured meat (Hocquette, Liu, Ellies-Oury, Chriki, & Hocquette, 2022).

Past consumption and repeated exposure to alternative proteins also contribute to increased acceptance among consumers (Bryant, Szejda, Parekh, Deshpande, & Tse, 2019; Onwezen et al., 2021). For example, Hoek et al. (2013), discovered that repeated exposure to plant-based meat alternatives increased liking for certain segments of consumers (Hoek et al., 2013). Several research on insects have also shown that past consumption of insects positively affects sensory perception and increases future consumption (Onwezen et al., 2021).

Providing a familiar context for consumers by integrating alternative proteins into familiar products enhances consumer acceptance also. For example, studies where insects were processed and incorporated as an ingredient in familiar products such as biscuits, and tortilla chips resulted in positive consumer perceptions and increased interest in further consumption after tasting (Barton, Richardson, & McSweeney, 2020). Similarly, consumer acceptance of plant-based meat substitutes increased when evaluated in meal contexts similar to regular everyday meals (Elzerman, Hoek, van Boekel, & Luning, 2015; Elzerman et al., 2011).

Familiarity with the known raw material used in producing the alternative protein such as in the case of plant-based alternatives also increases consumers' willingness to try and accept these products (Szenderák et al., 2022).

3.6. Consumer lifestyle

The enjoyment of eating meat is a significant barrier to adopting a plant-based diet or alternative proteins (He, Evans, Liu, & Shao, 2020). Sociocultural attachment to meat are continually reinforced by the extensive promotions and positioning of meat as focal point in meals (Dagevos, 2021).

Consumer dietary patterns, spanning omnivores to vegans, significantly influence acceptance of alternative proteins (Gousset et al., 2022; Onwezen et al., 2021). Omnivores, who consume both animal and plant products, may be hesitant to fully switch to alternative proteins but are often open to incorporating them as supplements. Flexitarians, who consciously reduce meat intake are generally more receptive and instrumental for market growth. Vegans and vegetarians, who avoid animal products, are naturally inclined towards alternative proteins but acceptance varies based on processing and ingredients (Faber, Henn, Brugarolas, & Perez-Cueto, 2022).

Graça, Oliveira, and Calheiros (2015), found that willingness to reduce meat consumption correlates with meat attachment levels with those less attached more opened to plant-based diets.

Studies affirm that dietary patterns strongly influence acceptance

and preference for alternative proteins (Circus and Robison, 2018; Kühn, Profeta, Kriksler, & Heinz, 2023; Lonkila and Kaljonen, 2021; Possidónio, Prada, Graça, & Piazza, 2021; Weinrich and Elshiewy, 2019).

3.7. Naturalness

Consumers highly value the concepts of nature and naturalness in food, making it a critical product attribute influencing the acceptance of alternative proteins. Natural foods are perceived as healthier, tastier and environmentally safer. Any indication of tampering is negatively perceived, as consumers associate naturalness with minimal processing, absence of artificial ingredients and non-genetically modified organisms (Román, Sánchez-Siles, & Siegrist, 2017).

The acceptance of cultured meat is hindered more by the perception of unnaturalness compared to plant-based alternatives (Liu et al., 2021). This is primarily because cultured meat production techniques differs greatly from traditional farming, raising concerns about the nature of the final product among consumers.

Conversely, plant-based alternatives are also viewed as less natural than traditional meat, often considered as overprocessed and containing a lot of additives and preservatives (Giacalone, Clausen, & Jaeger, 2022; Hartmann, Furtwaengler, & Siegrist, 2022).

3.8. Cultural appropriateness

Cultural context, specifically the role particular food holds within local culinary traditions, also plays a big role in shaping the acceptance of alternative proteins. In cultures where insects are already part of the diet, consumers are more willing to eat insect-based products and rate them favourably, while in Western cultures, insects are perceived as inappropriate and have lower acceptance levels (Hurd et al., 2019; Onwezen et al., 2019; Ordoñez López et al., 2023).

Additionally, meat consumption is strongly tied to cultural notions of masculinity in Western societies, posing a barrier for the acceptance of plant-based meat alternatives among men. However, such cultural association is not as pronounced in the same degree in Asian countries like India or China (Giacalone et al., 2022).

3.9. Social norms

Social norms, which are the perceived appropriate behaviour within a group or community, significantly influence behaviour and acceptance of alternative proteins (Figueira, Curtain, Beck, & Grafenauer, 2019; Jensen and Lieberoth, 2019; Onwezen, Verain, & Dagevos, 2022; Sogari, Menozzi, & Mora, 2017). Social norms can either be a driver or a barrier to acceptance. For example, in a study by Jensen & Lieberoth (2019), the more participants thought other participants ate products containing mealworms, the more likely they were to eat the products themselves (Jensen and Lieberoth, 2019). Conversely, the negative opinions of family and friends may hinder Western consumers from adopting insects as part of their diet (Sogari et al., 2017).

3.10. Food neophobia

Food neophobia is defined as an aversion to new foods and is conceptualized as a personal trait, quantified using the Food Neophobia Scale (FNS) by Pliner & Hobden (1992) (Pliner and Hobden, 1992). It has been identified as a key barrier to the acceptance of novel alternative proteins including insects, cultured meat, and algae (Onwezen et al., 2019; Tso et al., 2021) and numerous studies have consistently supported these findings. For insects, food neophobia has been identified as a major obstacle to their acceptance (Barton et al., 2020; pp, 1015, 5201; Ordoñez López et al., 2023; Orkusz, Wolańska, Harasym, Piwowar, & Kapelko, 2020; Sogari et al., 2017).

Similarly, food neophobia has been found to impact consumer acceptance of algae (Birch et al., 2019) and cultured meat (Boereboom

et al., 2022; Bryant and Barnett, 2020; pp, 1015, 5201). Notably, plant-based alternatives tend to score lower on the food neophobia scale compared to other novel alternative proteins. This is attributed to the fact that plant-based meat and dairy substitutes have been available and marketed for a longer time compared to insects, cultured meat, and algae (Hwang, You, Moon, & Jeong, 2020; pp, 1015, 5201; Szenderák et al., 2022). Also, other forms of neophobia such as food technology neophobia, can exacerbate consumers' food neophobia for novel alternative proteins (Krings, Dhont, & Hodson, 2022). Understanding and addressing food neophobia is essential in fostering consumer acceptance and adoption of alternative proteins across various categories.

3.11. Food technology phobia

Consumer acceptance of new food technologies, reflects their willingness to embrace innovation. The technology employed in food production can influence consumer purchasing decisions thanks to their growing interest in food production technologies in recent years, especially when perceived societal benefits are unclear (Siegrist and Hartmann, 2020a). New food technologies are often perceived as riskier than traditional ones, hindering product acceptance, as perceived risk is associated with purchasing and consumption willingness (Giacalone and Jaeger, 2023). Consumers tend to be cautious about foods involving new technology and assess them based on concepts, images, and perceptions of naturalness associated with the technology. This evaluation influences their decision about incorporating these products into their daily diet,

3.12. Price

Price significantly drives consumer choice, acting as a major barrier to transitioning to more sustainable diets especially in developed countries where animals based foods are cheaper and more accessible (Tufford et al., 2023). The pricing of alternative proteins is a crucial factor shaping consumer behaviour, as these products are often priced higher than their traditional animal counterparts. Understanding consumers' willingness to pay for alternative proteins is essential for businesses and policymakers to assess market viability and optimise pricing strategies (Katare, Yim, Byrne, Wang, & Wetzstein, 2023, pp. 13285).

Currently, cultured meat is the most expensive among alternative proteins due to its costly technology and the promised future price reductions raises questions about the safety and quality of such products.

3.13. Sociodemographic factors

When it comes to demographics, which include factors like age, gender and education, there are inconsistencies in literature. While some studies identified significant correlations, others do not. However, a common trend emerges: individuals who earn above-average income, are young, highly educated and live in urban areas consistently demonstrate higher acceptance of alternatives proteins (Giacalone et al., 2022; Hoek et al., 2011a; Liu et al., 2023; Onwezen et al., 2021; Ordoñez López et al., 2023; Siegrist and Hartmann, 2019).

Gender influence also differs across alternative proteins; for insects males have been reported to be more willing (Orkusz et al., 2020; pp, 1015, 5201; Sogari et al., 2017; Wilkinson et al., 2018; Woolf et al., 2019) while for plant-based alternative proteins, females show greater willingness (Michel et al., 2021). This variation is attributed to cultural associations, as masculinity is linked to meat consumption (Rozin, Hormes, Faith, & Wansink, 2012), and males are often more risk-takers, while females tend to be more aware of the negative impact of meat production and cautious about trying new foods (Michel et al., 2021).

3.14. Trust and Safety

Trust is necessary for the acceptance of alternative proteins, as

consumers need to believe producers' claims regarding their nutritional equivalence and environmental benefits. Although the public acknowledges the competency of the food industry, scepticism remains about its alignment with consumer values (Siegrist and Hartmann, 2020a). Recent happenings have eroded consumer trust in multinational food producers due to perceived transparency issues (EIT, 2023; Tso et al., 2021). This lack of trust can impede the adoption of alternative proteins, particularly novel options like cultured meat, by impacting perception of the risks and benefits. Studies show that higher trust in the food industry correlates with perceiving cultured meat as more natural (Siegrist and Hartmann, 2020b). Factors such as food neophobia, sociodemographic and consumer levels also influence trust.

Consumers have mixed perception about the safety of alternative proteins due to their novelty and the lack of long-term studies on their impact on health. This is especially true for insects and algae which are mostly produced on large scale from waste and may potentially contain contaminants (Tso et al., 2021). Cultured meat's long-term effects are currently unknown raising concerns (Bryant and Barnett, 2020; pp, 1015, 5201; Chriki and Hocquette, 2020).

Despite data showing processed and heat-treated insects are safe (Mutungi et al., 2019; Testa et al., 2017), consumers still perceive them as the least safe due to concerns about dirty, diseases and allergies (Castro and Chambers IV, 2019).

For algal protein, safety concerns relate to marine heavy metals and contaminants but studies indicate levels are insufficient to pose significant health risks due to current consumption patterns (Desideri et al., 2016; Hwang, Park, Park, Choi, & Kim, 2010; Tso et al., 2021).

3.15. Framing and labelling

Labelling and framing of alternative proteins, including technologies employed in their production can significantly influence consumer perception of risk and acceptance (Bryant and Barnett, 2020; pp, 1015, 5201; Bryant and Dillard, 2019). For instance, describing cultured meat as "clean meat" or "animal free meat" evokes positive emotions in consumers, shaping their behaviour positively (C.J. Bryant and Dillard, 2019; C. Bryant and Dillard, 2019; Siegrist and Hartmann, 2020b). Moreover, presenting additives using their chemical and common names, rather than E numbers, has been found to increase consumer acceptance and enhance the perception of naturalness (Siegrist and Sütterlin, 2017), despite technological processing typically having a negative image among consumers (Bearth, Cousin, & Siegrist, 2014; Hartmann et al., 2022).

Product labelling can also bias sensory perception. Studies have shown that consumer ratings of product containing insects change significantly after they discover the product contains insects (Hartmann and Siegrist, 2017). Additionally, consumers tend to associate longer ingredients list with less natural food products (Hartmann et al., 2022; Román et al., 2017).

3.16. Policy interventions

Given that many people lack the willpower to change their diet without external interventions, the public often expects a governmental stance to combat the consumption of unhealthy foods. High-level interventions are necessary to drive change in consumer behaviour (de Boer and Aiking, 2018; Tufford et al., 2023). Studies have modelled the potential capacity of different economic instruments, such as taxing and subsidies, true price regulation of animal products etc. (Manners, Blanco-Gutiérrez, Varela-Ortega, & Tarquis, 2020; pp, 1015, 5201; Springmann et al., 2018; Wellesley, Happer, & Froggatt, 2015). However, little political effort has been devoted to these strategies due to fears of political, industrial and social opposition (Saxe, Larsen, & Mogensen, 2013; Tufford et al., 2023).

Additionally bans such as the ban of cultured meat in major countries sheds a negative light on the product.

4. Cross country analysis

Understanding consumer acceptance of various alternative proteins across different countries is essential, as cultural norms, dietary habits, and trust in food technologies vary significantly worldwide. This cross-country analysis explores how perceptions and willingness to consume plant-based alternatives, fermentation-enabled protein alternatives, cultured meat, and edible insects differ across various nations. It highlights key factors influencing acceptance, including perceived naturalness, safety concerns, and trust in the food industry, providing insights into the global potential for adopting these alternative proteins and identifying strategies to address cultural and perceptual barriers.

4.1. Cultured meat acceptance

In one of the first consume studies on consumer perception of Cultured meat, consumers from Belgium, Portugal, and the UK exhibited initial reactions of disgust and concerns about its unnaturalness. While they saw few personal benefits, they acknowledged its potential global environmental and food security advantages. The perceived risks were framed in terms of safety and health uncertainties, and potential negative impacts on farming traditions, rural livelihoods, and eating habits. (Verbeke et al., 2015).

A study by Siegrist and Hartmann (2020b) across 10 countries (Australia, China, England, France, Germany, Mexico, South Africa, Spain, Sweden and the US) found varying levels of acceptance for cultured meat. French consumers were the least accepting, viewing cultured meat as unnatural and disgusting more than others. Germany and the US also had relatively low acceptance, whereas Mexico, South Africa, England, and Spain showed higher acceptance. Key factors influencing acceptance in all countries included trust in the food industry, food neophobia, food disgust sensitivity, and perception of naturalness. This is in line with findings from;

- Gómez-Luciano et al., (2019) found that Spanish consumers were more willing to accept cultured meat than those in the UK, Brazil and Dominican Republic with healthiness, safety and nutritional characteristic being the important factors.
- Bryant, van Nek, and Rolland (2020) reported that German consumers were more accepting than French consumers with safety and overprocessing been major
- Asioli et al. (2022) corroborates that British and Spanish consumers are more accepting than French consumers.

However, the results that US and Chinese consumers had no significant differences in their acceptance contradicts Bryant et al. (2019), whose studies showed that Chinese consumers showed higher levels of acceptance. Asioli et al. (2022) also differ from Gómez-Luciano et al., (2019) findings that Spanish consumers were more willing than British consumers to buy cultured meat. Both Gómez-Luciano et al., (2019) and Gómez-Luciano, Vriesekoop, and Urbano (2019b) findings show that Spanish respondents were more willing to accept cultured meat than Dominican Republic consumers.

In another study, Ford et al. (2024), found Australians were the least willing to accept alternative protein compared those from China and the UK, with perceptions of unnaturalness being top factors for Australians and UK consumers, and unappealing for Chinese consumers.

4.2. Edible insects

In Gómez-Luciano, Aguiar, Vriesekoop, and Urbano (2019a), acceptance for edible insects was generally low, with UK respondents being more willing, followed by Spain, Brazil and Dominican Republic respondents. UK respondents believed insect-based proteins were healthy, safe, nutritious and sustainable, scoring significantly higher than other countries. Conversely, Dominican Republic respondents

mostly disagreed, presenting the lowest scores. This aligns with a study [Gómez-Luciano et al. \(2019b\)](#), where Dominican Republic respondents exhibited intense disgust factor and were less willing to consume insects compared to Spanish respondents.

[Ford et al. \(2024\)](#), found that Chinese and UK consumers were extremely unwilling to consume edible insects compared to other alternatives, echoing the findings of [Gómez-Luciano et al. \(2019a\)](#), which aligns with an international survey conducted by ([Castro and Chambers IV, 2019](#)) in 13 countries (United States [USA], Mexico, Peru, Brazil, United Kingdom [UK], Spain, Russia, India, China, Thailand, Japan, South Africa, and Australia). It classified 8 countries (United States, Australia, Spain, India, Russia, South Africa, United Kingdom, and Japan) of the 13 as “disgust countries” where most respondents were unwilling to try a familiar product containing insect powder. In 9 countries, participants indicated they would likely stop buying products from such brands. Key reasons for rejecting insect-based foods included religious belief, perception that insects carry diseases and cause allergic reactions with the disease-carrying perception being significant in most of the countries.

4.3. Fermentation based alternative proteins

In [Gómez-Luciano et al. \(2019b\)](#), respondents in Dominican Republic were more willing to consider mycoprotein compared to Spanish respondents. However, in other cross-country studies on algae, no significant difference across countries were found though there was large variation among individual consumers ([Michel et al., 2021](#); [Weinrich and Elshiewy, 2019](#)).

4.4. Plant based proteins

In a study by [Ford et al. \(2024\)](#), Australians were extremely unwilling to adopt plant-based proteins compared to respondents from china and UK. This findings contradicts previous research that plant-based meat was generally favoured over cultured meat and edible insects ([Gómez-Luciano et al., 2019a](#); [Grasso, Hung, Olthof, Verbeke, & Brouwer, 2019](#)).

In [Gómez-Luciano et al. \(2019a\)](#), acceptance for plant-based meat was high across all countries studies. UK respondents were most willing, followed by those in Spain, Brazil and Dominican Republic respondents. Key factors influencing willingness in the UK, Spain, and Brazil included healthiness, safety and nutritional characteristics sustainability, taste, and lower price compared to conventional meat. In contrast, for Dominican respondents, ‘food technology neophobia’ and ‘buying decisions’ were more influential in shaping their WTP for plant-based proteins.

5. Discussion

Consumer behaviour regarding alternative proteins is complex, influenced by a myriad of interconnected personal, societal, and product-specific factors. Recognizing the complexities of these factors and their context-specific nature is crucial for crafting targeted interventions.

The relative importance of food choice motives varied across countries and by protein type. There is no “one size fits all.” approach. Significant differences exist among countries and distinct groups of consumers within a country, making generalisation problematic. This highlights the need for more cross-cultural research. Intervention on protein alternative should be considered on a country-by-country basis, leveraging appropriate motivations to increase acceptance ([Ford et al., 2024](#)).

Transforming our food systems require a multifaceted approach, given the dynamic nature of these systems. Integrating alternative protein options into diet and consumers’ repertoire must occur at different levels (a diets, dishes, ingredients and bits) and context, each requiring

careful consideration and development.

While reducing consumption of animal products benefits public health and the environment, major development and changes are needed still needed for alternative proteins to gain traction. be able to gain the needed traction needed to reduce consumption of animal proteins. Companies should consider developing hybrid products, combining plant and animal proteins to improve textural/sensory properties without overprocessing or excessive use of additives, which are major turn-offs for consumers. Additionally, some consumers prefer quality, tasty alternatives with distinct characteristics rather than imitations of meat ([Faber et al., 2022](#)). These products can cater to vegans, vegetarians and others with limited meat attachment.

Although, protein transition is primarily occurring in the western world, incorporating alternative proteins in diets should also be a focus in the global south, Africa and Asia due to the rapid urbanisation and increase in income which is usually accompanied by growth in meats ([Gómez-Luciano et al., 2019a](#); [Huang and Uehara, 2023](#)).

6. Conclusion

Our study serves as a foundational in understanding consumer behaviour regarding alternative proteins. Future research should delve deeper into exploring innovative strategies that enhances the sensory appeal and nutritional value of these proteins. Additionally, this is important to develop strategies that are not solely consumer-focused to facilitate the acceptance of alternative proteins.

Country and consumer segment specific targeted interventions and initiatives aimed at improving societal perceptions of alternative proteins will be instrumental in driving market uptake. For better comparability of results, particularly across countries, future studies should consider using the same survey instruments comparing acceptance as previous studies and ensuring their samples are representative of the population for more accurate generalisation.

Furthermore, countries should consider including alternative proteins in their dietary guidelines to support this transition. By integrating these strategies, we can foster a widespread acceptance and consumption of alternative proteins, moving towards a more sustainable food system.

Overall, this study enriches existing research by providing nuanced, context-specific recommendations and highlighting the importance of cross-cultural and multi-level approaches in promoting alternative proteins.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CRediT authorship contribution statement

Sghaier Chriki: Writing – review & editing, Validation, Supervision, Methodology, Investigation. **Liu Changqi:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Florence Akinmeyer:** Writing – original draft, Investigation, Formal analysis. **Sami GHNIMI:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Jing Zhao:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization.

Declaration of Competing Interest

There are no conflicts of interests.

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