Understanding consumer behaviour regarding sustainability in the food sector:

The role of meat reduction and protein alternatives.

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These past four years spent engaged in the research of this PhD have flown by, with a pandemic chucked in for good measure. Although I feel the sweet taste of submission on the horizon, I know there have been a few challenges to reach this point.

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Abbreviations

ANOVA: Analysis of Variance

AVE: Average Variance Extracted

BCW: Behavioural Change Wheel

BFI: Big Five Inventory

CA: Correspondence Analysis

CART: Classification And Regression Tree

CATA: Check-all-that-apply

CBC: Choice-based Conjoint

CBM: Cell-based Meat

CBS: Cell-based Seafood

CD: Conventional Dairy

CFA: Confirmatory Factor Analysis

CFI: Comparative Fit Index

CHAID: Chi-squared Automatic Interaction Detector

COM-B: Capability, Opportunity, Motivation, Behaviour

CR: Composite Reliability

EI: Edible Insects

FG: Focus Group

FN: Food Neophobia

FTN: Food Technology Neophobia

GHG: Greenhouse gas emissions

MA: Meat Attachment

MAQ: Meat Attachment Questionnaire

MS: Meat Substitutes

OL: Overall Liking

PBM: Plant-based Meat

PBS: Plant-based Seafood

PFD: Precision Fermented Dairy

RMSEA: Root-mean-square Error of Approximation

RT: Regression Tree

SD: Standard Deviation

TA: Thematic Analysis

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Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.
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Preface

"It is among the 21st century's greatest challenges to eat within planetary limits yet giving health, pleasure and cultural identity." [1]

Before diving into my thesis findings, I want to reflect on why I was initially interested in this thesis topic. Mainly, it was to gain a better understanding of why consumers choose the foods they do and how that translates to the 'hot' topic of sustainability. I didn't realise this would take me down a path of meat-eating behaviour which underpins a lot of sustainable diets. Nor did I think it would make me consciously change my own consumption habits.

Throughout the four years of my PhD, studying in the UK and Australia, both countries have experienced numerous climate change events. For example, the UK recorded it's wettest day on record on the 3rd October 2020, and it's hottest day on record (40.3°C) on the 19th July 2022. Both of which I had the pleasure of experiencing. Whilst Australia experienced the Black Summer bush fires which continued into 2020 as well as numerous catastrophic floods. These events provide a snapshot of the frequency and severity in which climate change events are occurring. Yet, it can be hard for consumers to equate such events with food choices despite more evidence suggesting the two are intrinsically linked. Indeed, what's available to buy and what we choose to eat is reliant on an increasingly fragile and unsustainable food system.

I feel lucky that I have never felt bored with my PhD subject but increasingly invested in what the future of food will look like, and the important role consumers play in shaping that landscape. Equally, it is overwhelming to consider the enormity and complexity of sustainable food choices. It's no surprise consumers are confused about what they should and shouldn't eat. Nonetheless, the next few years will be pivotal in determining whether climate targets can be achieved. Maybe Winston Churchill foresaw correctly when he stated, '*fifty years hence, we shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium*'.[2]

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[1] T. Lang, "Sustainable Diets and Biodiversity: The Challenge for Policy, Evidence and Behaviour Change". Directions and Solutions for Policy, Research and Action (Rome, Italy: FAO, 2010), 20–26.
[2] "Thoughts and adventures" (Churchill, 1932).

Abstract

The need to better understand and shift current consumer behaviour towards more sustainable food consumption habits is imperative for achieving a more food secure future. Increasingly, consumers are encouraged to reduce consumption of animal-sourced protein and transition towards a wider array of protein sources to alleviate associated environmental pressures and to address public health issues. Yet, the success of a protein transition is partly underpinned by consumer acceptance towards alternative products and changes to consumption habits. Considering the multifaceted nature of sustainability and the complexity of food choice behaviour, it is important to target and explore the influence of certain variables on consumer behaviour to inform behavioural change strategies.

Addressing growing sustainability concerns, this thesis understood consumer perceptions, motivations and attitudes towards sustainable food, specifically focusing on consumer acceptance towards meat reduction and a range of protein alternatives (i.e., plant-based meat substitutes, edible insects, cultured meat) some of which are comparatively under-explored (i.e., plant-based seafood, cultured seafood and precision fermented dairy). It also reviewed some of the key variables likely to influence sustainable food behaviours, specifically socio-demographic (i.e., age and gender), socio-cultural (i.e., comparing Australian, Chinese and UK consumers) and psychological factors (i.e., food neophobia, meat attachment, personality traits). Different data collection techniques were utilised to explore these variables, including; focus group discussions, online surveys and sensory evaluations. In addition, a basic machine learning technique (i.e., regression tree analysis) was applied to analyse complex datasets.

Overall, important insights on the socio-demographic, cultural and psychological factors influencing consumer behaviour regarding sustainable foods were discovered. For example, Australians, especially those aged 35-54 were more attached to meat and were significantly less willing to reduce and adopt alternatives compared to Chinese and UK consumers. Conversely, Chinese females were more attached to meat, with Chinese males more willing to reduce meat and adopt alternatives. The

opposite trend was found in the UK, with males more attached to meat and less willing to reduce and adopt alternatives. Differences in acceptance towards protein alternative type was also apparent. Specifically, Australians were more willing to adopt edible insects, whereas Chinese and UK consumers were more willing to adopt plant-based meat substitutes. Moreover, consumers associated with high meat attachment were lower in the personality trait neuroticism in the UK and Australia and higher in neuroticism in China.

Results also provide an improved understanding of the differing motivations, barriers and attribute trade off's consumers face when considering meat reduction and the acceptance of protein alternatives. In general, food safety and the environmental benefits were the most important motives irrespective of cultural backgrounds. However, the magnitude of importance differed for some protein alternative types. For example, Chinese consumers rated food safety as more important in the context of accepting edible insects. In terms of barriers towards meat reduction and protein alternatives, the mindsets of extremely unwilling consumers, which are a currently under-explored cohort, were reviewed. Open-ended responses related to the belief that meat consumption is necessary for health reasons and that protein alternatives are Unnecessary, Unappealing, Unnatural, Unsafe, Unhealthy and Unsustainable.

Findings contributed to the current literature in the field of sustainable consumer food behaviour and extended findings by considering gaps in the research field. Particularly, novel aspects related to the comparisons between a range of protein alternatives and between western and non-western consumers. It also considered novel technologies (i.e., precision fermented dairy) including within a sensory tasting (i.e., 'hypothetical' precision fermented yoghurt). This thesis also reviewed under-explored psychological associations (i.e., meat attachment and personality traits) and consumer cohorts (i.e., extremely unwilling consumers). Subsequently, results highlight the need to include country-specific meat reduction strategies, which include appropriate protein alternatives, applicable to specific consumer-segments. The suggestions provided in relation to how best to support protein transitions are therefore of interest to the wider food industry, policy makers and fellow researchers.

Thesis structure

Research detailed in this thesis has either been published in peer reviewed journals (chapters 2, 3, 4 & 5), or currently submitted for consideration (chapter 6). Results are therefore presented as a series of manuscripts as summarised below.

Chapter 2

A qualitative insight into young meat-eaters' sustainable food consumption habits and perceptions towards current and future protein alternatives.

Qualitative methods on the topic of novel alternatives are currently under reported. The results detailed in this chapter related to eight online focus groups (n=38) conducted with young meat-eaters (18-34) in the UK. In summary, the study provided in-depth consumer insights on a range of topics from current consumption habits (i.e., meat reduction, plant-based meat/ seafood (PBM/S)), towards future protein alternatives (i.e., cell-based meat/seafood (CBM/S) and precision fermented dairy (PFD)). Some of the alternatives are considerably under-explored (PBS/CBS/PFD) and therefore provided novel insights. Focus group recordings were transcribed, and codebook thematic analysis was applied using the Framework Matrix as a tool. The key themes identified were presented as barriers or enablers in relation to the COM-B model (Capability, Opportunity, and Motivation) which allowed for behavioural intervention strategies to be identified and discussed. This chapter was published as a research paper in the journal *Appetite* on September 8th, 2023.

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Chapter 3

Investigating the effect of sharing environmental information on consumer responses to conventional and hypothetical 'precision fermented' yoghurt.

The focus group discussions highlighted the importance of information on increasing consumer acceptance towards novel food technologies. This chapter therefore complements Chapter 2, by using information as an intervention strategy. It also focused on precision fermentation, a novel technology, which compared to cultured meat, has received little research attention to date. Specifically, the primary aims were to explore the effect of sharing information under two conditions (blind and informed) on overall liking and emotional response for yoghurts thought to be made using different methods (conventional and precision fermented). Yoghurts were chosen due to their popularity and fermentation process, which may therefore represent a more familiar and acceptable format in which to consume precision fermented dairy. Findings also considered the psychological effect of food technology neophobia and food neophobia and how this influences overall liking and emotional response. At the time of research, no other study had reviewed consumers overall liking and emotional response to hypothetical precision fermented dairy within a tasting context. This chapter was published in the *International Journal of Food Science and Technology* on May 5th, 2024.

Ford, H., Thibodeau, M., Newton, L., Child, C., Yang, Q. Investigating the effect of sharing environmental information on consumer responses to conventional and hypothetical 'precision fermented' yoghurt. *International Journal of Food Science and Technology*. 10.1111/IJFS.17228

Chapter 4

Applying regression tree analysis to explore willingness to reduce meat and adopt protein alternatives among Australia, China, and the UK.

This chapter addresses the current gaps in research related to cross-cultural and socio-demographic differences when reviewing meat-eating behaviour. The results detailed related to three online surveys which collected responses from meat-eaters in Australia (n=503), China (n=785) and the UK (n=489). The aim being to understand meat consumption habits and the associations between consumers' willingness to reduce meat/ adopt protein alternatives (meat substitutes, edible insects, cultured meat), with age, gender, and country. The data was analysed using regression tree analysis with the CHAID algorithm which provided an alternative way of exploring complex interrelationships between numerous variables. Furthermore, the comparisons made between countries with differing meat-eating habits and the inclusion of Chinese consumers, which are a currently under-researched cohort, provided interesting and novel findings. This chapter was published in the journal *Food Quality and Preference* as part of the EuroSense special edition on October 30th, 2023.

Ford, H., Zhang, Y., Gould, J., Danner, L., Bastian, S.E.P., Ford, R., & Yang, Q. (2023). Applying regression tree analysis to explore willingness to reduce meat and adopt protein alternatives among Australia, China and the UK. *Food Quality and Preference*. 112, 105034. https://doi.org/10.1016/j.foodqual.2023.105034

Chapter 5

Comparing motivations and barriers to reduce meat and adopt protein alternatives amongst meat-eaters in Australia, China and the UK.

Using the same survey data, this chapter compliments Chapter 4 by applying regression tree analysis to understand how meat-eaters motivations to reduce meat and to adopt protein alternatives (meat substitutes, edible insects, cultured meat) differs dependent on country. It also collected and analysed 1,300 open-ended responses from consumers who were extremely unwilling to reduce meat and to adopt alternatives. It therefore addressed a knowledge gap by reviewing the underlying reasons given by consumers who are the most resistant to change. Furthermore, it provided novel insights into how motives compare across a range of alternatives. This chapter was published as a research paper in the journal *Food Quality and Preference* on April 28th, 2024.

Ford, H., Zhang, Y., Gould, J., Danner, L., Bastian, S. E. P., & Yang, Q. (2024). Comparing motivations and barriers to reduce meat and adopt protein alternatives amongst meat-eaters in Australia, China and the UK. *Food Quality and Preference*. 118, 105208. https://doi.org/10.1016/j.foodqual.2024.105208

Chapter 6

Exploring the associations between meat attachment, age, gender and personality traits. A cross cultural study.

This chapter utilises the same survey data to present results in relation to the influence of the psychological factors on meat-eating behaviour. In particular, it is thought attitudes towards meat and personality traits impact consumption habits. Furthermore, hypotheses can be drawn from the focus group discussions in Chapter 2 in relation to meat attachment acting as a barrier to change. Yet, it is not fully understood how meat attachment may vary across countries and by demographics and whether this is linked to certain personality traits. To the best of my knowledge, this is thought to be the first study to explore the relationship between meat attachment and personality traits and to consider cross-cultural differences. Results included the validation of the meat attachment questionnaire across countries and reviewed model fit through multi-group confirmatory factor analysis. It also included regression tree analysis to explore inter-relationships between age, gender, personality traits on overall meat attachment. Findings therefore complemented the regression trees included in Chapters 4 and 5. At the time of final submission (May 2024), this chapter is under review as a research paper.

Covid-19 Impact Statement

Having commenced my PhD on the 1st February 2020, I was subsequently affected by the Covid-19 pandemic which continued throughout 2020-2021. Considering this thesis is via a jointly awarded doctoral programme between the University of Nottingham and the University of Adelaide it has made it difficult to plan studies in advance due to a combination of Covid and relocation to Australia which was also delayed due to boarder closures. Therefore, the research methods applied reflect the impact of the national lockdowns/ planned closures, building access restrictions and relocation on the ability to run more face-to-face sensory testing. Subsequently, the majority of data collection is from online techniques (surveys, focus groups).

Chapter 1

Introduction

This chapter provides a general introduction to the research topic. It firstly outlines the current challenges and therefore the need for this research. It then delves into how sensory and consumer science can be applied to understand consumer behaviour. Subsequently, an overview of food related sustainability and the key factors that influence sustainable food choices are discussed.

1.1 The current challenge

One of humanity's greatest challenges relates to feeding the world in a sustainable healthy way within the planetary boundaries (Willett et al., 2019). Currently, the food sector is the second greatest contributor to Greenhouse Gas (GHG) emissions, following the energy sector, accounting for one third of global emissions making it a major driver of climate change (IPCC, 2019; Poore & Nemecek, 2018). In particular, meat production is estimated to contribute to more than half of foods GHG emissions (Poore & Nemecek, 2018), with red and processed meats, especially beef and dairy cattle, having the highest environmental impact (FAO/UN, 2017).

Overall, the consumption of animal protein is increasing globally and has done so since the mid twentieth century, with meat production expected to double by 2050 (FAO, 2018a). Partly this is to meet the nutritional demands of the growing global population which is predicted to reach over 9.7 billion people by 2050 (UN, 2021). However, it is also due to rapid economic growth, an increasing middle class and urbanisation, especially in China, India and parts of Africa. Subsequently, the consumption of processed foods, imported foods and meat is increasing exponentially making most diets unsustainable. Such practices result in high agricultural land and water use, deforestation, soil pollution, overuse of pesticides and antibiotics, as well as biodiversity loss (Poore & Nemecek, 2018).

In parallel, despite meat being a convenient source of essential nutrients (Iron, zinc, vitamin B12), it is overconsumed in many affluent countries. For example, in the UK, 43% of adults consume more than the recommended 70g/day of the total red and processed red meat guidelines (Hobbs-Grimmer et al., 2021). A notable dilemma arises in which low-income countries require an increase in meat consumption to reduce nutritional deficiencies, whilst higher-income countries require behavioural changes to reduce meat consumption that are arguably not easy to enforce and likely to take time (Parlasca & Qaim, 2022). The latter is therefore of interest to this research.

Consequently, the overconsumption of red meat, especially processed meat, is associated with an increased risk of developing various major chronic diseases (Wolk, 2017). The strongest adverse effect being observed between highly processed meat consumption and colorectal cancer (Godfray et al., 2018). By comparison, partial substitution of red or processed meat with plant-based foods has been proven to reduce Type 2 Diabetes (Maukonen et al., 2023). Therefore, shifting consumer behaviour towards sustainable eating patterns is imperative for personal and planetary health and cannot be achieved exclusively through changes to production systems (Willet *et al.,* 2019). Specifically, it is estimated that there needs to be an average 75% reduction in meat consumption in order to mitigate climate change effects (Springmann et al., 2018). Ideally, changes need to take place in the next few decades before causing irreversible damage to our planet (IPCC, 2019). If implemented on a global scale the changes can be substantial (Garnett & Finch, 2016).

Considering food to some extent connects us all, it provides a personal element that the other sectors (i.e., energy, transport) perhaps lack. Food is a necessity and what we eat is largely determined by the individual. Indeed, the decisions consumers make about what and how much they consume can inevitably change the path agricultural systems, product developers, manufacturers and retailers decide to take, by impacting not just what and how much is produced, but also how it is processed. Therefore, how consumers behave with regards to making sustainable food choices and whether industry can meet those needs, has great leverage on determining the future of food which requires greater understanding.

1.1.1 Sensory and consumer science as a tool to understand consumer behaviour

Sensory and consumer research plays a key role in contributing to a sustainable food system (Aschemann-Witzel et al., 2019; Knaapila, 2022). This relates to reviewing consumer attitudes, preferences, and overall liking towards various sustainable foods and products, whether that be in relation to plant-based diets or novel alternatives to conventional meat and dairy. Sensory and perceptual features are highly influential in determining food choice, as recognised in twenty-six behavioural models (Chen & Antonelli, 2020). Moreover, combining sensory and hedonic findings with emotions can help us to understand the full picture and reduce the chance of product failure (Low et al., 2022). This is especially important as it is estimated that between 50% and 75% of new product developments fail within their first year on the supermarket shelf (Dijksterhuis, 2016).

As the market for sustainable food grows, understanding how consumers evaluate the benefits and risks of products and how attribute trade-offs are made (e.g., health vs environmental benefits) is of particular interest when considering future challenges (Frewer & van Trijp, 2007). Overall, reviewing consumer behaviour provides valuable and reliable information for product developers, food manufacturers and marketers who wish to understand which attributes are driving consumer acceptance and what needs to be modified to meet expectations, demands, and increase adoption (Aschemann-Witzel et al., 2019; Knaapila, 2022). For example, this could include improving the sensory appeal of plant-based meat substitutes or increasing consumer trust in novel alternatives by communicating information related to health and safety more effectively. Subsequently, increasing consumer acceptance towards a wider range of protein alternatives can facilitate a transition towards sustainable diets where the impact on the environment, public health and food security will be positive (e.g., reduced GHG emissions, reduced obesity, more accessible protein sources) (BDA, 2019; Clark & Tilman, 2017; Willet et al., 2019).

Furthermore, in relation to promoting sustainable dietary shifts, policy makers can make use of consumer insights, especially regarding specific consumer segments, to write sustainable development goals (i.e., updated dietary guidelines, educational programs, coherent eco-labels). Considering the influence of cultural differences in food preferences, such targets will likely need to be tailored to each country (Rozin, 1988). However, in circumstances where current climate targets cannot be achieved, the likelihood of limited food choices and social unrest will increase. In such instances, sensory and consumer science will be paramount in ensuring consumer satisfaction towards new foods that, for example, will need to be resistant to extreme weather conditions and have longer shelf-lives (Aschemann-Witzel et al., 2019).

1.1.2 Sensory and consumer science methods applied to understand behaviour

Consumer behaviour is defined as the study of the processes involved when individuals or groups select, purchase, use, or dispose of products, services, ideas, or experiences to satisfy needs and desires (Solomon, 2018). Consumers therefore influence the future of food and the role it plays within society at three stages: pre-consumption, consumption and post-consumption. All three stages offer consumers the chance to make sustainable choices. For example, at the pre-consumption stage, consumers can choose food products that are sustainable (e.g., contain sustainable ingredients, reduced packaging, of local origin and ethically produced). During the consumption stage, consumers can follow a sustainable diet and consume a wide variety of protein sources including both animal and non-animal sources. Lastly, at the post consumption stage, packaging can be recycled, food scraps composted, and leftovers utilised thus reducing food wastage. Therefore, it is important to understand what drives or prevents consumers from performing these behaviours.

A range of sensory and consumer science methods can be used to understand consumer perceptions, acceptance, motivations/barriers towards sustainable foods. In the context of this thesis methods include; focus group discussions, surveys, sensory evaluations and emotional responses. The advantages and considerations behind each method are briefly discussed alongside some examples of their applications on relevant topics.

1.1.3 Focus groups

Focus groups employ an exploratory qualitative technique to probe the responses of a small number of participants. It allows for a more in-depth understanding of topics through group discussions and interactions that would potentially be missed using quantitative methods. In particular, online focus groups have grown in popularity following the Covid-19 pandemic and offer unique advantages in terms of accessing participants from different locations and being more convenient for consumers to attend (Nobrega et al., 2021). Furthermore, consumers are thought to feel more comfortable in their home environment which encourages greater disclosure of information (Wilkerson et al., 2014). However, the virtual environment can pose challenges such as; additional privacy issues, technical difficulties (freezing, lost connection), participants being reluctant to turn on their camera, and difficulty reading body language (Guest et al., 2020; Nobrega et al., 2021). Technological requirements may also exclude older age groups from taking part (Dos Santos Marques et al., 2021).

Numerous studies have applied focus groups to understand consumer behaviour regarding sustainable food, including the acceptance of protein alternatives (Collier et al., 2021; Kerslake et al., 2022; Macdiarmid et al., 2016; Varela et al., 2022; Weinrich, 2018). In particular, focus groups are useful when reviewing novel products and ideas which consumers may be unfamiliar with, such as cellular agriculture (van der Weele & Driessen, 2019; Verbeke et al., 2015) and precision fermentation (Broad et al., 2022).

More recently, focus groups have incorporated a cooking session to actively explore the motivations and barriers towards cooking meat-substitutes in real time (Collier et al., 2022). They can also have a creative focus, in which participants complete interactive tasks such as photo-collages, projective mapping, story completion and third person techniques (Varela et al., 2022). They are therefore a flexible, established and valued research tool, but comparatively under represented on the topic of sustainable food consumption in comparison to quantitative methods (Graça et al., 2019; Onwezen et al., 2021). Partially this is due to the fact that they involve a small number of consumers and therefore the results cannot be generalised. Subsequently, they are often applied as a complimentary method to quantitative measurements.

1.1.4 Surveys

The use of questionnaires in consumer research can take many formats dependent on the research objectives. However, an increasing amount of consumer research is now conducted online (Jaeger & Cardello, 2022). This is partly in response to technological advancements, but also due to the 2020 pandemic which increased the need for remote data collection. Subsequently, online surveys are often the most popular method to review the topic of meat reduction and protein alternative acceptance (Graça et al., 2019; Onwezen et al., 2021). In particular, surveys are able to capture a range of variables, including; socio-demographics, consumption habits, attitudes, expectations, motives and barriers towards sustainable foods (Heijnk et al., 2023). Moreover, surveys can measure various psychological and personality traits through validated scales (Machado-Oliveira et al., 2020; Rabadán & Bernabéu, 2021; Wang & Scrimgeour, 2021; Wendt & Weinrich, 2023). Frequently used scales include; the Food Choice Questionnaire (FCQ) (Steptoe *et al*.,1995), the Meat Attachment Questionnaire (MAQ) (Graça et al., 2015a), the Food Neophobia Scale (FNS) (Pliner & Hobden, 1992) and the Food Technology Neophobia scale (FTN) (Cox & Evans, 2008).

When designing questionnaires, consideration should be given to the flow of questions, the language used and the layout (Lawless & Heymann, 2010). Assumptions with regards to consumer understanding of the topic or frame of mind should never be made (Schaefer, 1979). In this instance, definitions can ensure a coherent understanding and reduce ambiguity around unfamiliar or confusing terminology. A review by Jaeger & Cardello (2022), offers advice for achieving good data quality when considering the survey design, consumer recruitment, survey dissemination, and analysis methods.

It is also worth noting that many surveys include theoretical frameworks to assist in understanding, predicting and influencing food choice behaviour (Frewer & van Trijp, 2007). When the fields of sensory, psychology and marketing overlap in consumer research, these theories often come into play. Prominent cognitive theories include; The Theory of Reasoned Action which later became the Theory of Planned Behaviour (Ajzen, 1991; Fishbein & Ajzen, 1975) and Self-Determination Theory (Deci & Ryan, 2000). Collectively, these theories have been applied to review meat reduction, the adoption of plant-based diets (Lentz et al., 2018; Wang & Scrimgeour, 2021) and sustainable food choice motives (Schösler et al., 2014; Schulze & Janssen, 2024). However, there is a need for an overarching framework to be applied to research within this field, to provide structure to outputs and to coordinated behavioural change strategies (Graça et al., 2019). Subsequently, the COM-B model, which includes a range of theoretical domains (i.e., Capability, Opportunity, Motivation) (West & Michie, 2020), has become a useful tool to inform behavioural change strategies towards sustainable food choices (Bryant et al., 2023; Jiang & Farag, 2023; Nguyen et al., 2022; Ran et al., 2022; van den Berg et al., 2022; Veiga et al., 2023).

Overall, there are many advantages to conducting surveys online, including the ability to access a wide pool of consumers from different geographical regions, collecting large sample sizes, quick processing of data outputs and low administration and project costs (Evans & Mathur, 2018; Jaeger & Cardello, 2022). This has translated to a growing number of studies including cross-cultural elements to research sustainable foods (Bakr et al., 2022; Banovic & Grunert, 2023; Torán-Pereg et al., 2023; Weinrich, 2018). Furthermore, the anonymity around answering questionnaires is attractive to some consumers and is thought to result in more honest responses (Jaeger & Cardello, 2022).

1.1.5 *Sensory evaluations*

Sensory evaluation is defined as "*a scientific discipline used to evoke, measure, analyse, and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing*" (Kemp *et al*., 2009; Lawless & Heymann, 2010; Civille & Oftedal, 2012). Whilst consumer science is driven by psychology, sensory science is driven by psychophysics which understands the relationship between physical stimuli and human perception (Grunert, 2015).

To date, compared to focus groups and surveys, there is a comparative lack of sensory studies reviewing consumer preferences towards protein alternatives, some of which are in too early a product development phase (e.g., cultured meat). Yet, sensory evaluation techniques are key to improving products, meeting consumer expectations and increasing acceptance (Aschemann-Witzel et al., 2019). Partly this is due to the global pandemic which prevented face-to-face data collection techniques at a time when research on this topic was gaining momentum. Additionally, sensory studies are more costly and time consuming compared to the use of surveys.

Of the reported studies, research has mainly evaluated products on the market or those suitable for consumption. Therefore, the majority relate to plant-based and hybrid meat substitute products (Caputo et al., 2023; Cordelle et al., 2022; Elzerman et al., 2011; Gonzalez-Estanol et al., 2023; Grasso et al., 2022; Sogari et al., 2023), as well as edible insects (Cicatiello, 2020; Mishyna et al., 2020; Schouteten et al., 2016; Ventanas et al., 2022). Studies have applied a range of techniques to capture information, some of which include choice-based experiments (Caputo et al., 2023) hedonic scoring (Cicatiello, 2020; Elzerman et al., 2011; Schouteten et al., 2016; Ventanas et al., 2022), ranking tasks (Grasso et al., 2022; Sogari et al., 2023), check-and-rate-all-that-apply (Cordelle et al., 2022; Gonzalez-Estanol et al., 2023; Grasso et al., 2022) and open-ended questions (Grasso et al., 2022). These measurements have helped to understand; the overall liking of products, the most and least preferred products, the sensory attributes driving and preventing liking, the effect of information, meal context and other food components on sensory evaluation as well as the language consumers use to describe products.

Additionally, sensory studies have highlighted that the sensory properties of foods and acceptance can be influenced by the meal context and the inclusion of other food components (Elzerman et al., 2011). For example, the off-flavours and texture defects of a plant-based burger can be partially masked by the inclusion of a burger bun and sauce (Gonzalez-Estanol et al., 2023). It is also thought that supplying information related to ingredient composition can enhance consumers acceptability of plant-based products (Grasso et al., 2022). However, information on the composition of animal-like plant-based products can also increase negative attributes such as ‘processed’ and ‘unpleasant’ smell (Sogari et al., 2023).

In relation to edible insects, the level of processing and whether the insects are hidden or visible influences sensory appeal and acceptance (Cicatiello, 2020). Moreover, once products are tasted, consumer acceptance increases, highlighting the importance of a positive first tasting experience (Ventanas et al., 2022). However, it is thought the more novel and unfamiliar the food, like insects, the lower the general sensory appeal (Tan et al., 2017).

Often, comparisons are made with conventional meat products, to help improve the sensory qualities (i.e., mimic the sensory profile of meat), and to understand the extent to which overall liking differs (Caputo et al., 2023; S. Grasso et al., 2022; Schouteten et al., 2016; Sogari et al., 2023). However, results are mixed, with studies highlighting a preference for conventional meat (Caputo et al., 2023; Schouteten et al., 2016), hybrid products (Grasso et al., 2022) and plant-based animal-like protein (Sogari et al., 2023). This is likely due to the different product formulations and the differing range of products compared.

1.1.6 Emotional responses

In circumstances when products are equally liked, it is necessary to go ‘beyond hedonic liking’ to understand what is driving the response (Meiselman et al., 2022). Combining hedonic liking with emotional measurements can provide a more discriminative representation of the relationship between food and the consumer (Low et al., 2022). For example, consumers equally liked a conventional snack product and a snack product containing a sustainable ingredient (Bambara groundnut) (Yang et al., 2020a). However, when reviewing the emotional responses, the sustainable product elicited more positive emotions, including less 'guilty' (Yang et al., 2020a). Subsequently, emotional measurements (implicit and explicit) are becoming a popular tool to incorporate, especially within a sensory laboratory environment (Low et al., 2022). A common explicit method used is the EsSense Profile which is considered the pioneer of predefined emotional lexicons (King & Meiselman, 2010; Nestrud et al., 2016; Low et al., 2022). However, it should be noted that the EsSense Profile has a larger proportion of positive compared to negative terms and does not capture emotions specific to product categories (Orr et al., 2023). Subsequently, the development of a product specific, consumer-led emotional lexicon (e.g., for meat and plant-based burger patties) can provide a more accurate insight over a generic lexicon (Orr et al., 2023).

1.2 Defining sustainability

Global interest in sustainability has continued to gain momentum, yet it is an abstract multidimensional concept with an increasing amount of research perceiving it through an ecological lens. It is a credence characteristic and cannot be seen or tasted (Bangsa & Schlegelmilch 2020; Grunert, 2011). Most definitions of sustainability are covered in the sustainable consumption concept which states, '*sustainability is the act of minimizing consumption while caring for future generations and aiming for a better quality of life'* (Bangsa & Schlegelmilch, 2020; OECD, 2000). Yet, sustainable consumption is loosely defined due to its application in various behavioural domains (Verplanken & Roy 2015). Although there is no clear consensus on what constitutes sustainability, it has been categorised by three 'pillars' relating to social, economic and environmental factors (Purvis et al., 2019). Further complexity is added when the environmental aspect of sustainability relates to specific themes such as GHG emissions, biodiversity, land and water use, all of which play an individual role in contributing to sustainability overall.

Socio-demographics and cultural variables play a big part in how we define and perceive sustainability as they can be specifically related to a certain area of sustainability that is valued by that group the most. In some countries the focus will be on the protection of the environment for others it may be linked to the standard of living (Grunert *et al*., 2014). Overall, understanding how consumers perceive the concept of 'sustainability' provides the foundations for understanding how to integrate sustainable initiatives to assist in shifting consumer behaviour (White et al., 2019).

1.2.1 Food related sustainability

Sustainability is now part of many food company policies and goals and often embedded into brands (Derqui, 2020). In general, sustainable products can be defined as having environmental and or social attributes. Specifically, environmental attributes relate to preserving natural resources and the environment mainly in relation to carbon footprints, water, waste and recycling (FAO, 2018b). Alternatively, social sustainability attributes are concerned with health, animal welfare and fair labour practices (FAO, 2018b). Interestingly, it is thought that consumers can show psychological distinction between these two sustainable dimensions, with the environmental factors relating to a more conscious decision in the knowledge that the effects will be long term and have an impact on a global scale (Catlin *et al*., 2017). In comparison, social factors are thought to be driven by unconscious emotions which are believed to be more personal in the effects it has on people directly, short-term and local (Catlin *et al*., 2017).

1.2.2 Sustainable diets

Sustainable production and consumption are increasingly being highlighted as an important agenda amongst many international agencies like the United Nations Food and Agricultural Organization (UN/FAO), the World Health Organisation (WHO) and the Intergovernmental Panel on Climate Change (IPCC). Ultimately, this has been reflected in the recent COP 28 summit, which for the first time recognised sustainable and healthy diets as a valuable tool in which to transform the current food system. The declaration was signed by 141 countries who acknowledged that the current food system is failing to support the population nutritionally and failing to prevent environmental degradation. The official definition of a sustainable diet is provided by the Food and Agricultural Organization (FAO, 2012) of the United Nations which states, '*Sustainable Diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and* *ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy while optimising natural and human resources'*.

Recent guiding principles of what constitutes a healthy and sustainable diet have reiterated these points and emphasised the role of food consumption and diets in contributing to the achievements of the Sustainable Development Goals (FAO/WHO, 2019). Most notably in 2019, the infamous Eat-Lancet commission's report offered the first scientific review of what a healthy diet encompasses from a sustainable food system, with the hope of providing guidelines to meet global demand without exhausting the Earth's natural resources (Willett et al., 2019). The review recommends more than doubling the consumption of fruits, vegetables, legumes and nuts with a greater than 50% reduction in added sugars and red meat (Willet et al.,2019).

More recently, this report has been reviewed in the EAT- Lancet commission 2.0, which aims to expand and update the existing guidelines to include, amongst other factors, a greater focus on regional considerations which was an initial criticism (Eat, 2024). The recognition that dietary targets will be quite different in Asia compared to Europe highlights the importance of culturally specific dietary goals. Although, national food-based dietary guidelines reflect different dairy and red meat recommendations across countries, few have included environmental sustainability aspects (Herforth et al., 2019).

Research reviewing consumer understanding of sustainable diets has found it to be culturally determined. For example, a study amongst Spanish, Danish and Slovakian respondents found diverse ways of interpreting the link between food and sustainability which also varied dependent upon product category (Torán-Pereg et al., 2023). For example, the statement 'comes from my country' was more important and mentioned more frequently amongst Slovakian consumers when reviewing meat products.

Additionally, a study amongst UK participants found there to be a general understanding of what sustainable eating encompasses which were considered beneficial and in alignment with the FAO definition (Whittall et al., 2023). However, this study also noted that there were many conflicting definitions, gaps in knowledge and uncertainty in responses. This supports previous research amongst Australians, which found a lack of awareness on the topic of healthy and environmentally friendly food choices (Hoek et al., 2017; Mann et al., 2018). The multifaceted nature of sustainable eating and the complexity that surrounds its interpretation is therefore a big barrier for consumer adoption. Overall, irrespective of a coherent definition, it is less clear how willing consumers are to follow a sustainable and reduced meat diet and therefore the role they play in driving a dietary transition (Dagevos, 2021).

1.3 Changes in food related sustainable consumer behaviour

Over the last few decades there has been a considerable increase in the production and consumption of sustainable food products. Partly this is due to producers responding to the climate change crisis and wanting to meet the more sustainably conscious consumer needs (Ran et al., 2022). Indeed, the impending threats of climate change are increasingly reported in the media. Sea levels are rising, our planet is warming and extreme weather conditions such as heatwaves are becoming a constant (IPCC, 2019). Consequently, this is reflected in consumer food choices and trends.

1.3.1 The emergence of the 'flexitarian' diet and meat reduction trends

A notable food trend includes the 'flexitarian' diet in which consumers who self-identify as flexitarian are considered to consume animal products occasionally without abstaining from them, with healthy plant-based food as the main source of protein (Marinova & Bogueva, 2022). Subsequently, an increase in research on this topic has found this distinct consumer food segment to be growing exponentially amongst high-income countries (Dagevos, 2021). However, despite an increase in self-identified flexitarians amongst Dutch consumers, from 13% in 2011 to 43% in 2019, actual progress towards flexitarianism is thought to be slow (Verain et al., 2022). Furthermore, although flexitarianism has become mainstream, there is still no coherent understanding of what it constitutes. For example, some Australian consumers identified as flexitarian despite consuming meat ≥ 4 days / week (Malek & Umberger, 2021). Therefore, there is a need for a food related policy to be developed to clearly define the different dietary categories. Consequently, greater clarity regarding what constitutes a flexitarian diet from a meat consumption perspective will help to provide guidance for consumers who are trying to follow a more sustainable/ healthy diet.

Irrespective of how flexitarianism is interpreted, evidence suggests a growing number of consumers are currently and / or willing to reduce personal meat consumption. For example, in the UK, a public attitude study in 2022 found 65% of consumers were willing to consider eating less meat compared to only 34% of consumers surveyed in 2013 (Dibb & Fitzpatrick, 2014; Eating Better, 2022). However, it is worth noting that the 2022 survey reported only 21% of consumers were eating less meat compared to a year ago. Indeed, modest reductions in meat have been observed from analysis of the UK national diet and nutrition survey (Stewart et al., 2021).

Comparatively, resistance to meat reduction has been observed amongst other studies within various Western countries (Hartmann & Siegrist, 2017; Malek et al., 2019b). Such observations suggest an 'attitude-intention' gap, which has been the focus of much research in recent years (Sheeran & Webb, 2016), including in relation to transitioning towards low meat diets (De Gavelle et al., 2019). In summary, consumers may have positive intentions to reduce meat for sustainability/ health reasons, but such actions are not always reflected in food choice behaviour. Overall, it can be concluded that consumers are starting to reduce meat consumption, as indicated by the rise of flexitarianism, but this trend needs to be accelerated if climate targets are to be achieved (Stewart et al., 2021). In particular, the rate consumers are reducing meat needs to be reviewed, ideally with more objective meat consumption data (Hendrie et al., 2022).

1.3.2 The rise of plant-based alternatives

The inclusion of a variety of "alternative proteins" in the diet is thought to provide opportunities for a transition across to a reduced meat and therefore a more sustainable diet which can help to alleviate environmental and public health stresses. A recent study amongst UK consumers revealed that an increase in the consumption of meat and dairy replacements, aligned with a decrease in conventional meat and dairy intake (Bryant et al., 2023). With the rise in flexitarianism, an increased consumer demand for meat and fish substitute products has arisen.

The most notable increase relates to plant-based sources which are generally categorised as either conventional or meat analogues (Siegrist & Hartmann, 2023). Conventional sources include; beans, lentils, pulses, cereals or other legumes with some (i.e., chickpeas, chia, soya, quinoa) providing a complete source of protein (Marinova & Bogueva, 2022; Tso et al., 2020). Soya derived products such as tofu and tempeh and wheat proteins (e.g., seitan) are an affordable and functional protein source and have been a traditional part of many consumers diets for centuries. Yet, with increasing food security concerns, these alternatives which are less familiar to many western consumers, are now being considered as potential replacements to animal sourced protein (Tso et al., 2020).

By comparison, highly processed plant-based meat analogues, which are described henceforth as plant-based meat substitutes in this thesis, are gaining popularity with consumers (Marinova & Bogueva, 2022). These products are predominantly made of textured soya and pea protein as well as fungi based mycoprotein (i.e., Quorn) and often mimic the appearance, taste and texture of conventional meat (Tso et al., 2020). In Europe, the plant-based alternative market is booming and estimated to have grown by 68% in the past two years, with the UK representing the highest sales values (Smart Protein, 2021). However, in other countries like the USA, market growth has stagnated in recent years which suggests consumer acceptance has plateaued (Delloitte, 2022). This agrees with a systematic review which found a general low level of acceptance for plant-based products (Onwezen et al., 2021). Therefore, understanding what drives acceptance within different countries is important to ensure continued market growth. In particular, plant-based seafood is predicted to be one of the most lucrative categories (Smart Protein, 2021), yet little is known about consumer perceptions towards products (Kim et al., 2023).

1.3.3 The prospect of novel alternative proteins and technologies

Looking towards the future, key novel alternatives are thought to include edible insects and cultured meat/seafood (also known as *in-vitro*, cell based, synthetic, or laboratory grown meat/seafood) (Onwezen et al., 2021). There has also been an increased interest in the future of precision fermentation technology to produce dairy more sustainably (Banovic & Grunert, 2023).

Both cultured meat and precision fermented dairy, utilise similar cellular based technologies which can produce products with molecular compositions comparable to their conventional counterparts (Halpern et al., 2021; Post, 2012; Waschulin & Specht, 2018). Therefore, products are likely to replicate the sensory aspects and functionality of meat, seafood and dairy more closely. Currently, Singapore is the only country to approve the commercial sale of cultured meat, with products available in the form of chicken nuggets in late 2020 (Poinski, 2020). Similarly, precision fermented dairy products (milk and ice cream) are available in Singapore and America (Dang, 2023; Mendly-Zambo et al., 2021). At the time of reporting, an estimated 156 companies were thought to be developing products globally for the cultivated meat and seafood market (Bushnell et al., 2022a) and 62 focusing on precision fermentation (Bushnell et al., 2022b). Therefore, it is likely that a range of novel alternatives will reach more supermarket shelves soon, but the extent to which they disrupt the market depends largely on consumer acceptance.

By comparison, edible insects have been consumed for millennia and form part of the diet of several hundreds of millions of people (Van Huis et al., 2022). However, consumption amongst western consumers, where there is no tradition of eating insects, is low, but growing interest and investment for insects as food means this could soon change (Ponce-Reyes & Lessard, 2021). Additional novel products and sustainable ingredients showing promise include microalgae (Van Der Stricht et al., 2024; Yang et al., 2024), jellyfish (Torri et al., 2020), Duckweed (de Beukelaar et al., 2019), Bambara Groundnut (Yang et al., 2020a) and hybrid products which utilise plant and animal-based ingredients in various proportions (Grasso & Goksen, 2023). Reviewing consumer acceptance towards such a wide range of sustainable food products is beyond the scope of this thesis. Nevertheless, it is important to acknowledge them as playing a potentially supportive role in future protein transitions.

Specifically, this thesis reviewed plant-based meat/fish, edible insects, cultured meat/seafood and precision fermented dairy which are discussed in detail throughout the subsequent chapters. These alternatives represent current and future products at various stages of development, with different processing techniques and several potential environmental and health benefits.

1.3.4 Acceptance of protein alternatives

Initial reviews of individual protein alternatives suggest a growing number of consumers are willing to try edible insects (Van Huis & Rumpold, 2023), cultured meat (Bryant & Barnett, 2020) and precision fermented dairy (Zollman Thomas & Bryant, 2021). However, in general, consumer willingness to try and or adopt is thought to vary across product categories (Hartmann & Siegrist, 2017; Onwezen et al., 2021). For example, in studies comparing across a range of alternatives, plant-based products tend to be favoured more than cultured meat and edible insects (Circus & Robison, 2019; Gómez-Luciano et al., 2019; Grasso et al., 2019; Heijnk et al., 2023; Motoki et al., 2022). Therefore, differences are likely due to the to the hypothetical nature of some alternatives where perceptions are largely based on expectations which could change once products become available and more familiar. Overall, the literature shows that numerous factors influence willingness to try and / or adopt. Therefore, there is a need to understand the underlying reasons driving the varying levels of acceptance.

1.4 Factors influencing sustainable food choices

Food choice is a dynamic behaviour, meaning that it is continuously changing and can relate to both unconscious conditioning and cognitive learning (Frewer & van Trijp, 2007). In recent years, there has been an explosion of research reviewing consumer behaviour towards the general topic of sustainable food. Findings have been summarised in literature reviews in relation to; meat reduction and plant-based diets (Abe-Inge et al., 2024; Biasini et al., 2021; Dagevos, 2021; Graça et al., 2019; Hoek et al., 2021; Stoll-Kleemann & Schmidt, 2017; van Bussel et al., 2022) and consumer acceptance towards a range of protein alternatives (Hartmann & Siegrist, 2017; Onwezen et al., 2021; Siddiqui et al., 2022a). Additionally, individual reviews have considered acceptance towards plant-based meat substitutes (Szenderák et al., 2022), edible insects (Florença et al., 2022; Kröger et al., 2022; Mina et al., 2023; Van Huis & Rumpold, 2023) and cultured meat (Bryant & Barnett, 2020; Kouarfaté & Durif, 2023; Mina et al., 2023; Pakseresht et al., 2022; Tsvakirai et al., 2024).
A multitude of factors influence consumer food-choice that cannot be exclusively defined by socio-demographic, socio-economic or socio-cultural factors. A model developed by Stoll-Kleemann & Schmidt. (2017) provides an overview of how various

internal and external factors influence meat eating behaviour. Specifically, the model highlights three influential areas; 1) personal factors (i.e., socio-demographics, personality traits, knowledge, skills, emotions, cognitive dissonance, values and attitudes), 2) socio-cultural factors (i.e., culture and religion, social norms, social identity and lifestyles), 3) external factors (i.e., political and economic landscape, food environment and infrastructure).

In the context of novel foods similar drivers have been included within a framework of acceptance, namely; 1) product-related factors, 2) psychological factors and 3) external attributes (social environment, trust and culture) (Onwezen et al., 2021; Siegrist, 2008). Therefore, this follows closely with the perspective of person, food and environment (Sobal et al., 2006). Using these frameworks as guidance, an overview of the key variables influencing meat reduction and the adoption of protein alternatives are discussed below.

1.4.1 Food related attributes

Key food-choice motives are thought to relate to nine factors; health, mood, convenience, sensory appeal, natural content, price, weight control, familiarity and ethical concern as outlined in the Food Choice Questionnaire (Steptoe et al., 1995). More recent additions are included in the Ethical Concern Subscale which cover environmental and animal welfare factors (Lindeman & Väänänen, 2000). Understanding which factors motivate and act as barriers to change are therefore central to determining consumer food choices.

In relation to meat reduction and subsequent transitions towards sustainable diets, key motives are thought to relate to health benefits, animal welfare and environmental/ sustainability concerns (Cheah et al., 2020; Graça et al., 2019). Conversely, barriers can relate to the lack of knowledge and awareness regarding the environmental impact of a high meat diet (Hartmann & Siegrist, 2017; Hartmann et al., 2022), the perception that personal meat consumption has a minimal impact upon climate change (Macdiarmid et al., 2016) and that a reduced meat diet would result in less nutrients (Hoek *et al*., 2017). Raising consumer awareness of the benefits of sustainable diets is therefore key, but it also requires consumers to adapt and change their eating behaviours. Specifically, providing knowledge on the relationship between these top three motives can be a useful strategy to increase meat reduction (Harguess et al., 2020).

Similar motivations apply to plant-based meat substitutes, but health and taste are thought to be prominent drivers of acceptance (Onwezen et al., 2021). Furthermore, familiarity, convenience and the ease of cooking replacements to meat are valuable attributes (Graça et al., 2019). Nonetheless, achieving these positive attributes can also act as a barrier towards acceptance. For example, improving the sensory appeal of meat substitute products requires additional processing which can often lead to negative perceptions around health, safety and unnaturalness (Varela et al., 2022).

For novel protein alternatives (i.e., edible insects, cultured meat, precision fermented dairy) taste and the environment are considered to be key drivers of acceptance (Onwezen et al., 2021; Powell et al., 2023). However, it is thought consumers have mixed perceptions on the sustainability of alternatives (Onwezen et al., 2021). Indeed, the estimated environmental effects of various alternative proteins are widely debated and can vary substantially dependent on the variables being measured and compared (e.g., production system, meat type) (Green et al., 2022).

Conversely, concern over safety, health and lack of familiarity can act as barriers for edible insects (Van Huis & Rumpold, 2023), cultured meat (Bryant & Barnett, 2020; Pakseresht et al., 2022) and precision fermented dairy (Broad et al., 2022). However, as products become more available, this narrative may change as consumers become more familiar and trusting towards products. Other attributes worth considering relate to unnaturalness and concerns over affordability which are likely to reduce acceptance of cultured meat (Bryant & Barnett, 2020; Pakseresht et al., 2022; Siddiqui et al., 2022b).

1.4.2 Socio-demographic factors

A range of socio-demographic variables have been considered when reviewing consumer behaviour towards sustainable foods such as; age, gender, education, income, urban living, political orientation, household size and presence of children. These factors are thought to have varying degrees of influence on consumers ability to adopt sustainable diets, reduce meat and accept alternatives (Graça et al., 2019;

Hartmann & Siegrist, 2017; Onwezen et al., 2021; Onwezen & Dagevos, 2023). However, age and gender are considered to be especially influential, therefore, to fit within the scope of this thesis, these were the main demographic factors of interest.

In relation to gender, research amongst consumers from Europe, Australia and America have consistently found males to be less willing to reduce meat consumption and to adopt a plant-based diet compared to females (Hielkema & Lund, 2021; Malek et al., 2019b; Neff et al., 2018; Prattala et al., 2007; Schösler et al., 2015; Siegrist et al., 2015; Tobler et al., 2011). To some extent, this is expected as men on average consume more meat compared to women based on requiring a greater daily caloric intake, consequently reduction may be more challenging. However, for protein alternatives, gender differences are less defined. In general, plant-based alternatives are thought to be more accepted by females (Gómez-Luciano et al., 2019), whereas males seem more open to edible insects (Florença et al., 2022; Mina et al., 2023) and cultured meat (Bryant & Barnett, 2020; Mancini & Antonioli, 2019). Indeed, additional research has observed negative perceptions especially towards edible insects amongst females compared to males (Heijnk et al., 2023; Kröger et al., 2022).

By comparison, age is thought to be less influential than gender (Hartmann & Siegrist, 2017) and findings across studies are less consistent (Graça et al., 2019). In general, younger consumers are thought to be more intent on reducing meat consumption (Hielkema & Lund, 2021) and willing to try plant-based foods (Szenderák et al., 2022). They are also thought to have a greater acceptance of edible insects (Mina et al., 2023; Wilkinson et al., 2018) and cultured meat (Bryant & Barnett, 2020; Zhang et al., 2020b). For precision fermented dairy, demographic research is comparatively lacking, but current findings suggests that younger consumers (<35 years) are more accepting (Powell et al., 2023). Overall, these observations provide an optimistic outlook for the acceptance of protein alternatives amongst younger consumers, who to some extent, will shape the future of food.

1.4.3 Socio-cultural factors

Sustainable food has arguably become a trend across the world and understanding how food liking and preferences differ across cultures and amongst consumer segments is imperative for successful product development. However, the field of “cross-cultural” research, in which two or more groups of people from differing cultures or cultural groups are compared is complex as summarised by Frewer & van Trijp (2007). ‘*Cross cultural factors affecting food choice are many, some directly related to perception and focus of attention, while others are related to language and how language directs focus of attention, while others have social, or cultural origin related to group or sub-culture*.’ (Chapter 13, pg. 313).

Overall, cultural backgrounds have numerous effects on food preferences, preparation and quantity consumed. Many of these factors are determined by a countries economic and political landscape (e.g., food availability, familiarity and affordability), whilst others are associated with psychological experiences (e.g., disgust) which shape our beliefs, values and food related traditions. A review of the effects of cross-cultural backgrounds on consumer perception and acceptability of foods and drinks by Jeong & Lee (2021) provides an overview of the schematic relationship between key factors. Overall, it highlights that increased acceptance is related to increased familiarity, which in turn are thought to positively influence discriminant ability and overall liking in relation to sensory preferences between products. It also highlights the importance of cultural experiences in influencing expectations and overall social value and belief which are based on surrounding information, labels, government policy and social atmosphere (Jeong & Lee, 2021). A few of these key differences in relation to cross-cultural sustainable food choices are discussed below.

1.4.4 Cross-cultural differences in meat consumption

In many countries meat consumption is the cultural norm, yet across countries there are differences in meat preferences and quantities consumed. A recent review by Font-i-Furnols (2023) provides an insight into meat-consumption patterns across countries using FAOSTAT data. For example, in Australia and the United States per capita meat intake continues to be unsustainably high (>115 Kg/year). In particular, it was reported that Australia increased per capita red meat consumption (+10Kg) between 2019-2020 (Font-i-Furnols, 2023). By comparison, per capita meat consumption in the UK is lower (78Kg/year) whilst other countries including New Zealand reduced per capita red meat consumption by more than 10Kg (FAO, 2022; Font-i-Furnols, 2023). Notably, the biggest regional increase has been observed in

Asia, especially China, whose per capita meat consumption has increased rapidly (+60Kg) since 1961 (FAO, 2022). Considering the differing meat consumption habits across Australia, China and the UK, these three countries were of particular interest in this thesis and provide a western and non-western perspective.

In an increasingly multi-cultural world, trends in meat consumption continue to change due to several factors, some of which include; increased migration and urbanisation, economic development, and access to mass media. It is predicted that poultry consumption will continue to increase, accounting for 52% of the rise in meat consumption between 2021 and 2030 (OECD/FAO, 2021). In addition, meat consumption in China is predicted to grow exponentially, including red meat intake (OECD/FAO, 2021). However, due to the numerous factors influencing food trends and as consumers become more sustainably conscious it is increasingly difficult to predict future consumption habits. Considering the negative environmental impacts associated with high meat intake, it is important to continuously monitor any changes in meat consumption and preference. Subsequently, countries over-consuming meat and or consuming unsustainable sources of meat can be managed through targeted intervention strategies. In circumstances where there is meat reduction, it is necessary to question what is being substituted in the diet.

1.4.5 Cross-cultural differences in sustainable food choice motives

Reasons for consuming meat varies between and within countries, which is reflected in differing motives partially shaped by cultural backgrounds. For example, UK consumers are thought to value price in relation to meat reduction which may be due to the current cost of living crisis (Eating Better, 2022). Conversely, food safety and quality are extremely important factors for meat consumption amongst Japanese consumers, partially due to reports of food safety scandals (Sasaki et al., 2022).

The relative importance consumers place on motivations to adopt and or try protein alternatives also differs across cultures and by category (Hartmann & Siegrist, 2017; Onwezen et al., 2021; Tso et al., 2020). Differing rates of meat consumption and familiarity across cultures is thought to be one explanation as previously discussed (Font-i-Furnols, 2023). However, it can also be based on a country's political landscape. For example, the Italian government has legislation preventing the sale of cultured meat partly because it is seen as a threat to the country's food heritage (Holland, 2023). In comparison, other countries (including Australia, China and the UK) are developing regulatory provision around the sale of cultured meat (Tsvakirai et al., 2024).

When reviewing consumer acceptance across a range of protein alternatives, the trend that plant-based products are favoured more than cultured meat and edible insects is consistent across consumers from; Brazil, Dominican Republic, Finland, Germany, Japan, the Netherlands, Poland, Spain and the UK (Circus & Robison, 2019; Gómez-Luciano et al., 2019; Grasso et al., 2019; Heijnk et al., 2023; Motoki et al., 2022). However, the level of acceptance can differ across countries as found in two cross-cultural studies (Gómez-Luciano et al., 2019; Grasso et al., 2019). For example, compared to UK consumers, those residing in the Netherlands, Finland and Spain were ≥ 1.5 times more likely to consume insect-based protein sources, whilst Polish consumers were 61% more likely to eat plant-based protein sources but 29% less likely to consume cultured meat (Grasso et al., 2019).

In addition, a study reviewing willingness to purchase, found UK consumers scored higher for plant-based and insect-based protein sources compared to consumers form Spain, Brazil and the Dominican Republic. However, Spanish consumers were more willing to purchase cultured meat compared to UK consumers (Gómez-Luciano et al., 2019). One explanation for the differing levels of acceptance relates to familiarity and availability. Previous literature has highlighted how prior consumption of meat substitutes (Hoek et al., 2011) and edible insects (Schlup & Brunner, 2018) can increase acceptance, whilst greater awareness can create more positive attitudes towards cultured meat (Heijnk et al., 2023).

1.4.6 Food neophobia and food technology neophobia

Food neophobia (FN) is often defined as a reluctance to eat and / or willingness to try novel or unfamiliar foods (Pliner & Hobden, 1992). Overcoming this psychological trait can be challenging when it is thought to be hereditary (Knaapila *et al.,* 200; Rabadán & Bernabéu, 2021). The FN scale consisting of ten statements was developed to capture consumer segments who have an aversion to trying new foods (Pliner & Hobden, 1992). However, with the emergence of novel food technologies there was a need to develop a scale that goes beyond the measure of food itself. Therefore, the Food Technology (FTN) scale consisting of thirteen statements was developed in 2008 to capture consumer segments that are resistant to foods containing these novel food technologies (Cox & Evans, 2008). In particular, it encompasses statements pertaining to four factors which include, the necessity of new food technologies, perception of risk, healthy choice, and the role of information/ media.

Understanding the extent to which neophobia influences consumer acceptance is especially important when consumers are increasingly encouraged to consume a wider range of products such as novel foods (e.g., edible insects) and foods made through novel technologies (e.g., 3D printed food, cultured meat, precision fermented dairy). Considering these products are thought to be part of the global solution to address sustainable consumption, product success based on consumer acceptance is imperative.

Overall, neophobic consumers are thought to have a more complex cognitive structure, attaching emotion to new products compared to non-neophobic consumers (Barrena & Sánchez, 2013). Often, the expected sensory experience is negative (Pliner et al., 1993). Currently, research has consistently found FN and FTN to have a negative effect on acceptance of edible insects (Kröger et al., 2022; Verbeke, 2015). Indeed, it is considered to be one of the most prominent factors affecting consumer willingness towards the concept of insects as food (Florença et al., 2022; Onwezen & Dagevos, 2023). Likewise, research suggests that higher levels of FN and FTN leads to a lower level of acceptance for cultured meat (Krings et al., 2022; Wilks et al., 2019).

Food neophobia is closely associated with concerns around food safety which is also known to contribute to a reduction in consumer acceptance (Onwezen et al., 2021). Other factors linked with neophobia include the emotional response related to disgust sensitivity. In particular, disgust is often a prominent psychological barrier towards insect-based products (Mina et al., 2023; Russell & Knott, 2021; White et al., 2023) and an important predictor of consumer acceptability of insects as food (Lammers et al., 2019). Disgust is also a barrier towards cultured meat, although one study observed it to be less influential compared to edible insects (Chia et al., 2024).

Additional attitudes, norms and behaviours associated with high and low levels of FTN are provided in a review by Wendt & Weinrich (2023).

1.4.7 Personality traits

It is generally believed that personality traits can play a role in predicting dietary habits and food choices (Pfeiler & Egloff, 2018a, 2018b, 2018c, 2020). Therefore, understanding whether certain personality traits are more or less inclined to follow sustainable food consumption habits is of interest when developing products for specific consumer segments. Traits are often described in the context of the Five Factor Model which encompass the Big Five (Digman, 1990); Openness (i.e., curious, imaginative), Conscientiousness (i.e., thorough, productive), Agreeableness (i.e., considerate, forgiving), Extroversion (i.e., talkative, outgoing) and Neuroticism (i.e., emotionally unstable, anxious).

Literature has described the link between personality traits and food choice (Machado-Oliveira et al., 2020). For example, more open, conscientious and extroverted young adults consumed more plant-based foods (Conner et al., 2017). Whilst a study with middle-to-older adults found healthy eating habits to be associated with more agreeable, conscientious, open and less neurotic individuals (Weston et al., 2020). In relation to dietary preferences, non-meat eaters are found to be more open (Holler et al., 2021; Pfeiler & Egloff, 2018a), but also more neurotic compared to meat-eaters (Forestell & Nezlek, 2018). Additional research has also found meat consumption to be negatively associated with Openness as well as Agreeableness and Conscientiousness (Keller & Siegrist, 2015; Pfeiler & Egloff, 2018b). Extroversion was likewise associated with higher overall meat consumption (Pfeiler & Egloff, 2018c; Tiainen et al., 2013).

Interestingly, food neophobia has also been partially associated with personality traits, with an avoidance to trying new foods significantly, negatively correlated with Extraversion, Agreeableness, and Openness and significantly, positively associated with Neuroticism (Nezlek and Forestell, 2019). However, there is still a lack of research reviewing other psychological factors such as meat attachment and its association with sustainable food consumption.

1.4.8 Cognitive dissonance and meat attachment

Despite consumers stating the importance of animal welfare, this does not always result in a changed behaviour towards meat reduction. Instead, consumers divorce their association with regards to the processing of animals. Subsequently, a certain level of wilful ignorance is applied, especially amongst western consumers who are detached from the meat production processes. For many meat-eaters, reducing their meat consumption creates a moral dilemma (Lin-Schilstra & Fischer, 2020). This dilemma is appropriately named the ‘meat-paradox’, in which, the presence of an emotional human-animal bond does not reflect their broader meat-eating behaviour (Loughnan et al., 2010). Based on the theory of cognitive dissonance, it relates to the conflict individuals may feel if a behaviour does not match a belief or attitude (Rothgerber, 2020). Research exploring the reasoning behind this conflict found consumers tend to justify meat eating as natural, normal, necessary and nice (Piazza et al., 2015).

Within this reasoning is Meat attachment (MA), which is described as a subconscious emotional behaviour which in essence relates to a positive relationship towards meat consumption (Graça et al., 2015a). To provide an in depth understanding of the positive relationship with meat, the Meat Attachment Questionnaire (MAQ) was developed by Graça et al. (2015a). The MAQ consists of sixteen statements with four factorial constructs relating to; hedonism (i.e., the joy gained from eating meat), affinity (i.e., overall liking for eating meat), entitlement (i.e., the right to eat meat) and dependence (i.e., reliance on meat in the diet).

In general, consumers with high MA are less willing to reduce meat (Szczebyło et al., 2022), less likely to follow a plant-based diet (Circus & Robison, 2019; Graça et al., 2015a) and accept plant-based meat alternatives (Bakr et al., 2022; Profeta et al., 2021b). In addition, highly meat attached consumers are thought to demonstrate less sustainable food consumption behaviours. Therefore, decreasing MA is an important challenge that needs to be addressed to aid meat reduction (Van Dijk et al., 2023).

1.4.9 Other factors

In parallel to these processes are other factors, such as habits which play a huge role in the sub-conscious element of consumer decision making. Habits are usually ingrained in us, inherent traits that develop overtime due to repetition. Purchases are made continuously every day; this repetition reinforces the habit through automaticity where a lack of awareness and engagement leads to unconscious purchases (Verplanken, 2018). Context also contributes to habits as highlighted in the definition by Verplanken & Aarts (1999) which states; "*Habits are learned sequences of acts that have become automatic responses to specific cues and are functional in obtaining certain goals or end states*". Strong habitual traits and the connection between goals and cues therefore make it harder for sustainability choices to be made. Such choices are more likely to happen if people hold the sustainability attribute as a core value where the choice is deliberate (Verplanken & Roy, 2015).

1.5 Research objectives and knowledge gaps

The growth of research with regards to consumers sustainable food choices highlights the importance of this topic. It also suggests a sense of urgency to bring about behavioural change in order to address the climate crisis. Therefore, any knowledge that contributes to this field is important especially in an increasingly polarised society. Nevertheless, certain research gaps have emerged which relate to the topics discussed and are highlighted below.

Knowledge gaps:

- An increasing number of novel foods have emerged over the past few years as discussed. However, there is a comparative lack of research on consumer acceptance towards cell-based and plant-based seafood and precision fermented dairy compared to other protein alternatives. To fill this knowledge gap, insights into the barriers and enablers towards these products, alongside more researched alternatives (i.e., plant-based meat, cultured meat) are included in Chapter 2.
- Of the few studies that have reviewed consumer perception towards precision fermented dairy, none have been conducted within a tasting context and none

have considered the effects of FN and FTN on consumer acceptance. This research gap is addressed in Chapter 3.

- Previous literature observed that aside from gender, there is a current lack of research reviewing the influence of age or cultural backgrounds regarding sustainable protein consumption (Hartmann & Siegrist, 2017). Despite an increase in cross-cultural research in the past few years, results around the influence of age remain inconclusive (Graça et al., 2019). This knowledge gap is addressed in Chapter 4.
- Studies often focus on one type of protein alternative and lack an understanding of how perceptions and the magnitude of motivations differ across alternative categories (Onwezen et al., 2021). Therefore, the holistic nature of diets is often overlooked. This knowledge gap is addressed from a qualitative perspective in Chapter 2 and from quantitative data in Chapters 3 and 4.
- Currently, the majority of research focuses on the motives of consumers who are to some extent willing to reduce meat and adopt alternatives. Yet, it is equally important to study the extremely unwilling consumers as they represent the most resistance to change. At the time of writing, the perspective of extremely unwilling consumers was lacking in the current literature. This knowledge gap is addressed in Chapter 5.
- The inclusion of environmental benefits as a motive has become more prominent in recent years as previous findings suggested health was of greater concern (Hartmann & Siegrist, 2017). Therefore, it is important to explore if the environment remains a top motive across countries which is reviewed in Chapter 5.
- From a psychological perspective, a study is yet to consider the association between meat attachment and personality traits. Findings could therefore be relevant for targeted social marketing campaigns using consumer segmentation tactics. This knowledge gap from a cross-cultural perspective is addressed in Chapter 6.

The objectives of this research were to:

i. Examine consumers perceptions, motivations and attitudes towards sustainable food behaviours, specifically focusing on meat reduction and current and future protein alternative consumption.

ii. To understand the influence of cross-cultural, socio-demographic and psychological differences on attitudes towards sustainable food and related behaviours.

The end goal being to provide an overview of likely interventions regarding the promotion of sustainable food consumption in relation to meat reduction and protein alternatives considering key cross-cultural, socio-demographic, and psychological differences.

Chapter 2

"I guess it's quite trendy". A qualitative insight into young meat-eaters' sustainable food consumption habits and perceptions towards current and future protein alternatives

Highlights:

- *Sustainable food consumption is mostly associated with eating British and local produce.*
- *Trends in meat reduction driven by moving away from home, living independently and limited food budgets.*
- *Participants aware but unable to quantify the environmental impact of food.*
- *Availability, convenience and sensory appeal increased acceptance of plant-based meat/seafood.*
- *Concern around affordability, unnaturalness and food safety reduced acceptance of cell-based meat/seafood and precision fermented dairy.*

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Abstract

As the market for sustainable food continues to expand, there is a need to understand how consumers' consumption habits and perceptions are changing. Targeting the younger populations is of interest as they arguably will shape the future of food. Therefore, the present study aimed to provide in-depth consumer insights on a range of topics from current consumption habits (i.e., meat reduction, plant-based meat/ seafood (PBM/S)), towards future protein alternatives (i.e., cell-based meat/seafood (CBM/S), precision fermented dairy (PFD)). Online focus groups were conducted in the UK with meat-eaters (n=38) aged 18-34. Codebook thematic analysis was applied using the Framework Matrix as a tool for data analysis. Key themes were presented using the COM-B model (Capability, Opportunity, Motivation), which identified areas of behavioural change. Results found a trend towards meat reduction, partially initiated by moving away from home and limited food budgets. Overall, participants acknowledged the environmental impact of food, but a notable knowledge gap was apparent when quantifying the effect, especially for dairy and seafood. Compared to PBM, few participants had tried PBS products, partially due to lower availability and familiarity. Enablers for PBM/S included convenience, positive sensory experiences and the influence of others, whilst barriers related to negative health connotations and over-processing. For CBM/S and PFD, animal welfare, curiosity and optimised nutrition acted as enablers, whilst barriers related to wider consumer acceptance, affordability and unnaturalness. In general, participants felt changing food consumption habits can have an impact on climate change and were optimistic about novel technologies supporting future protein transitions. Increasing public understanding around the environmental impact of food, especially seafood and dairy, and prioritising the affordability of sustainable food are suggested as intervention strategies to encourage sustainable food consumption.

2.1 Introduction

Food production and consumption causes detrimental environmental impacts to our ecosystems which include, amongst other factors, greenhouse gas emissions (GHG), biodiversity loss, high land and water use and polluted oceans (Barange et al., 2018; Poore & Nemecek, 2018; Willett et al., 2019). In response, consumers are encouraged to follow more sustainable food consumption habits which reflect a low consumption of animal sourced foods, a high intake of plant-based and whole foods, whilst consuming fish from sustainable sources (IPCC, 2022; Poore & Nemecek, 2018; Willett et al., 2019).

For the UK population, a 20% reduction in beef, lamb and dairy by 2030 is recommended (Committee on Climate Change, 2020). Despite being a country reliant on animal-derived products, recent surveys provide promising results, in that >60% of UK adults are willing to reduce meat (Eating Better, 2022). Research has also found UK participants are able to define sustainable eating and are willing to change towards more sustainable food consumption habits (Whittall et al., 2023). Yet, trends in UK meat consumption have found reductions to be modest (Stewart et al., 2021), which suggests an 'attitude behaviour gap'. Therefore, more research needs to be done to understand the underlying behaviours to accelerate changes.

Understanding the barriers and enablers surrounding meat reduction provides valuable insights for behavioural intervention strategies aiming to promote more plant-based diets (Graça et al., 2019). Qualitative studies amongst UK participants have reviewed a range of topics related to sustainable consumption habits, some of which include; the environmental impact of food and willingness to reduce meat (Macdiarmid et al., 2016), potential changes to food-related practices (O'Keefe et al., 2016), meat reduction in everyday life (Mylan, 2018), nudging strategies to reduce meat consumption (McBey et al., 2019), and consumer understanding of sustainable diets (Whittall et al., 2023). Alongside, quantitative studies with UK consumers, findings have found key motives in meat reduction to relate to; animal welfare, cost savings and personal health/ wellbeing (Clonan et al., 2015; Eating Better, 2022; Mylan, 2018; Whittall et al., 2023). Whilst barriers include the pleasure gained from eating meat, a lack of awareness of the link between meat and climate change and social influences (Macdiarmid et al., 2016; Mylan, 2018; O'Keefe et al., 2016; Whittall et al., 2023).

Although the aforementioned studies allow for a greater understanding of sustainable consumption, it is important to provide updated insights, especially following the Covid-19 pandemic which may have created a shift towards more sustainable food habits at home (Filimonau et al., 2021; Pluck & Morrison-Saunders, 2022; Williams et al., 2023). However, some consumer groups increased their consumption of comfort foods (e.g., sweets, fried and processed foods), therefore there is likely to be variations in behaviour (Bennett et al., 2021). To extend findings it is also important to understand perceptions towards current protein alternatives such as plant-based meat (PBM) and plant-based seafood (PBS) products, as well as future protein alternatives such as cell-based meat (CBM), cell-based seafood (CBS) products and precision fermented dairy (PFD) (also known as animal free dairy).

2.1.1 Plant-based meat and seafood

Plant-based products are predominantly made using a variety of ingredients (e.g., soy, wheat, pea protein, fungi, beans and lentils) and have grown in popularity, with the UK having the second highest plant-based food sales in Europe (GFI, 2023). Products often imitate the role of meat and seafood in the diet and provide viable opportunities for consumers to transition towards a reduced meat and seafood diet (Hoek et al., 2011; Nowacka et al., 2023). Many reviews have assessed consumer acceptance towards PBM products (Andreani et al., 2023; Onwezen et al., 2021; Weinrich, 2019), but there is little evidence regarding consumer perceptions towards PBS (Kim et al., 2023). Current research suggests concerns around PBS, relate to the taste and texture (GFI & Kelton Global, 2021). Whilst familiarity with PBS, ingredient information, price and consumer age are important factors determining willingness to pay (Kim et al., 2023). In relation to PBM, consumers in the UK are thought to perceive them as being healthier but lacking in sensory appeal compared to conventional meat (Hoek et al., 2011; Vural et al., 2023). Indeed, previous research suggests sensory appeal could be both a motive and a barrier for consumer acceptance (Onwezen et al., 2021; Weinrich, 2019). Therefore, one solution to this sensory dilemma, comes from the development of cellular agriculture/aquaculture technologies, which produce animal/seafood proteins through fermentation, in theory, enabling a closer replication of the sensory properties (Waschulin & Specht., 2018).

2.1.2 Cell-based meat and seafood

Cellular agriculture/ aquaculture, is thought to have the potential to alleviate environmental degradation, improve animal/fish welfare, and provide health benefits (Halpern et al., 2021; McClements et al., 2021; Mendly-Zambo et al., 2021; Nobre, 2022; Saget et al., 2021). In its simplest form, the process for making CBM starts by harvesting stem cells from a living animal, inoculating the cells in a suitable nutrient dense media and transferring to a bioreactor to allow for cell proliferation (i.e., expansion and differentiation of cells) (Post, 2012). A similar process is used to make CBS, with muscle strands extracted from fish, molluscs, or crustaceans (Halpern et al., 2021). Whilst for PFD, the desired protein (e.g., whey and casein) are extracted and inserted into the DNA of the host organism (e.g., yeast) before being transferred to a bioreactor (Waschulin & Specht., 2018).

There is a growing body of research exploring consumer acceptance towards CBM (Bryant & Barnett, 2020; Pakseresht et al., 2022), including comparisons with plant-based products (Hartmann & Siegrist, 2017; Onwezen et al., 2021). Research with UK consumers found prevalent motives for CBM to be associated with curiosity, environmental friendliness, and reassurance in relation to the health benefits and sensory appeal compared to conventional meat (Circus & Robison, 2019, Verbeke et al., 2015), whist barriers relate to it being perceived as 'unnatural', evoked disgust, and fear of long-term health effects (Circus & Robison, 2019; Verbeke et al., 2015). Negative perceptions of CBM are also found to be greater in omnivores who have high levels of food technology neophobia (Krings et al., 2022).

In contrast, research reviewing consumer acceptance towards CBS is currently under reported but is likely to align with CBM findings given the similar production processes. Current literature has focused on the influence of nomenclature with 'cell-based' often perceived more positively compared to other names (Hallman, 2020, 2021; Malerich & Bryant, 2022). A recent study reviewing a range of novel food technologies, found both CBM and CBS to have low consumer acceptance, especially amongst American and Australian consumers (Giacalone & Jaeger, 2023). However, cross-cultural differences in dietary habits are likely to influence willingness to accept novel food technologies like CBM (Bryant et al., 2019; Gómez-Luciano et al., 2019).

2.1.3 *Precision fermented dairy*

Another notable gap in research relates to understanding consumer acceptance towards PFD products. This is surprising considering products are currently available to purchase in the United States and Singapore with a high likelihood of reaching wider markets due to technological advancements, and simpler production processes compared to CBM (Mendly-Zambo et al., 2021). To date, current research has found 28% of consumers in the UK to be willing to try PFD (labelled as 'synthetic milk' in the survey), with 50% concerned about what it would contain (Perkins, 2018). Considering this survey was over five years ago, consumers' views and perceptions could be rapidly evolving. For example, a more recent survey found 67.6% of UK consumers to be willing to try cheese made using this method (Zollman Thomas & Bryant, 2021). To some extent, consumer acceptance is dependent on high taste expectations and a need for it to be sensorily better or comparable to conventional dairy products (Perkins, 2018; Powell et al., 2023; Zollman Thomas & Bryant, 2021). Additional motives for trying PFD are thought to relate to potential animal welfare and environmental benefits (Powell et al., 2023). Whilst barriers are associated with concerns over safety, naturalness and its contribution to health and climate change (Broad et al., 2022). Interestingly, PFD was found to be more appealing to non-vegan consumers under the age of 35 (Powell et al., 2023). Therefore, the target consumers could potentially be younger generations who incorporate dairy into their diet.

2.1.4 *Focus Groups and the COM-B model*

Understanding consumer perceptions towards novel alternatives requires a conducive environment, as many consumers may be unfamiliar with the concept of products made through novel technologies such as cellular agriculture/aquaculture. Focus Groups (FG) provide an efficient qualitative consumer research method allowing participants to openly discuss their opinions, attitudes and habits in detail whilst allowing for debates. It is also thought consumers of a similar age are likely to feel more comfortable sharing opinions given the comparable life reference points (Grønkjær et al., 2011).

Increasingly, a range of qualitative studies have applied focus groups to review sustainable food behaviours (Collier et al., 2021; Kemper, 2020; Macdiarmid et al., 2016; Markowski & Roxburgh., 2019; McBey et al., 2019; O'Keefe et al., 2016; Tucker, 2018; Varela et al., 2022), perceptions towards PBM/S (Collier et al., 2022; Elzerman et al., 2013; Kerslake et al., 2022; Weinrich, 2018), CBM (Shaw & Mac Con Iomaire, 2019; van der Weele & Driessen, 2019; Verbeke et al., 2015) and PFD (Broad et al., 2022). FG's are therefore a valuable research tool in which to gain deeper qualitative insights towards sustainable consumption which is currently under-represented compared to quantitative methods (Graça et al., 2019; Onwezen et al., 2021).

Identifying coherent behavioural change strategies is difficult as findings regarding sustainable food consumption habits and the acceptance of alternatives remain disjointed. To assist in providing structure to findings, the COM-B framework, a theoretical behavioural model that covers three key components: Capability (e.g., knowledge, cooking skills, planning ability), Opportunity (e.g., social norms, environmental influences, availability of resources), Motivation (e.g., conscious decisions, desires and habits) can be utilised (Michie et al., 2011). The model allows for interactions between the three essential components which are thought to form the core of a 'behaviour system' as part of a 'behaviour change wheel' (BCW) (Michie et al., 2011).

The BCW is based on the synthesis of 19 frameworks of behaviour which demonstrates its high heuristic value. The BCW includes nine intervention functions (e.g., Education, Incentivisation, Restrictions) that can be targeted dependent on the COM-B analysis output (Michie, 2014). In general, it is thought that a behaviour will occur in an individual if they have the capability and opportunity to engage in the behaviour, and they feel motivated to prioritise that behaviour above others in a given time (West & Michie, 2020). Further classification breaks down each component into two types (e.g., physical, psychological), as detailed in Figure 2.1. It should be noted that capability and opportunity are both thought to influence the relationship between behaviour and motivation. By reviewing the interactions and exploring the barriers and enablers within each domain, behavioural change strategies can be identified and implemented (Michie, 2014; Michie et al., 2011; West & Michie, 2020). Currently, the model is increasingly being recommended and used as a tool to inform behavioural change strategies in relation to food and sustainability (Bryant et al., 2023; Graça et al., 2019; Graça et al., 2023; Hyland et al., 2022; Jiang & Farag, 2023; Nguyen et al., 2022; Onwezen, 2022; Ran et al., 2022; Trewern et al., 2022; van den Berg et al., 2022; Veiga et al., 2023).

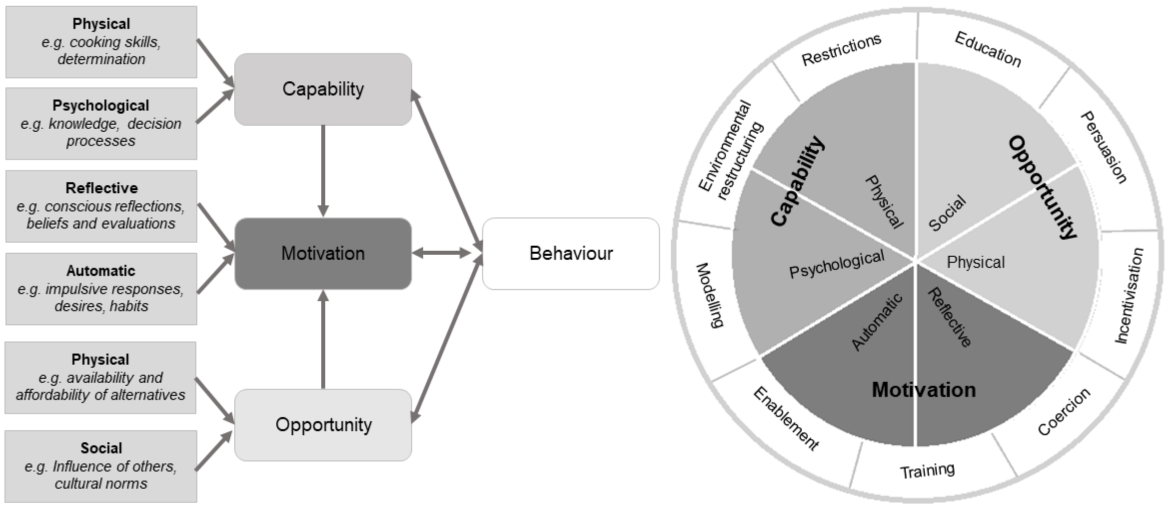

Fig. 2.1 The Capability, Opportunity, Motivation and Behaviour (COM-B) framework and Behavioural Change Wheel (BCW). The inner wheel represents the sources of behaviour, and the outer wheel represents the intervention functions. Reproduced from (Michie et al., 2011).

2.1.5 Study aims and outcomes

In recent years, there has been an explosion of research conducted around the general topics of sustainable consumption, transitioning towards more plant-based diets and acceptance of protein alternatives, some of which are summarised in recent literature reviews (Biasini et al., 2021; Dagevos, 2021; Graça et al., 2019; Harguess et al., 2020; Hartmann & Siegrist, 2017; Hoek et al., 2021; Kwasny et al., 2022; Onwezen et al., 2021; Onwezen, 2022; Stoll-Kleemann & Schmidt, 2017; van Bussel et al., 2022; van der Weele et al., 2019).

In general, it is suggested that young consumers are more accepting of PBM/S, CBM/S and PFD (Bryant & Barnett, 2020; Bryant & Sanctorum, 2021; Ford et al., 2023a; Giacalone & Jaeger, 2023; Powell et al., 2023; Siegrist & Hartmann, 2019; Szejda et al., 2021; Thomas & Bryant, 2021; Wilks et al., 2019). In addition, research analysing trends in UK consumption found Millennials[3] to be amongst the highest consumers of both meat and plant-based products, whilst Generation Z[4] reportedly increased meat intake over time (Alae-Carew et al., 2022; Stewart et al., 2021).

[3] Millennials, also known as Generation Y, is the demographic cohort born between 1981-1996.
[4] Generation Z is the demographic cohort born between 1997-2012.

Considering these trends in food consumption habits and the high acceptance towards alternatives, this demographic is a particularly interesting and important one to understand.

Studies which have incorporated young adults include quantitative surveys exploring; meat consumption and reduction (Choi & Lee., 2023; de Boer et al., 2017), attitudes and knowledge towards plant-based diets (Faber et al., 2020) and acceptance of CBM (Bogueva & Marinova, 2020). Whilst qualitative findings have reviewed young adults' experiences of flexitarianism (Kemper & White, 2021), transitions towards plant-based and vegan diets (Von Essen, 2021; Williams et al., 2023), and motives, barriers and strategies towards meat reduction (Kemper, 2020; McBey et al., 2019). With the exception of two studies (McBey et al., 2019; Williams et al., 2023), findings are in relation to consumers from outside of the UK, where differences in cultural backgrounds and dietary habits may influence outcomes (Faber et al., 2020). Furthermore, the focus is often on one topic, which does not always comprehend the holistic nature of diets. Additionally, a review by Onwezen et al. (2021) highlighted a need for future research to compare across multiple alternative proteins, especially plant-based products and CBM. Consequently, there is a need to extend findings to explore the enablers and barriers towards a range of topics from current consumption habits (i.e., meat reduction, substitution with PBM/S products), towards potential future consumption habits (i.e., inclusion of CBM/S and PFD products). To assist in the organisation of a broad range of topics the COM-B model was applied.

In summary, this study aimed to firstly identify any changes young meat-eaters are making to consumption habits and perceptions towards sustainable foods. Findings will provide added insights to current literature amongst UK consumers on similar topics (Bryant et al., 2023; Macdiarmid et al., 2016; McBey et al., 2019; Trewern et al., 2022; Whittall et al., 2023). Furthermore, it will provide results from a meat-eater perspective which was not explicitly stated in previous research (McBey et al., 2019; Trewern et al., 2022; Whittall et al., 2023). Secondly, this study will extend findings by comparing the barriers and enablers to a range of protein alternatives (PBM/S, CBM/S, PFD), some of which are comparably under-explored (e.g., PBS, CBS and PFD). Considering young consumers to some extent shape the future of food, findings were expected to provide insights for product developers when marketing and launching new products.

2.2 Materials and methods

The study was approved by the University of Nottingham's Faculty of Medicine and Health Sciences Ethics Committee (UK Ref. number:354-0921). Participants were asked to acknowledge a series of statements and give their consent to take part in this research before completing the FG screening questionnaire which checked eligibility. Upon completion of the FG session, participants were given a small shopping voucher.

2.2.1 Participants and recruitment

Participants were recruited through poster advertisements on social media platforms (Twitter, LinkedIn) as well as via email chains across the University of Nottingham. The recruitment information outlined the eligibility requirements which included: Aged between 18-34, consumer of meat, fish and dairy, and being computer literate with access to a camera and microphone. Interested participants voluntarily filled out a screening questionnaire administered through Jisc online surveys (JISC®, 2022). The first part of the screener captured general socio-demographic data (age, gender, ethnicity, education, urban/rural living, income). Next, to ensure meat, fish and dairy consumers were selected, participants self-identified their dietary preference (omnivore, flexitarian, vegan, vegetarian, pescatarian) and were given definitions for each dietary category to avoid misinterpretation.

Consumption frequencies were captured for beef, lamb, chicken, pork, meat from other animals, fish/seafood, dairy, and meat substitutes using the following categories; 'Do not consume', 'Less than once per month', '1-3 times per month', 'Once per week', '2-3 times per week', '4-6 times per week', 'Everyday'. As the level of meat consumed can influence food choice motives and mindsets (de Boer et al., 2017; Lentz et al., 2018), participants were grouped into High (H), Standard (STD) and Low (L) meat-eater categories[5]. This enabled a balanced representation of consumption rates within each group.

[5] Meat-eater categories are based on the sum of the five meat consumption frequencies (beef, lamb, chicken, pork, other meat). Quartile analysis identified three cut-off points (25^{th}, 50^{th}, 75^{th}) to allow for total meat consumption to be split into low (<25^{th}), standard (25^{th} – 75^{th}) and high meat-eaters (>75^{th}).

Subjective knowledge was also captured to gauge how informed consumers are on the topic of sustainable foods. Five statements adapted from a validated scale (Flynn & Goldsmith, 1999) measured responses with the anchors ‘strongly disagree (1)’ to ‘strongly agree (7)’. Where possible, participants were grouped based on similar knowledge levels to help them feel at ease when discussing topics related to sustainability.

In total, eight online FGs were conducted (n=38) using the video-call platform Microsoft Teams lasting approximately 90-120 mins, with the same moderator throughout to ensure consistency. Eight FGs ensured both code and meaning saturation had been achieved (Braun & Clarke, 2021; Hennink et al., 2019). The number of participants within each FG ranged from four to five with a balance of ages and meat consumption habits. The demographic composition and responses of FG participants to the screening questionnaire can be found in Table 2.1.

Following the FG session, participants completed a short follow-up questionnaire consisting of thirteen statements related to the Food Technology Neophobia Scale (Cox & Evans, 2008). Responses were captured with the anchors ‘strongly disagree (1)’ to ‘strongly agree (7)’. In general, participants overall disagreed that new food technologies were unnecessary (M=3.55, SD±1.08) but also disagreed that they were a healthy choice (M=2.66, SD±1.01). Largely participants agreed that the media provides a balanced and unbiased view of new food technologies (M=5.34, SD±1.68) but gave on average neutral scores for perception of risk (M=4.20, SD±1.01) (Table 2.1).

Table 2.1
Demographic composition of focus groups and participant responses to the Subjective Knowledge Scale and the Food Technology Neophobia Scale.

	N	(%)
Age groups		
18 – 24 y/o	19	50
25 – 34 y/o	19	50
Gender		
Female	26	68.4
Male	12	31.6
Ethnicity		
Caucasian	25	65.8
Asian	6	15.8
African or African American	3	7.9
Mixed or multiple ethnic groups	3	7.9
Prefer not to say	1	2.6

	N	(%)
Education		
Some secondary school	8	21.1
Technical/ trade/ diploma/ vocational training	2	5.3
Completed University graduate (Bachelor’s degree)	9	23.7
Completed Postgraduate/ Doctorate degree	17	44.7
Prefer not to say	2	5.3
Location		
Urban/Suburban;	31	81.6
Rural	6	15.8
Prefer not to say	1	2.6
Estimated household income		
<£20,000	16	42.1
£20,000 - £35,000	7	18.4
£35,001 - £50,000	6	15.8
£50,001 - £75,000	3	7.9
£75,001 - £100,000	1	2.6
>£100,000	1	2.6
Prefer not to say	4	10.5
Dietary preferences		
Omnivore	31	81.6
Flexitarian	7	18.4
Meat eater status		
Low	8	21.1
Standard	16	42.1
High	14	36.8
Have you recently heard anything about sustainable food in the mass media?		
Yes	32	84.2
No	6	15.8
Subjective knowledge towards sustainable foods		
1 – 3 (disagree)	11	29.0
4 (neutral)	15	39.5
5 – 7 (agree)	12	31.6
Food Technology Neophobia Scale	**M**	**SD**
New food technologies are unnecessary	**3.55**	**1.08**
New food technologies are something I am uncertain about	3.71	1.80
New foods are not healthier than traditional foods	4.29	1.23
The benefits of new food technologies are often grossly overstated	4.05	1.25
There are plenty of tasty foods around, so we do not need to use new food technologies to produce more	2.97	1.72
New food technologies decreases the natural quality of food	3.50	1.72
There is no sense trying out high-tech food products because the ones I eat are already good enough	2.79	1.44
Perception of risk	**4.20**	**1.01**
New food technologies are unlikely to have long term negative health effects*	3.71	1.35
New food technologies may have long term negative environmental effects	4.29	1.18
It can be risky to switch to new food technologies too quickly	4.89	1.41
Society should not depend heavily on technologies to solve its food problems	3.89	1.96
Healthy Choice	**2.66**	**1.01**
New food technologies gives people more control over their food choices*	2.58	1.22
New products using new food technologies can help people have a balanced diet*	2.74	1.18
Information media	**5.34**	**1.68**
The media usually provides a balanced and unbiased view of new food technologies*		

Please note: Subjective knowledge scale and Food Technology Neophobia Scale, 1= strongly disagree, 4 =neutral, 7= strongly agree. M= mean, SD= standard deviation. Reverse coded statements indicated by *.

2.2.2 Focus Group design

The FG sessions were designed to understand the responses and behaviours of the participants, as well as to encourage further group discussions and debates. Two initial FG pilot sessions (n=7) helped refine the topics and maximise discussions. A range of open-ended questions were constructed to explore five key topics as outlined in the FG discussion guide (Supplementary material, Table S2.1). These were; 1) Sustainable consumption habits, 2) Awareness of the environmental impact of food, 3) Consumer experiences and perceptions of PBM/S[6], 4) Consumer perceptions of CBM/S, 5) Consumer perceptions of PFD. The range of topics were accompanied by PowerPoint slides containing images and definitions to support interpretation. The chat box function was also utilised throughout to reference questions and obtain quick one-word responses and maintain engagement. Microsoft Forms were used to create interactive poll questions which were integrated within the Microsoft Teams meetings and allowed for full traceability of the author and respondents. The results of the poll questions are shown in Table 2.2. All FG sessions were video-recorded and accompanied by notes taken by the moderator during the call.

Table 2.2
Poll questions asked during the FG discussions (n=38).

Poll questions	**(%)**
Participants who are willing to reduce meat	86
Participants who are willing to reduce dairy	69
Participants who have previously heard of cell-based meat	82
Participants who have previously heard of cell-based seafood	13
Participants who find both cell-based meat and seafood appealing	74

Please note**:** Willingness is a sum of participants who scored slightly, moderately, and extremely willing.

2.2.3 Data analysis

The FG video recordings were imported into the Qualitative data analysis software NVivo 12 for Windows (Burlington, USA) where they were transcribed verbatim.

[6] Plant-based products were defined as any products which imitate the role of meat/seafood. Examples of plant-based products were shown to participants via a power point slide and the moderator followed a script which read: *“plant-based products most commonly contain a variety of; soy, wheat, and pea protein while others are based on mushrooms, beans or even tofu. Alternatively, you have Quorn products which are made from mycoprotein, a form of fungi. These products come in a wide array of formats from ingredients to cook with like mincemeat, ready-to-eat products like the turkey slices and tuna flakes or ready meals like the plant-based lasagne”.*

Personal identifiers were removed to ensure participant confidentiality. Codebook Thematic Analysis (TA) using the Framework approach was applied to explore the transcribed data following a mixed inductive-deductive approach. Initially, inductive reasoning was applied, meaning the codes were data-driven (Thomas, 2006). Only when the final themes were determined was the coded data subsequently applied following a deductive approach to the appropriate barriers and enablers within each COM-B domain. Initial coding was conducted by one of the authors (HF) and cross-checked with another author (QY). Themes were further identified and discussed by all authors to ensure credibility, with ongoing analysis deliberated in regular meetings to ensure inter-coder reliability was kept consistent over time. This qualitative content analysis method allowed for a comprehensive review of consumers original narratives in an efficient and structured way, whilst allowing for transparency and rigour (Gale et al., 2013). The five phases outlined by Braun and Clarke (2022), were used as guidance and included; Stage 1) familiarisation with data to understand initial patterns, 2) systematic data coding, 3) generation of initial themes based on coded data, 4) review and development of themes, 5) refining, defining, and naming themes taking into consideration the thematic map and the data set. To answer the research objectives and identify behavioural change strategies, the themes which captured topic summaries were grouped into barriers and enablers under the respective domains of the COM-B model of behaviour (Michie, 2014; Michie et al., 2011; West & Michie, 2020).

2.3 Results: Sustainable food consumption

2.3.1 Changes to consumption habits

A reduction and/or complete removal of meat was the most frequently cited change to consumption habits, mentioned by 63% of participants. Subsequently, many increased their consumption of plant-based foods as substitute products to meat. Moving away from the family home and/or to university was one of the main drivers for changing consumption habits, especially meat intake. Being self-sufficient, the influence of others and a restricted food budget were reasons given for behavioural change, highlighting the significance of this life stage.

“I'm definitely reducing the amount of red meat, kind of moving to alternatives like Tofu or just veggie”. (F, 25-34, STD).

"I've sort of tried to cut down on meat specifically just because of like money being a student and moving away as well". (F, 18-24, H).

Additional motives driving meat reduction were frequently related to environmental and sustainability reasons, indicating growing awareness. Consumer trends and health benefits were also mentioned although by fewer participants.

2.3.2. Perceptions towards sustainable food consumption

When describing sustainable food consumption habits, the top factors mentioned related to eating British produce and/or locally sourced food and making conscious food choices that consider the production and environmental impact of food. Reducing food waste and eating seasonal produce were also discussed by a few, however, the ethical elements of sustainable diets (e.g., animal welfare, fair labour practices) received little mention (Table 2.3). Furthermore, some participants talked about meat reduction, but there was slight disagreement as to whether it should be completely removed from the diet or reduced.

Table 2.3
Themes mentioned by individual participants when discussing what sustainable food consumption means, from high to low frequency. The frequency count in brackets refers to how many individuals mentioned the themes. Example quotes are given beside each theme.

Themes	Direct Quotes
High frequency (16-20 mentions)	
Eating home grown and or locally sourced food.	*"Making sure when you, I don't know, if you go to the supermarket reading labels and choosing the radishes that come from the UK instead of South Africa for example".* (F, 18-24, S)
	"Some sustainable changes you can make would be eating foods that are produced locally like vegetables from farmers market maybe". (M, 18-24, S).
Considers the environment	*"I would say like sustainable food consumption is all about like eating stuff in a sensible way so if you are gonna eat meat you need to make sure the meat you are eating isn't impacting on the environment too much"* (F, 25-34, H)
	"For me sustainable consumption would take into consideration not just health but the environment as well so looking at things like the carbon footprint, food miles and things like that". (M, 18-24, H)
Reducing food waste	*"I would say also try and not waste too much like I try and like eat everything I have got in my fridge rather than letting things go past their sell by date and then throwing it in the bin".* (F, 18-24, L)

Medium frequency (6-11 mentions)	
Reducing meat	*"I feel like eating sustainably is mostly about cutting out meat, so red meats"*. (M, 18-24, STD)
Eating seasonally	"*When you eat more seasonally it means that the demands of water or fertiliser is dropping a little bit"* (F, 25-34, L).
Eating more plant based	*"How do you eat more sustainably, eat less meat, more fruit and veg"* (M, 25-34, L).
Reducing or selecting recyclable packaging	*"I guess it's more like buying vegetables that are not wrapped in plastic when they don't need to be".* (F, 25-34, STD)
Low frequency (<5 mentions)	
Affordable and convenient	*"Whatever you do has to work well financially yes with what's accessible to you but also with your lifestyle and those external pressures as well".* (F, 25-34, STD).
Considers animal welfare	*"Not compromising on the quality of sort of welfare and the food production I think that is part of sustainability as well".* (F, 18-24, H).
Supporting farmers and growers	*"It's also supporting all those who work in the British food supply chain as well".* (F, 18-24, H).

2.3.3 Applying the COM-B framework to understand sustainable food consumption habits

In relation to the poll questions answered during the FG, the majority of participants were willing to reduce meat intake (86%) for the environment's sake. Fewer participants were willing to reduce dairy (69%), but overall, the scores indicate potential for changing habits (Table 2.2). Following the COM-B framework, a range of themes with barriers and enablers to sustainable consumption habits were identified. Findings have been broken down by domain and summarised below. In general, there were no variations in the types of responses between genders and age brackets, but meat-eater status did reveal some variations.

2.3.4 Capability

Overall, participants were very knowledgeable regarding the environmental impact of the livestock industry and consumption of meat, perceiving it to play a contributing role in climate change. However, notable knowledge gaps were also observed, specifically relating to uncertainty around making sustainable food choices (e.g., which plant-based milk is better for the environment) and mixed perceptions around the environmental impact of different foods (e.g., local meat is better/worse compared to plant-based foods shipped from abroad). In particular, participants lacked awareness when discussing the sustainability of seafood, especially in contrast to meat. Interestingly, a range of information sources that had influenced consumption habits were mentioned (e.g., documentaries, articles, magazines, social media, labelling). One example included the Netflix documentary 'Seaspiracy', which for some viewers resulted in a reduction or complete removal of fish from their diet.

Participants mentioned being in control of the food shop, planning meals and cooking skills enhanced their sustainable consumption. Feeling more responsible led some to reduce meat and food waste, whilst cooking skills provided the ability to utilise alternative ingredients to meat. One participant gave the example of using mushrooms and a beef stock cube instead of beef mince to make a bolognaise. However, for participants who lacked cooking skills, a dissatisfaction with meat-free meals not being filling and an increased reliance on meat were mentioned. Findings from the capability domain are summarised in Table 2.4.

Table 2.4
Thematic themes for the capability domain, listing the Barriers (B) and Enablers (E) towards sustainable food consumption habits with supporting quotes taken directly from the FG sessions with young UK consumers.

Capability - *psychological*	**Direct quotes**
Uncertainty around making sustainable food choices (B)	*"Moving from normal milk to like almond milk or oat milk or soy milk for instance, I don't actually know the answers to this, but which one is actually better for the environment?" (F, 25-34, STD).*
	"If I can't have beef and I can't have chicken and stuff like that or like milk or something and then I now shift towards having fruit like am I still eating unsustainably?" (F, 18-24, H).
Mixed perceptions around the environmental impact of food (B)	*"You know eating a potato that's come from Australia will have a lot lower carbon footprint than eating a cow that's come from the UK".* (M, 25-34, L).
	"My like gut reaction would be meat is worse than dairy but then….to be honest I think neither of them are great like yeah I don't know if one is worse than the other". (F,18-24, L).
Lack of knowledge regarding the environmental impact of fish (B)	*"I don't really know too much about how the fish thing affects the environment and overfishing and things like that and I don't think it's much of a focus generally when people talk about food and sustainability which is probably why I haven't thought about it too much".* (F, 18-24, STD).

	"I feel like you don't hear as much about it [referring to fish] so it makes you...I guess you just presume that maybe it's not as bad as meat consumption". (F, 18-24, H).
Media sources influencing consumption habits (E & B)	*"I guess I've always thought that eating fish or the way you know we as a society consume fish is more sustainable and I don't know where I got that idea from, then I watched of course the Netflix documentary Seaspiracy and that sort of turned my idea on its head but yeah until that I always just saw fish as a more sustainable option for consumption than other you know types of meat".* (M, 25-34, H).
	"I watched a documentary recently about the impact that avocados had on the water supply where they're grown so trying to limit the consumption of that". (F, 25-34, L).
Ecolabels & magazines as information sources (E)	*"I look out for like accredited you know like the accredited symbols that you get on the packet that say it's like a sustainable fish or caught in a sustainable way".* (F, 25-34, STD).
	"I follow recipe magazines and stuff so I'm aware of what's in season because the recipes were based on what's coming in season and I'm probably quite led by the offers by supermarkets as well which usually sinks in with what is in season". (F, 25-34, H).
Being in control of the shopping/ planning of meals (E)	*"Because I am more in control and more responsible when I am shopping like it's easier to take time to look at the labels and plan out my meals".* (F, 18-24, H).
	"I am sorting all my own stuff out, so I am probably buying less meat but also trying to utilise like the ingredients that I do buy in several different ways over the week, trying to not buy too many different things but do different things with them". (F, 18-24, STD).
Capability – *Physical*	
Cooking skills (B & E)	*"I feel like I am not really a good cook so I kind of have to use meat to make it taste better".* (M, 25-34, H)
	"The hardest bit is like bulking out meals because I just get very hungry so if you cut out meat its harder to make those meals more filling". (M, 18-24, STD).

2.3.5 Opportunity

Social opportunities included the influences of others, which were positively linked to consumer trends and acted as an enabler to change. Some participants noted how the increase in non-meat eaters has increased the availability of alternatives and started to normalise the phenomenon of selecting meat-free options. Indeed, one participant mentioned, they had reduced meat intake because, '*I guess it's quite trendy*'. However, a few participants touched on the topic of masculinity and meat, stating that the men in their life tend to be the most resistant to change.

Physical opportunities related to changing environments and lifestyle factors, such as moving away from the family home and being in control of what to cook and eat, which both acted as enablers to sustainable consumption. This was partly related to being on a low income which for some meant they could no longer afford to eat as much meat as before. However, in general, sustainable food consumption was perceived as expensive and not always attainable on a low budget. This was especially apparent when participants discussed packaging, sharing their frustration that often loose fruit and vegetables are more expensive than the packaged equivalents. Access to zero waste shops and recycling centres provided examples of services that enabled sustainable practices. Findings from the opportunity domain are summarised in Table 2.5.

Table 2.5
Thematic themes for the opportunity domain, listing the Barriers (B) and Enablers (E) towards sustainable food consumption habits with supporting quotes taken directly from the FG sessions with young UK consumers.

Opportunity - *Social*	**Direct quotes**
Influence of others (B)	"*Genuinely speaking I would be happy to eat less meat, would be willing to buy less meat, but my partner wouldn't*". (F, 18-24, H).
	"*There's a trend certainly in my life that the men in my life tend to be keener on having meat in the meal for their protein source than having veggie alternatives*". (F, 25-34, STD).
Consumer trends and social norm (E)	"*If I eat out with my friends instead of with my family I tend to have more plant-based dishes especially since there are more vegetarian vegan people now*". (F, 18-24, STD).
	"*I feel like year on year there's just more and more pressure personally to eat less meat like there's a lot more people doing it so there's more pressure for you to kind of have a go, so I've kind of just started trying to do that recently*". (F, 18-24, STD).
Opportunity - *Physical*	
Changing environments - moving away from the family home (E)	"*I do have quite a lot of veggie days during the week especially now that I am living at uni and I am cooking for myself and can cook for my friends and stuff it does take more of a veggie route*". (F, 18-24, STD)
Low income (E & B)	"*I've sort of tried to cut down on meat specifically just because of like money being a student and moving away as well*". (F, 18-24, H).

	"*I am on a student budget so I'm not, I've not got a lot of you know, finance is not necessarily the easiest part for me to be able to be sustainable, so I'd like to be*". (F, 18-24, STD).
Unnecessary packaging (B)	"*For students its especially you want to be sustainable but if the packaged option is cheaper then sometimes you can't help it*". (F, 18-24, STD).
	"*In some supermarkets its just impossible form a financial point of view it's so much cheaper to buy a multipack of peppers for example than each loose pepper*". (F, 18-24, STD).
Zero waste shops and recycling services (E)	"*I often, not all the time, go to zero waste shops as well so there seem to be now on most highstreets zero waste shops*". (F, 25-34, STD).
	"*I was glad to find the soft plastic recycling in Tesco's now so you can take it there and a lot of the stuff is now recyclable so yeah*". (F, 25-34, STD).

2.3.6 Motivation

High attachment to meat and dairy and personal beliefs around being incapable of living without animal products emphasised the habitual nature of consumption. Despite consciously recognising the sustainability benefits of reducing meat and dairy, some participants were still unwilling to reduce highlighting an awareness behaviour gap. In general, the environmental benefits related to meat reduction were repeatedly mentioned whilst other factors such as health, animal welfare and ethical elements of sustainability did not dominate discussions. The belief that individual changes can make a difference were stated by many participants indicating individuals were engaged on a personal level and showed an optimistic outlook for the future. However, there were still a couple of participants who felt that changes on the individual level would not make a difference in tackling climate change. For some participants, being sustainably minded evoked negative emotions. Feelings of guilt, pressure and exhaustion were mentioned with a level of annoyance evident when discussing the impact food consumption may have on climate change as one participant commented, "*the best thing for the climate is to just lie down and die, and I don't really want to do that*". Findings from the motivation domain are summarised in Table 2.6.

Table 2.6
Thematic themes for the motivation domain, listing the Barriers (B) and Enablers (E) towards sustainable food consumption habits with supporting quotes taken directly from the FG sessions with young UK consumers.

Motivation – *reflective*	**Direct quotes**
Attachment to meat and dairy (B)	***"****I'd like to be the kind of person that does like help the environment and eat more sustainably but then at the same time I just do prefer meat ".* (F, 18-24, STD).
	"It's just purely selfish because I don't think I could live without cheese". (F, 25-34, STD)
Environmental benefits of reducing meat (E)	*"My main reason for cutting down on meat is more environmental and more fairness about eating protein sources from plants".* (F, 25-34, L).
Scepticism around logos and accreditation (B)	*"If you're buying a tin of tuna from, I don't know a supermarket and like what we've learnt from those logos, those ethical logos, actually don't mean anything apparently".* (F, 25-34, STD).
	"So, it's kind of just like the education, kind of knowing like them [referring to ecolabel certification schemes] tricking the consumer into thinking they are shopping sustainably when they actually aren't, I know there's quite a lot of that trickery especially in the fish kind of trade area". (F, 18-24, STD).
Individual changes can make a difference (E)	*"I think there's more of a focus on food often because that's actually somewhere where we can make a difference by changing personally what we do we can have a big impact".* (M, 25-34, L).
	"If people collectively are conscious about sustainability then in a way we are going to influence what we think is sustainable production and sustainable economics". (M, 18-24, H).
Individual changes will not make a difference (B)	*"I don't think myself if it's just me making a change I don't think I'm gonna solve climate change at all I think the problem is more at an industrial level".* (F, 18-24, L).
	"I always have this perception that if I walk into the supermarket and I choose not to pick up that packet of mince beef or that litre of oat milk, if I choose not to pick it up eventually someone else will pick it up". (M, 18-24, H).
Motivations - *automatic*	
Negative emotions towards sustainability (B & E)	*"We can't write off everything, we can't not have everything in our lives".* (F, 18-24, H).
	"I think there's a lot of pressure, it can be very easy to fall into the trap of feeling like you are not doing enough". (F, 25-34, STD).

2.4 Results: Consumer acceptance towards protein alternatives using the COM-B framework

The most frequently mentioned themes discussed within each domain differed across the three alternatives as summarised below and detailed in Tables 2.7, 2.8 and 2.9.

2.4.1 Plant-based meat/seafood

Few participants had tried PBS products, which were thought to be less prevalent in shops. However, the majority of participants had tried a wide range of PBM, with Quorn (mycoprotein-based products) most frequently mentioned. Some participants who did not like the imitation aspect preferred unprocessed plant foods, such as chickpeas and lentils. The main reason for trying PBM products related to the influence of others, highlighting the importance of social norm and consumer trends. Although many recounted negative sensory experiences, this was outweighed by the number of mentions for positive sensory experiences. This indicates how trial and error these products can be, which to some degree involves a certain level of risk taking. The 'booming' plant-based market was referenced by some participants, who found substituting meat easier due to increased availability. One participant commented on how PBM provided support for people who really enjoyed meat to transition towards a non-meat diet. Convenience and ease of cooking also acted as enablers, with functionality and food safety in terms of being able to cook from frozen and not worrying about under cooking products mentioned.

The biggest barrier towards acceptance related to the negative perception that plant-based products are overly processed and therefore unhealthy. The level of processing led to scepticism around how environmentally friendly plant-based products are compared to their conventional counterparts. However, a large majority of participants perceived them to be advantageous towards sustainable consumption, predominantly due to the supportive role they play in reducing the consumption of animal products. Only a few participants mentioned animal welfare as a motive for consuming plant-based products, with sustainability and environmental benefits dominating the discussions. Participants were uncertain as to whether PBM/S products are healthier compared to conventional meat and fish and therefore it was not considered a main driver. Findings for PBM/S products are summarised in Table 2.7.

Table 2.7
COM-B model with thematic themes for PBM/S products, listing the Barriers (B) & Enablers (E) with supporting quotes taken directly from the FG sessions with young UK consumers.

Opportunity - ***Social***	**Direct quotes**
Influence of others (E)	*"I am only having them if I'm out with my vegetarian friends".* (M, 25-34, H).
	"I think the main reason why I started trying them was because one of my flatmates went vegetarian and we used to cook together, and I was like yeah why not and then realised they're actually quite nice, I'm not sure if I would have eventually tried them just by myself". (F, 18-24, STD).
Opportunity - ***Physical***	
Convenience and easy to substitute in cooking (E)	*"I think the good thing about Quorn mince is that you can cook it from frozen which obviously you can't do with regular beef mince*". (F, 18-24, STD).
	"I think that they are sometimes easier to cook and there's less sort of space for error I think in terms of like over cooking or under cooking". (F, 18-24, STD).
Availability of plant-based alternatives (E)	*"Meat I could definitely reduce a lot more easily because some really good substitutes out there now".* (F, 18-24, STD).
	"I would say it has sort of become easier just because there are so many alternatives now, there's like, I don't feel like I am missing out on meat as much". (F, 18-24, STD).
Motivation – ***reflective***	
Negative health connotations (B)	*"A problem that I have with them is that the nutritional value is not exactly the same, for example if you swap a sausage for the mushroom sausage, you might not be getting the same nutrients".* (F, 25-34, STD).
	"They can contain products in the processing that aren't good for you". (F, 18-24, H).
Overly processed (B)	*"For me it just seems a bit too much processing that's really what puts me off".* (F, 18-24, H).
	"My experience genuinely with them is that they are so highly processed, and they have so many additives and so many things added that are not necessarily good for us but just to replicate the taste or I don't know the smokiness or certain things that meat has, or fish has". (F, 25-34, STD).
Negative environmental impact (B)	*"Another disadvantage is that it might like leave people to think that that they are being more environmentally friendly when it might not necessarily be the case because of all the processing involved and sourcing of all the wide range of ingredients".* (M, 18-24, STD).

	"Often ultra-processed foods, could lead to environmental damage such as issues with palm oil and soybean production". (F, 25-34, H).
Sustainability and environmental benefits (E)	*"I think one of the obvious advantages is that you're not eating meat or fish so that has a big impact especially on the environment".* (F, 25-34, L)
Motivation – *automatic*	
Positive sensory experience (E)	*"Things like the hoisin duck I have tried which is really tasty I would like definitely recommend those ".* (F, 18-24, STD).
	"Usually, it's a choice for taste it's like ah I love these, these are brilliant, I'll buy them". (M, 25-34, STD).
Negative sensory experience (B)	*"I think I found with a lot of them that they might do well with replicating the taste of meat but then the texture would always fall down".* (M, 18-24, STD).
	"To be honest everything that I have ever tried that's trying to copycat in this world of like replacement meat and fish is just a poor comparison, so I don't really seek it out". (F, 25-34, H).

2.4.2 Cell-based meat/seafood

The majority of participants had heard of CBM (82%) and only a minority had heard of CBS (13%). In terms of consuming for the sake of the environment, once the methods of production were explained, many participants felt both technologies appealed to them (74%). However, during discussions a minority of participants felt CBS would be harder to emulate due to the large variety of fish species and the whole format in which they are often presented and or eaten. One participant suggested '*squid rings*' as a more suitable product rather than '*whole prawns or something like that'*.

A large majority of participants demonstrated an optimistic outlook and attitude when discussing the future potential of CBM/S, with a few perceiving them to be a more environmentally friendly option compared to conventional meat/seafood. However, a lack of knowledge surrounding CBM/S was frequently mentioned as a barrier towards acceptance, due to reduced confidence and scepticism over food safety and possible long-term health risks.

In general, several participants were concerned about wider consumer acceptance rather than personal approval and questioned the role of CBM/S within cultural norms.

However, curiosity was identified as a key driver, predominantly linked to an interest in sensory attributes. When discussing advantages, the most frequently mentioned motive related to animal welfare. The potential environmental benefits and the opportunity to personalise products to reflect optimised nutrients also steered conversations. Findings for CBM/S are summarised in Table 2.8.

Table 2.8
COM-B model with thematic themes for CBM/S, listing the Barriers (B) and Enablers (E) with supporting quotes taken directly from the FG sessions with young UK consumers.

Capability – *Psychological*	**Direct quotes**
Scepticism over food safety & health (B)	"*I'll try it now, but I am also quite sceptical and want to wait until studies have been done on like nutritional content and like long term health implications for people that consume that for a long period of time."* (M, 25-34, STD).
Lack of knowledge regarding production methods (B)	*"For me the whole lack of information and the lack of knowledge around cell-based foods and things really reduces my confidence".* (F, 18-24, STD).
	"I've like heard about it I've heard the name, but I really don't know enough about it for me to straight away be like yes I am willing to put that in my body". (F, 18-24, H).
Increasing knowledge on production methods & health implications (E)	*"I think they should share with the consumers more details on the methodology and if they're using chemicals or if the process creates like bad ingredients for people's health*". (F, 25-34, L)
Opportunity – *Social*	
Consumer acceptance (B)	*"As much as it could be a good sustainable option it's actually getting consumers to want to buy, and some are going ah there's a lab-based piece of bacon here over a normal slice of bacon people tend to go with what they know over what's new even if it could have a positive impact".* (F, 18-24, H).
	"*I think one disadvantage I can think of would be the cultural acceptance, I think food brings people together right so if you were to present a plate of cell based or cell cultured meat over Christmas dinner for example, I think many of the older generations adults would be resistant to try probably question its origins and how it came about".* (M, 18-24, H).
Opportunity - *Physical*	
Affordability (E&B)	*"I just think that it's really exciting and I would definitely be keen if it was affordable".* (F, 18-24, STD).
	"I can imagine it being very expensive". (F, 18-24, STD).
Motivation – *reflective*	

Unnatural (B)	*"The way to be sustainable in my opinion is going down the natural route erm rather than starting to bring in something like cell-based meat, as much as it's interesting and exciting it just doesn't appeal to me".* (F, 18-24, H).
	"The thought of having something that has been made in the lab I don't know it's just a bit scary". (F, 18-24, H).
Optimistic sustainability outlook (E)	*"I feel like there's a lot of potential in the future for it to become more environmentally friendly even if it's not the case at the moment compared to like the same amount you produce from a cow."* (M, 18-24, STD).
	"I just think it's great it's so exciting why would you not want to have meat that tastes like meat is fundamentally meat doesn't hurt animals and doesn't damage the planet so much". *(*F, 18-24, STD)
Animal welfare (E)	*"It depends why someone would be reducing meat and fish consumption and I think if its animal cruelty then 100% I think this is better".* (F, 18-24, L).
Environmental benefits (E)	*"If I know that it's going to be more eco-friendly then definitely".* (F, 18-24, STD).
Optimised nutrition (E)	*"Being able to control fat content precisely which could help to tackle some chronic health issues associated with overconsumption of saturated fat".* (F, 18-24, STD).
Motivation – *automatic*	
Curiosity (E)	*"I would like to see how it tastes, how it cooks, and you know whether or not whether it looks or feels any different to regular meat".* (F, 18-24, STD).
	"It is just curiosity I'd be really intrigued to see what it's like compared to you know naturally grown meat". (M, 25-34, H).
Positive sensory experience (E)	*"If I would carry on consuming it, it's another question because it depends on how it would be on the first experience".* (F, 25-34, L).

2.4.3 Precision fermented dairy

Overall, participants were intrigued by the concept of PFD but recognised it would need to be marketed well and would take time for consumers to understand and accept. Only a minority of participants were optimistic about the production method, but they were not challenged on this opinion by other participants. Curiosity, especially in relation to what it would taste like dominated discussions and were key motives for trying. Many stated how current dairy alternatives were not appealing from both a sensory and functionality perspective which highlights a gap in the market which PFD could fulfil. Some participants also appreciated the opportunity for products to be nutritionally optimised, whilst meeting the needs of lactose intolerant consumers. Animal welfare was the most frequently mentioned advantage, with some participants mentioning the possible environmental benefits. Findings for PFD are summarised in Table 2.9.

Table 2.9
COM-B model with thematic themes for PFD, listing € Barriers (B) and Enablers (E) with supporting quotes taken directly from the FG sessions with you–g UK consumers.

Opportunity – *Social*	**Direct quotes**
Consumer acceptance (B)	*"Would be hard for people to wrap their heads around".* (F, 18-24, H).
	"Consumer acceptance, it needs to be marketed well!" (F, 25-34, STD).
Opportunity - *Physical*	
Current dairy alternatives not appealing (E)	*"I don't know whether anyone has tried dairy free cheese, it's generally quite disgusting in my opinion, it's just kind of plastic smells a bit weird doesn't last for very long".* (F, 18-24, STD).
	" No one milk alternative makes a bechamel as well as it goes in a porridge as well as it you know goes in a cake so it's just easier just to have milk because I know it's got the functionality for everything I want to do with milk". (M, 25-34, Low).
Affordability (E&B)	*"Depending on the price, if it's like five times as expensive then I'll wait a few years or months".* (M, 25-34, STD).
	"This sounds like quite an expensive way to make the milk and until it's you know really common and it's the same price as normal milk then it would become like something that I would always buy just from a cost point of view." (F, 18-24, STD).
Motivation - *reflective*	
Scepticism over sensory appeal (B)	"*In my head I'm just thinking it's going to be fizzy I don't know why*". (F, 18-24, STD).
	"*The milk I just can't imagine it tasing that nice, but I could be wrong*". (F, 18-24, H).
Health and optimised nutrition (E)	"*I know that sometimes the plant-based milks are not very easy to digest for some people so yeah I think it's really interesting.* " (F, 25-34, L).
	"*Opportunity to improve nutrition*". (M, 25-34, STD).
Environmental benefits (E)	"*If they were able to have lab-grown cheese that erm is better for the environment I would be willing to try*". (F, 18-24, STD).
Animal welfare (E)	*"I have been all about the environment and then when it comes to dairy products before the environmental impact I think of animal welfare and that's purely because I've seen dairy cows and I've seen calf's be separated from mums you know as soon as they are born and put into crates really quickly and I think that it's that emotional impact that then makes me think I want less of that and I will try anything*." (F, 25-34, STD).

Motivation – *automatic*	
Positive sensory experience (E)	"*As long as it tastes the same, same texture and everything then you know everyone should be doing it*." (F, 18-24, STD).
	"*I have got to consume quite a lot of this stuff in my lifetime, so I want to enjoy it I don't want to dread making a coffee because I know the milk is going to taste horrible or whatever just because I am trying to do the sustainable thing".* (F, 25-34, H).
Curiosity (E)	"*To be honest I have tried to eat cheese that is plant based and I didn't really like it so I would be very interested to see the flavour of those kind of cheese or milk".* (F, 25-34, L).

2.5 Discussion

This study aimed to provide added insights into young meat-eaters consumption habits and perceptions towards sustainable foods. Furthermore, it aimed to provide novel insights by comparing the barriers and enablers to a range of protein alternatives, some of which are currently not well understood. The COM-B model gave structure to the findings and identified areas of behavioural change which are suggested and discussed below.

2.5.1 Changes to food consumption habits and perceptions of sustainable foods

Initial discussions regarding changes to food consumption habits, without any prompts regarding sustainability, identified an undeniable trend towards meat reduction amongst the consumers in this study and subsequently an increase in the consumption of protein from other sources. Findings reflect current reports regarding reduced meat intake in the UK (Bryant et al., 2023; Deloitte., 2022; Stewart et al., 2021; The Vegan Society., 2022) and supports the growing demand for protein alternative products (GFI, 2023; YouGov, 2019).

Interestingly, the Covid-19 pandemic was not mentioned as an influential factor in changing dietary habits which is in contrast to previous qualitative studies amongst UK consumers (Filimonau et al., 2021; Pluck & Morrison-Saunders, 2022; Whittall et al., 2023; Williams et al., 2023). Instead, for many, moving away from home and living independently acted as the catalyst for change. Similar findings have been observed amongst studies with young adults (Kemper & White, 2021; van den Berg et al., 2022), in which transitional life stages are likely to influence eating habits (Poobalan et al., 2014). Although findings contradict a previous study (McBey et al., 2019), in general, research has shown that intervention strategies during life stages can lead to a greater openness to new information (Verplanken & Roy, 2016).

Environmental/sustainability benefits were mentioned by some as drivers for changing food habits, especially meat reduction, which supports previous FG findings amongst young adults (Kemper et al., 2020). Results also signify a shift in consumer awareness compared to previous studies with UK consumers (Clonan et al., 2015; O'Keefe et al., 2016). However, a more apparent motive on sustainable food choices related to limited food budgets. For some participants it facilitated meat reduction, but adversely it also meant choosing the cheapest option for fruit and vegetables which were often the most packaged. Practical concerns relating to the cost of sustainable foods have been previously noted amongst UK consumers (Whittall et al., 2023), and is considered a prominent barrier to eating a sustainable diet (FSA, 2021).

Trade-offs with price left some participants feeling that wealthier individuals were more at liberty to make sustainable food choices. Indeed, competing demands and the recognition that sustainable eating is a privilege for the wealthy has been a prior consideration (Weber et al., 2022; Whittall et al., 2023). Contradictory to previous studies with UK consumers, personal health and animal welfare were scarcely mentioned when discussing reductions to meat intake (Clonan et al., 2015; Defra., 2011; Dibb & Fitzpatrick., 2014; Mylan, 2018). To some extent this highlights the importance of alternative factors such as price and the influence of others in driving change. Furthermore, considering this study was conducted before the full effects of the 'cost of living crisis', (where inflation outweighs income wage and benefit increases), price may be even more significant now (Hourston, 2022). The notion that consumers following plant-based diets spend less could therefore unintentionally bring about change (Pais et al., 2022).

Reviewing participants perceptions towards sustainable foods, the most discussed themes related to consuming homegrown and or locally sourced food. The importance placed on these factors have been observed in previous studies and is often linked to eating seasonally (Bows et al., 2012; Lea & Worsley, 2008; Polleau & Biermann, 2021; Whittall et al., 2023). However, as the UK imports 46% of the food it consumes, it is not always possible to eat locally sourced food (Defra., 2021). In general, participants considered the environmental impact of food based on the distance it had travelled, with many mentioning ‘food miles’ and ‘carbon footprints’. As the origin of production is often one of the few pieces of information on pack, it makes sense that consumers are more aware of this attribute. However, ‘localness’ is not always an accurate measurement of sustainability as the carbon footprint is not always lower (Stein & Santini, 2022). Instead, the type of food commodity is more important (Ritchie, 2020a). To some extent this was discussed when a participant compared the carbon footprint of an Australian potato compared to local beef. Findings therefore reinforce that it is not easy to know how to be a “sustainable consumer” and how best to quantify the environmental impact of food choices (van Bussel et al., 2022).

When describing sustainable food behaviours, a reduction in meat, especially red meat, was not mentioned as frequently as other behaviours (e.g., eating local, seasonal, reducing food waste), despite it being the main self-reported dietary change in earlier discussions. Dietary changes were also not explicitly linked to a specific type of diet (i.e., vegetarian, vegan or plant-based) (Faber et al., 2020). Findings support results from a recent survey of nationally representative UK adults, in which meat reduction is not listed as the top sustainable lifestyle action (Deloitte, 2022). Perhaps the results re-affirm that meat reduction is driven by alternative factors discussed (e.g., moving away, the influence of others, restricted budgets) compared to ‘sustainability’ reasons. In addition, only one participant mentioned a reduction in dairy, perhaps indicating even lower awareness compared to meat. Instead, the importance was placed on how environmentally friendly the processes involved in the production methods are (e.g., transport, GHG emissions, water usage). Findings therefore indicate the mounting evidence that sustainability is increasingly being viewed through an ecological lens, with the social and economic elements (e.g., decent working conditions, fair trade, supporting communities) often overlooked (Jones et al., 2016).

2.5.2 Barriers and enablers towards following sustainable food consumption habits

In general, participants acknowledge food production and consumption negatively contributes to climate change, with a minority specifically referencing meat. Similar to Bryant et al. (2023), reflective motivations were greater than automatic motivations, with the majority of participants positive towards the idea that individual changes to food consumption habits will make a difference to climate change. Findings indicate an increase in awareness regarding the environmental impact of food, and a potential shift in consumers attitudes compared to prior research conducted with UK consumers (Macdiarmid et al., 2016; Mylan, 2018). It also supports the idea that younger consumers are more informed (McBey et al., 2019) and likely to believe their food choices will affect the environment (Ran et al., 2022). This shift in awareness could partially be due to the majority of participants indicating they had recently heard about sustainability in the mass media (Table 2.1). To some extent increased awareness is likely to enable conscious sustainable food consumption habits. In particular, intervention strategies involving information have been successful in encouraging red meat reduction and increased green eating behaviours (Carfora et al., 2019; Monroe et al., 2015). However, information as an intervention may have limited effectiveness, dependent on the length and time of exposure and participants subjective knowledge (Weingarten, 2022). It may also only be effective for consumers who believe in the negative impact of meat on the environment (Vainio et al., 2018). Therefore, strategies should be combined with other approaches, as information on its own may be insufficient (McBey et al., 2019).

Despite increased awareness, it was apparent that the majority of participants struggled to quantify the size of the environmental impact of food which has been previously observed (Hartmann et al., 2022; Hoek et al., 2017; Shi et al., 2018; van Bussel et al., 2022). This is to be expected as it depends on many factors (e.g., water and land use, carbon footprints, pollution issues, waste management) and there is still considerable debate amongst the scientific community. Lack of information as a psychological barrier was particularly applicable when participants discussed the sustainability of seafood, and to some extent dairy. Subsequently, concern around the environmental impact of these food commodities appeared lower and dominated discussions less than meat. Indeed, some participants felt that the environmental impact of meat was more of a prevalent topic of conversation compared to seafood. Apart from the origin and sustainability certification on pack, participants had little knowledge from which to make informed choices when purchasing seafood. Furthermore, only a small minority mentioned the issue of overconsuming the same variety of fish which are usually non-native species to the UK. Therefore, better education is required to help consumers understand how to consume seafood as part of a sustainable diet, which includes a broader variety of fish species (Steenson &

Creedon, 2022). Different cooking methods could be applied as a strategy to increase the diversification of fish species consumed. For example, preparing oysters outside of their traditional raw format and into familiar foods such as burgers provided a viable approach to increase consumption in Sweden (Costa et al., 2023).

Labelling schemes which communicate the sustainability of food (e.g., carbon footprints) provide a promising avenue for tackling the knowledge gap and changing consumer behaviour, especially towards meat consumption (Camilleri et al., 2019). However, a level of scepticism towards accreditations such as 'dolphin friendly' and the 'Marine Stewardship Certification' (MSC) was evident amongst some participants during the FG discussions. The mistrust being partially driven by information gained through media outputs, such as the 2021 Netflix documentary 'Seaspiracy', where amongst other topics, the efficacy of the MSC label was discussed. This highlights the power the media has in shaping consumers consumption habits, but it could be argued not always in a sustainable direction. For example, after watching 'Seaspiracy' a number of participants recounted reducing or removing fish from their diet, yet fish is considered to be part of a healthy and sustainable diet in the UK (PHE, 2018). The recommendation to 'stop eating fish' in the documentary has subsequently been criticised and questioned by many scientists and organisations (Sivertsvik, 2021). It is therefore essential that messaging is accurate and reliable considering on average participants agreed that the media provides a balanced and unbiased view of new food technologies (Table 2.1).

Another theme that dominated discussions was the influence of others on changing behaviour, especially in relation to preventing meat reduction. As discussed in a previous study, whether meat consumption was avoided or consumed depended on the social context and the need to avoid inducing a negative effect on others (Collier et al., 2022). Some participants mentioned consuming more meat when returning home and or being with family which supports a recent study reviewing influences on meat consumption in the UK (Horgan et al., 2019). In addition, some participants mentioned the presence of men as being a barrier to reducing personal meat intake, which supports the notion that meat consumption continues to be linked and shaped by masculinity (Carroll et al., 2019; Mesler et al., 2022). It also highlights a level of fear and stigmatization associated with avoiding meat consumption (Markowski &

Roxburgh., 2019). However, as the number of non-meat eaters and the availability of meat-free options continues to rise in the UK, new trends and social norms are becoming established and should be utilised to facilitate sustainable food consumption habits. Currently, further research is needed to understand the effectiveness of interventions on social norms which could prove successful (Kwasny et al., 2022). For example, 'dynamic' social norms (i.e., norms about the number of other people engaging in a behaviour), have been proven to encourage a reduction in meat consumption in a cafeteria setting (Sparkman & Walton, 2017).

An interesting finding related to the negative emotions that arose when discussing the potential role food plays in contributing to climate change. The multidimensional nature of what sustainable food encompasses meant consumers were often confused, and in some instances frustrated as to how to eat sustainably when substituting out a particular food source. A small minority of participants perceived being sustainable meant denying enjoyable foods. Others echoed sentiments of guilt that they were not doing enough, feelings of pressure to change their ways and mental exhaustion regarding food choices. This supports the notion that transitioning towards plant-based diets can be physically and emotionally challenging for young adults (Von Essen, 2021). Research has shown that guilt can positively impact consumers perceptions towards healthier and more sustainable food choices and eating habits (Yu et al., 2021). However, these negative emotions could deter some from engaging with sustainable food behaviours. Therefore, a successful behavioural change strategy could be to instead highlight the positive emotions. For example, highlighting how good consumers can feel when reducing their meat consumption is one way to positively influence consumers intention to reduce meat intake (Taufik, 2018). Alternative emotional motivations could come direct from consuming sustainable products which can elicit positive emotions and less guilt (Yang et al., 2020a). However, initiating behavioural change can be the biggest challenge and a good first impression, often sensory related, is critical in creating a shift in behaviour.

2.5.3. Barriers and enablers towards plant-based meat and seafood products

The majority of participants had tried PBM products or were regular consumers which reflects the growing popularity in the UK (GFI, 2023; Smart Protein, 2021). Unlike previous FG discussions, affordability was not mentioned as a barrier towards acceptance (Kerslake et al., 2022) but then price is likely to be a culturally sensitive factor (Weinrich, 2018). Instead, the functionality of products, being convenient, easy to cook and a good substitute for meat were mentioned frequently as advantages and supports previous findings (Elzerman et al., 2013). Fewer participants had tried PBS products which could be due to the smaller market presence compared to PBM (GFI, 2023). Subsequently, less availability and familiarity alongside an 'awareness gap' regarding the environmental impact of seafood, may explain the reduced need to replace seafood in a meal. Increasing consumer knowledge could help consumers better understand the supportive dietary role of PBS products, which potentially need to align with consumer seafood preferences (Kim et al., 2023).

Sensory appeal was a prominent motive in discussions which further establishes it as a crucial factor for determining regular consumption (Weinrich, 2019). The balance of positive and negative sensory experiences did not seem to deter participants from trying a range of products, which tended to be processed PBM substitutes (e.g., mince, burgers, sausages, nuggets). Only a few consumers in this study mentioned being against the mimicking aspect of substitutes, which is in contrast to previous FG's with French and Norwegian consumers (Varela et al., 2022). Indeed, meat-replacers that mimic the taste and texture of meat are most likely to succeed and appeal to high meat consumers (Hoek et al., 2011; Michel et al., 2021). However, in order to make plant-based products functional and palatable, they often undergo high levels of processing. For the majority of participants, the overly processed nature of some plant-based products acted as a barrier towards acceptance and led to discussions around lengthy ingredient lists, nutritional content and health implications.

The perception that plant-based products are overly processed and potentially non-beneficial to health has also been observed in previous studies (Collier et al., 2021; Hartmann et al., 2022; Weinrich, 2018). Although similar associations were not made during the FG when discussing conventional meat products, a quantitative study amongst UK consumers found PBM to be perceived as a 'healthier' option (Vural et al., 2023). This topic has been explored in the literature, especially from a nutritional perspective compared to conventional meat and seafood products. In general, findings show PBM products tend to be lower in fat, higher in dietary fibre, with many products high in salt (Alessandrini et al., 2021; Curtain & Grafenauer, 2019). PBS alternatives had similar nutritional shortcomings compared to their conventional counterparts, with some lacking in protein content and high in salt, but findings varied widely dependent on the product (Boukid et al., 2022). Overall, the balance between the advantage of sensory appeal and the disadvantages of processing on nutritional benefits needs to be considered.

Lastly, there was a level of scepticism about how beneficial plant-based products are for the environment, which has also been found in a FG amongst Swedish consumers (Collier et al., 2021) and remains widely debated in the literature, especially when compared to conventional meat (Andreani et al., 2023). Conversely, consuming PBM/S products were viewed by some as beneficial for the environment, due to the subsequent removal of meat and fish products from the diet. This indicates the participants in this study had a different perspective from previous literature, which found consumers to rate the environmental impact of meat and meat substitutes similarly (Siegrist & Hartmann, 2019). Therefore, highlighting the environmental impact on the packaging is one strategy found to increase acceptance (Martin et al., 2021), with a lack of information seen as a negative (Elzerman et al., 2013).

2.5.4 Barriers and enablers towards cell-based meat/ seafood and precision fermented dairy products.

In general, participants were positive about CBM/S and PFD being, curious and in some instances excited about the future potential of these novel technologies. This reflects the responses from the food technology neophobia scale, where on average participants felt that new food technologies were necessary (Table 2.1). However, as higher levels of food neophobia and food technology neophobia have been found to be associated with negative perceptions towards CBM, the findings may have been different amongst a wider cohort (Krings et al., 2022; Wilks et al., 2019). Additionally, it is important to note that these products are hypothetical and when available consumers may feel differently. For example, the level of processing was a concern for PBM/S products but was not mentioned during discussions around CBM/S and PFD. Potentially this is due to products and ingredient lists not being available.

In contrast to previous FG discussions, the disruptive nature of these cellular agricultural methods was only mentioned by a few participants (Verbeke et al., 2015). These few participants described having connections and or experiences with the farming industry which may explain the greater level of concern (Crawshaw & Piazza, 2023). Additionally, as the majority of participants lived in urban areas (Table 2.1), awareness and therefore concern of the impact CBM could have on agri-food businesses are likely to be lower than rural living consumers (Shaw & Mac Con Iomaire, 2019). However, it was apparent that PFD had fewer barriers compared to CBM/S which had greater levels of scepticism regarding food safety and health. This may be due to the name and description given to participants, where 'animal free dairy' was likened to the process of making beer and wine using fermentation tanks. Research has highlighted the importance of names and framing on consumer acceptance, and it is likely that the familiarity of the process method reduced consumer concern around food safety (Bryant & Barnett, 2019; Bryant & Dillard, 2019). Therefore, the way information is delivered and marketed for CBM/S and PFD will to some extent underpin acceptance and should be carefully considered. In the case of CBM, providing consumption frames that align conventional meat with CBM are likely to create more favourable attitudes (Fidder & Graça, 2023), whilst for PFD, frames related to animal welfare were viewed as the most pertinent for acceptance (Broad et al., 2022). Considering animal welfare was a key motive for PFD amongst the young meat-eaters in this study, which aligns with previous research (Powell et al., 2023), this frame is also likely to be the most influential.

The importance of sensory appeal was frequently mentioned for CBM/S and PFD, with repeat consumption reliant on a positive first sensory experience (GFI & Kelton Global, 2021; Perkins, 2018; Powell et al., 2023; Verbeke et al., 2015; Zollman Thomas & Bryant, 2021). Furthermore, participants predicted products will be expensive once they become available. This is probable especially in the case of CBM as the serum/medium used to grow cells during production is costly and often uses animal-derived foetal bovine serum (Hubalek et al., 2022). Therefore, not only will affordability and ethical concerns act as barriers to acceptance, but it is likely the high costs may increase consumer expectations around taste and quality. Consequently, compared to PBM/S products, it is questionable whether consumers will be as willing to compromise on a bad sensory experience for CBM/S and PFD.

Interestingly, several participants felt the main barrier towards CBM/S and PFD related to wider consumer acceptance rather than personal preferences. As one participant mentioned, food brings people together, questioning whether CBM would be appropriate for Christmas dinner and accepted by older generations. This in turn highlights situational appropriateness. Furthermore, whether CBM will be a societal success has previously been a concern associated with older rather than younger consumers (van der Weele & Driessen, 2019). The hypothetical nature of these products means we do not yet know how successful products will be and the consumer following they will get. Currently, research has suggested that compared to other novel food technologies, acceptance towards CBM/S is likely to be lower (Giacalone & Jaeger, 2023). It can be predicted based on the concerns participants had around cell-based products being 'unnatural' that this will be a key barrier towards acceptance and will need to be addressed (Laestadius, 2015; Siegrist et al., 2018; Verbeke et al., 2015). Strategies to overcome this negative perception have included changing the label to 'clean-meat' and highlighting the unnaturalness of conventional meat (Bryant et al., 2019; Bryant & Barnett, 2019). Whether similar approaches would work for CBS and PFD is yet to be understood. However, these strategies come with limitations and an alternative approach could be to highlight the top advantages discussed. For both CBM/S and PFD advantages included the animal welfare benefits, which have been previously observed in FG discussions around CBM in the UK (Bows et al., 2012; O'Keefe et al., 2016). Another advantage related to optimised nutrition (e.g., adjusting fat composition of meat and lactose-free dairy) which could be a unique selling point that product developers and marketing campaigns could take advantage of. As quantitative research amongst UK consumers found CBM to be perceived as a 'healthier' option compared to conventional meat this could become a key motive for acceptance (Vural et al., 2023).

2.6 Strengths and limitations

The findings contribute to an existing body of literature exploring sustainable food consumption habits in the UK and includes the novel topics of PBS, CBS and PFD which are considerably under-researched compared to meat substitutes. This study also provides a unique comparison of the barriers and enablers towards a range of topics, reviewing the diet from a more holistic perspective. However, due to the hypothetical situation of including novel alternatives it is hard to accurately define consumers perceptions to products which are not currently available in the UK (Palmieri et al., 2020; Weinrich et al., 2020). In comparison, plant-based products continue to rise in popularity and therefore FG participants had formed perceptions of them based on personal experiences, which may have contributed to the different barriers and enablers discussed.

In terms of the methods used, qualitative research using online FG's have increased in popularity especially following the Covid-19 pandemic and have the advantage of accessing participants from a wider geographical area making it more convenient than face-to-face sessions (Nobrega et al., 2021). Furthermore, it allows participants to talk in a familiar and safe environment which has been shown to result in greater disclosure than offline methods (Wilkerson et al., 2014). The use of FG's in this study allowed for rich insights into the reasoning underlying sustainable food choices. To our knowledge this is the first study to apply the COM-B model to FG data exploring the barriers and enablers towards protein alternatives. The use of the model is an additional step in the analysis that has increased study clarity and efficiency. Therefore, we recommend future studies aiming to encourage more sustainable food consumption consider using this model to allow for comparisons to be made, especially when reviewing intervention strategies.

However, several limitations should also be noted when interpreting these qualitative results. The first relates to the small sample size, meaning the results are not generalizable to the UK population. Also, the use of convenience sampling introduces self-selection bias. Despite efforts to recruit a range of young consumers, there was a skew towards female participants and more educated consumers. This may have influenced the changes participants made to their consumption habits, the level of awareness and knowledge around the environmental impact of food and the acceptance of alternatives. Future research should therefore employ quantitative research methods, with larger more representative sample sizes to explore additional demographic groups. For example, consumers with lower education and income levels may face more barriers towards sustainable consumption habits and be more resistant to accepting alternatives. Other factors worth considering relate to dietary preferences, cultural backgrounds, food neophobia, meat attachment and personality traits.

2.7 Practical implications

Our increased experiences with plant-based products provides foundational learnings for the barriers and enablers towards cell-based products. In general, to enable a more effective shift in behaviour, first impressions could be key, and therefore it is critical that products consider the balance between sensory appeal and over-processing. To initiate and maintain a shift in behaviour, the following factors mentioned should also be considered; affordability, functionality and convenience, as well as environmental, ethical and health benefits. If products are set to launch in the UK, the below factors may be of interest.

When developing PBM/S and CBM/S, consideration should be given to the preferred format in which to market products (i.e., processed, un-processed, whole, species type). Findings from this study, suggest consumers expect cell-based products to be available in a processed format (e.g., nuggets, burgers, calamari) instead of unprocessed (e.g., chicken breast, steaks, prawns). Partially, this could be due to consumers current experiences with processed plant-based products. Although presenting cell-based products whole could be more technologically challenging, which was acknowledged by participants, it would offer an opportunity for the cell-based market to differentiate itself from the plant-based market, which is somewhat saturated with processed alternatives. Furthermore, presenting CBM/S as unprocessed and whole (e.g., steaks, fish fillets) may reduce negative perceptions around over-processing, which plant-based products currently experience. Whether this is related to a more 'natural' appearance or reduced ingredient list is yet to be understood.

To improve and promote liking for PBS, CBS and PFD, it is important to clarify the necessity of these products in supporting sustainable seafood and dairy consumption. Messages should communicate the benefits of consuming seafood sustainably (e.g., protecting fish-stocks, reducing by-catch) and consuming dairy sustainably (e.g., reducing GHG emissions, improving animal welfare). Advice should also be given as to how best to consume seafood sustainably (e.g., consuming a wider variety of fish, consuming in moderation, substituting with PBS/CBS) and dairy sustainably (e.g., consuming in moderation, substituting with PFD).

In addition, for PFD, it will be important to highlight the added benefits products can potentially provide over current dairy alternatives. For many participants, not being able to find dairy alternatives that tasted the same or performed the same way when cooking or baking acted as barriers towards acceptance. It also prevented many from reducing dairy intake in general. So, highlighting the potential sensory and functional benefits alongside positive environmental, ethical and welfare factors is key when marketing products.

Lastly, Figure 2.2 provides a summary of behavioural intervention strategies given as general suggestions and opportunities for encouraging sustainable food consumption and builds on previous literature using the COM-B model (Onwezen et al., 2022). Strategies within each domain should be combined, as simply providing information, or making products affordable is not enough (Abrahamse, 2020). Considering the suggestions are generalised, future research would benefit from providing actionable routes for individual bodies, such as the food industry and policy makers. For example, a previous study applying the COM-B model outlined separate proposed actions around meat reduction for consumers and external agents (Veiga et al., 2023).

2.8 Conclusion

Consumers are increasingly encouraged to follow sustainable food consumption habits for personal and planetary health, which includes moving away from animal derived products. Current and future protein alternatives have the potential to support dietary transitions, but their success largely depends on consumer perceptions. This exploratory study with young adults identified some sustainable consumption habits and perceptions, in that there was a general trend towards meat reduction, an awareness of the link between food and climate change and an optimistic view of new food technologies supporting future protein transitions. New-found self-sufficiency gained from moving away from home, alongside limited food budgets and the influence of others created changes in consumption, which signifies the importance of this transitional life stage on the formation of new behaviours. However, barriers related to quantifying the environmental impact of food, which led to uncertainty around how best to make sustainable food choices. This knowledge gap was especially apparent for dairy and seafood compared to meat. To some extent this was reflected in the acceptance of plant-based products, in which consumers had increased consumption of PBM, but had little experience or interest in trying PBS. There was also a greater level of awareness around the concept of CBM compared to CBS and PFD. Moving forward, quantitative data and longitudinal studies with larger more representative samples are needed to monitor the ongoing changes consumers make to their dietary habits and to further understand perceptions towards future protein alternatives. Based on these findings, the research suggests opportunities for intervention strategies aiming to encourage more sustainable food consumption habits amongst young meat-eaters. Importantly, this includes increasing public awareness around the environmental impact of food, especially for seafood and dairy. The research also outlines factors that should be considered when developing and launching current and future protein alternatives aimed at young meat-eaters. Notably, this includes prioritising affordability.

OPPORTUNITY

COM-B domain & Target Behaviour	Example intervention functions
Opportunity (*Social*) **Social role & identity:** ▪ Encourage more positive consumer trends around meat reduction and sustainable eating. ▪ Allow the influence of others to have a positive impact on meat-eating behaviour.	**Modelling** - Provide representatives for young people to look up to in terms of meat reduction/ sustainable eating (e.g., celebrities/ endorsers/ influencers). - Encourage group identity. **Enablement** - Increased choice of meat-free options in restaurants and protein alternatives in supermarkets to encourage social norm. - Availability of products which replicate meat in terms of cooking functionality and sensory appeal to increase acceptance in social settings (e.g., BBQ with a group of meat-eaters). **Environmental restructuring** - Re-locating meat-free items in the supermarket to be sold alongside conventional products to decrease market segregation. - Merging meat-free options on menus with meat options.
Opportunity (*physical*) **Skills:** ▪ Improve cooking skills for meat-free meals, unfamiliar cuts of meat/ species of fish. **Environmental context & resources:** ▪ Making the most of the point at which young consumers gain independence/ move away from home/ take control of the food shop. ▪ Allowing sustainable food choices to be the most affordable, easier option.	**Training/ Enablement** - Opportunity to learn new cooking skills either through school/ college/ university engagement. - Access to cooking classes demonstrating how to cook and compile sustainable meals either face-to-face and or via various platforms (TV, social media, podcasts). **Enablement/ Environmental restructuring** - Enable unpackaged fruit and vegetables to be cheaper than packaged equivalents. - Enable sustainable meat to be affordable and accessible. - Increasing availability and affordability of zero waste shops. - Increasing availability and advertisement of recycling services (e.g., soft plastic recycling). **Restriction** - Encouraging food industries and retailers to reduce unnecessary packaging. - Taxes on unsustainable farming methods.

MOTIVATION

COM-B domain & Target Behaviour	Example intervention functions
Motivation *(reflective)* **Beliefs about capabilities:** ▪ Challenge meat and dairy attachment. **Intentions:** ▪ Harness the motivation to reduce meat for sustainability reasons. **Beliefs about labelling:** ▪ Challenge negative perceptions regarding eco-labelling. **Optimism:** ▪ Encourage positive beliefs that individual changes can make a difference.	**Persuasion** - Using media and advertisement campaigns to communicate the benefits of following a sustainable diet, the ability for meat-free meals to be tasty, nutritious and filling. - Utilisation of health care professionals (i.e., nutritionists, dieticians, doctors) to relay information regarding the nutritional benefits of a sustainable reduced meat diet. **Incentivisation** - Discounts for young consumers/ points/ rewards for; zero waste shops, meat-free meals in restaurants, 'sustainable shopping baskets'. **Education:** - Media and advertisement campaigns around eco-labels. - Engagement from food retailers/ marketing to include eco-label information on pack or a QR code for consumers to access more information. **Coercion:** - Raise the cost for unsustainable products (e.g., red meat produced unsustainably).
Motivation *(automatic)* **Emotion:** ▪ Challenge negative emotions elicited by the concept of following sustainable consumption habits.	**Enablement:** - Provide support (e.g., meal ideas/ planners), access to information (e.g., how to follow a sustainable diet), to alleviate the negative emotions and provide re-assurance that even small changes make a difference.

CAPABILITY

COM-B domain & Target Behaviour	Example intervention functions
Capability (*Psychological)* **Knowledge:** ▪ Increase knowledge and understanding of how to eat sustainably. **Behavioural regulation:** ▪ Increase ability to create and stick to sustainable eating habits.	**<u>Education</u>** - Increase understanding regarding the environmental impact of different foods, especially fish. - Advice on how much meat, dairy and fish products should be consumed as part of a sustainable diet. - Increase understanding of alternative ingredients which can be used to replace animal protein whilst still allowing for a nutritionally balanced diet. **<u>Training</u>** - Early consumer engagement at schools, how to compose sustainable meals. Part of the food technology national curriculum. **<u>Enablement</u>** - Strong messaging from retailers at point of purchase (e.g., seasonal/ locally sourced). - Coherent and unified eco-labeling and accreditation schemes based on Life Cycle Assessment analysis with government legislative backing to encourage consumer confidence. - Apps allowing consumers to track foods carbon footprint/ plan meals/ create shopping lists. - Informative campaigns from food retailers on pack (e.g., meal ideas, seasonal recipes). - Community sustainable eating initiatives.
Capability (*physical*) **Memory & attention:** ▪ Ability to improve and remember cooking skills.	**<u>Training/ Enablement</u>** - Ability to learn and remember new cooking skills regarding meat-free meals, unfamiliar cuts of meat/ species of fish. - Chance to put new cooking skills into practice.

<u>Desired Behaviours</u>

- Reduced scepticism, confusion.
- Increased transparency, consumer trust.
- More informed food choices and self-confidence.
- Reduced and more conscious consumption of meat.
- Reduced food waste as a result of planning meals.
- Increased confidence to cook meat-free meals.
- Less guilt/ pressure associated with sustainable consumption.

Fig. 2.2. COM-B domain and target behaviour with example interventions following the BCW model components.

Chapter 3

Investigating the effect of sharing environmental information on consumer responses to conventional and hypothetical ‘precision fermented’ yoghurt.

Highlights:

- *Participants were willing to try yoghurt labelled as precision fermented dairy (PFD).*
- *Overall, yoghurt labelled as conventional dairy (CD) and PFD were equally liked.*
- *Sharing information increased liking for PFD yoghurt and evoked positive emotions.*
- *Information decreased liking for CD yoghurt and evoked a slightly guilty emotion.*

Investigating the effect of sharing environmental information on consumer responses to conventional and hypothetical ‘precision fermented’ yoghurt.

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Key words: *Precision fermented dairy, Consumer acceptance, Information, Liking, Emotional response, Yoghurts, Barriers, Nutrition Education.*

Abstract

Precision fermented dairy (PFD) is a novel technology used to produce milk proteins that can be used to replicate conventional dairy (CD) products. With PFD products likely to be available soon in the UK, this study aimed to explore consumer acceptance of these products. Specifically, the effect of sharing information related to the process and environmental impact of PFD on overall liking and emotional response for yoghurts labelled as CD and PFD. Overall, all participants (n=62) were willing to try the yoghurts labelled as PFD, and no significant difference in liking between yoghurts labelled as CD and PFD were found, indicating acceptance and trust. However, sharing information slightly increased liking for PFD yoghurt and evoked more positive emotions (‘*understanding*’, ‘*adventurous*’ and ‘*enthusiastic*’). In contrast, information decreased liking for CD yoghurt and had minimal impact on the emotional response, but made participants feel slightly ‘*guilty*’. In particular, sharing information led high food neophobic and food technology neophobic individuals to be more ‘*understanding*’ towards PFD in comparison to the low neophobic groups. Findings suggest emotional responses can provide deeper insights beyond liking which will benefit the food industry when reviewing consumer attitudes. The results show promise that consumers will accept PFD products when available provided the novel technology can mimic the sensory properties of CD. Furthermore, when marketing products, sharing information may increase liking for sustainable products but future studies would benefit from exploring the effect of different types of information on consumer acceptance.

3.1 Introduction

Dairy remains a key commodity in many consumers' diets, being a good source of calcium and Vitamin D. However, the consumption of dairy in EU diets is thought to contribute to as much as one-third of dietary Greenhouse Gas (GHG) emissions (Sandström et al., 2018). Therefore, there are concerns over how to produce dairy in a sustainable way whilst meeting the nutritional needs and supply demands of future generations. Plant-based milks made from a variety of ingredients such as oat, soy, almond and rice offer viable sustainable alternatives to conventional cow's milk being lower in GHG emissions with less land and water use (Poore and Nemecek, 2018). However, these plant-based alternatives are not always nutritionally adequate, being higher in cholesterol and lower in protein (Collard and McCormick, 2021). Furthermore, the sensory properties and functionality of plant-based milks are very different from each other and sometimes give undesirable sensory characteristics such as beany flavours (e.g., in soy milk) (Sethi et al., 2016).

One novel solution to produce dairy more sustainably, whilst addressing health needs and sensory appeal, comes from the development of dairy through a process called precision fermentation (also known as microbial fermentation). In its simplest terms, yeast cells are infused with cow DNA and processed in a bioreactor to produce milk which aims to have a similar composition and sensory profile to conventional dairy (CD) milk (Mouat and Prince, 2018). This novel food technology is thought to have the potential to be more sustainable in terms of lowering GHG emissions (Behm et al., 2022; Perfect Day, 2021) and improving production efficiency (Teng et al., 2021). Additionally, it has the possibility to modify the macro and micro nutrient content to reflect optimised nutrition and taste (Mendly-Zambo et al., 2021). UK-based companies currently developing precision fermented dairy (PFD) products include Remilk and Better Dairy, whilst a more established American based company (Perfect Day) launched a range of ice cream products made using PFD in 2019. It is therefore likely that the UK market will not have too long to wait before products become available. However, as products are manufactured using this emerging technology, the success of PFD very much depends on consumer acceptance (Lavilla and Gayán, 2018).

Understanding emotional responses to products can provide additional insights, beyond consumer acceptance e.g. better prediction of food choice (Low et al., 2022). For example, sharing the sustainability benefits of products has been shown to elicit positive emotions and less guilt for more sustainable food products (Yang et al., 2020a). Research has also found that the perceived benefits of a product, including environmental effects, and consumer's food technology neophobia to be highly influential in shaping attitudes towards precision fermentation technology (Banovic and Grunert, 2023). Therefore, exploring the effect of environmental information and individual differences in food technology neophobia on emotional responses, will provide a richer overview, beyond liking, of consumer acceptance towards PFD products.

The provision of information (e.g., product composition, origin of ingredients, societal, personal benefits, quality and taste) alongside sensory evaluation is likely to increase consumer acceptance (Bschaden et al., 2022; Grasso et al., 2022; Rolland et al., 2020). However, whether environmental information alone increases acceptance in the context of PFD is yet to be explored. A previous study reviewing the effect of different information treatments (animal welfare, environmental concerns, GMO, farmer existence) found the animal welfare and environmental concern narratives to have higher willingness scores for precision fermented cheese, although the influence on consumer acceptance was deemed to be relatively small (Kossman et al., 2023). Considering the potential for information and sensory appeal to shape consumer behaviour, sensorial studies are required for a deeper understanding of consumer acceptance and or rejection of PFD (Boukid et al., 2023).

A survey of British consumers found that 67.6% were willing to try precision fermented cheese (Zollman Thomas and Bryant, 2021), with only a minority willing to adopt if it was priced comparatively with conventional dairy cheese (Slade and Zollman Thomas, 2023). However, a qualitative study amongst young British meat-eaters found participants to have positive feelings towards this novel technology (Ford et al., 2023a). Specifically, participants believed PFD would be beneficial for the environment, and animal welfare, with the potential for optimised nutrition and curiosity around sensory appeal also acting as enablers (Ford et al., 2023a). In contrast, barriers are thought to relate to scepticism around it's affordability, sensory appeal, safety, naturalness, contribution to climate change and health (Broad et al., 2022; Ford et al., 2023a; Powell et al., 2023). Overall, sensory appeal has always been identified as a key motive, which links to repeated consumption/purchase (Ford et al., 2023a; Powell et al., 2023; Zollman Thomas and Bryant, 2021).

Due to products being unavailable on the market in most countries, previous studies have a lack of physical product exposure. Therefore, studies including PFD have either utilised focus groups (Broad et al., 2022; Ford et al., 2023a), questionnaire-based surveys (Banovic and Grunert, 2023; Crawshaw and Piazza, 2023; Kossmann et al., 2023; Slade and Zollman Thomas, 2023; Zollman Thomas and Bryant, 2021) or a mixture of quantitative and qualitative data (Powell et al., 2023). However, given the technology aims to replicate and produce a similar sensory profile to CD, one approach could be to use CD labelled as PFD. Therefore, this study aims to address the gaps in research by conducting a sensory evaluation to understand the following research questions:

1) Are UK participants willing to try PFD?

2) Assuming the sensory properties are similar between PFD and CD, what are the differences in liking and emotional response between the same yoghurt when it is labelled as PFD or CD?

3) How does sharing information (environmental impact, PFD process) impact liking and emotional response to PFD and CD?

4) How does food neophobia and food technology neophobia influence liking and emotional response to PFD and CD?

3.2 Materials and Methods

3.2.1 Participants

In total, 62 healthy adults (46F, 16M) living in the UK, aged 20 – 62 (M = 28), from mixed ethnic backgrounds were recruited using convenience sampling, with the minimum sample size (n=>40) achieved (Gacula & Rutenbeck, 2006). The majority of participants self-identified as omnivores (79%) (Table 3.1) and were predominantly from a university cohort. Participants gave written informed consent to take part in the study and received a disturbance allowance at the end of the study. To reduce bias, the participant information sheet explained that the study was interested in understanding consumer acceptance of food produced using novel technologies and/

or sustainably but did not explicitly mention PFD. Participants who smoked, were pregnant/ breastfeeding, had any food allergies, were lactose intolerant, or had any anosmia/ ageusia were screened out. This study was given a favourable opinion by the University of Nottingham School of Biosciences Ethics committee (approval code: SBREC202223022FEO).

Table 3.1: Subject characteristics, results presented as n (%).

Total (n=62)		Food Neophobia Group		Food Technology Neophobia Group	
		Low (n=32)	High (n=29)	Low (n=26)	High (n=35)
Gender					
Female	46 (74)	22 (48)	24 (52)	21 (46)	25 (54)
Male	16 (26)	10 (67)	5 (33)	5 (33)	10 (67)
Age					
20 – 29 years	47 (76)	24 (51)	23 (49)	17 (36)	30 (64)
30 – 62 years	15 (24)	8(57)	6 (43)	9 (64)	5 (36)
Ethnicity					
African Caribbean	2 (3)	0	2 (100)	1 (50)	1 (50)
Asian	11 (18)	2 (18)	9 (82)	5 (45)	6 (55)
Mixed	2 (3)	0	2 (100)	1 (50)	1 (50)
White	47 (76)	30 (65)	16 (35)	19 (41)	27 (59)
Dietary preference					
Omnivore	49 (79)	24 (50)	24 (50)	17 (35)	31 (65)
Flexitarian	7 (11)	4 (57)	3 (43)	4 (57)	3 (43)
Pescatarian	3 (5)	2 (67)	1 (33)	3 (100)	0
Vegetarian	3 (5)	2 (67)	1 (33)	2 (67)	1 (33)

Please note: for the FN & FTN one person did not complete the data so total n=61. Low FTN (score ≤45), high FTN (≥46), low FN (≤23) and high FN (≥24). The dietary preferences were classified as follows: Omnivore: I eat meat from animals, dairy products, seafood and fish, Flexitarian: I have a primarily vegetarian diet but occasionally eat meat, dairy, fish and seafood, Pescatarian: I do not eat meat from animals, but I do eat dairy products, seafood and fish, Vegetarian: I do not eat meat from animals, seafood and fish.

3.2.2 Products

A commercial dairy yoghurt (Activia strawberry yoghurt, no added sugar, 0% fat) was used during the tastings. This yoghurt was selected because it is reflective of one of the leading yoghurt brands commercially available in the UK, therefore very familiar to consumers, with strawberry being one of the most popular flavours around the world (Thompson et al., 2007). The yoghurt samples were prepared at the start of each day and stored in a refrigerator (3 ± 2 °C) prior to the sessions. As PFD is not yet commercially available in the UK, the same CD yoghurt was used but labelled according to the experimental condition (PFD or CD). To conceal the brand and to ensure consistency, after thoroughly stirring the yoghurt, two tablespoons (~ 30g) were decanted into clear and odour-free plastic pots and labelled with a three-digit randomised code (See Appendix, Fig. S3.1).

3.2.3 Overall liking and emotional response

Overall liking (OL) was rated on a labelled affective magnitude scale (LAM) (Schutz and Cardello, 2001). Emotional response was captured using the EsSense25 questionnaire (King and Meiselman, 2010; Nestrud et al., 2016) through Check-all-that-apply (CATA). These emotions can be characterised into 16 positives (*active, adventurous, calm, enthusiastic, free, good, good-natured, happy, interested, joyful, loving, nostalgic, pleasant, satisfied, secure and warm*), 3 negatives (*bored, disgusted* and *worried*) and 6 unclassified (*aggressive, guilty, mild, tame, understanding* and *wild*) emotions (King and Meiselman, 2010). Subjects were asked to select all emotions that were elicited when consuming the samples and could choose to not select any emotions if they did not apply. Emotional terms were presented in a random order across participants, but the order was kept the same for each subject (King et al., 2013).

3.2.4 Food technology and food neophobia status

Participants completed the food technology neophobia (FTN) scale consisting of thirteen statements (Cox and Evans, 2008) and the food neophobia (FN) scale consisting of ten statements (Pliner and Hobden, 1992). All statements were measured using a 7-point Likert scale ranging from '*strongly disagree'* to '*strongly agree'* (Appendix, Tables S3.1 & S3.2). To avoid priming, participant responses were captured prior to the tastings to obtain any fears or concerns participants may have about novel food technology. For both questionnaires, the scores for each statement were summed with consumers segmented based on the group median score following a previous study (Yang et al., 2020a). The following groups were classified; low FTN (score ≤45), high FTN (≥46), low FN (≤23) and high FN (≥24) (Table 3.1).

3.2.5 Experimental design

Participants attended two tasting sessions at the University of Nottingham's Sensory Science Centre. A summary of the session procedures is detailed in Figure 3.1. Data was collected using Compusense Cloud (Compusense, Canada). Appropriate palate cleansers of water (Harrogate, England) and crackers (Matzo crackers, England) were provided during the one-minute break between samples. The data was collected across two separate sessions, as it was part of a larger project studying individual differences in taste preferences, personality and sustainable food attitudes.

In Session 1, participants were familiarised with the LAM scale and tasted the yoghurt labelled as CD with no other information provided (CD-Control). When tasting the yoghurt, participants were asked to taste two consistent teaspoons of yoghurt for rating emotional response, as there are 25 emotions to be evaluated, and one further teaspoon to rate OL.

In Session 2, participants were first provided with definitions for CD and PFD (Appendix, Table S3.3). Next, participants were asked if they were willing to try the yoghurt labelled as PFD (yes/no). If participants were willing, they tasted the PFD labelled yoghurt (PFD-Control) using the same protocol as in Session 1. If participants were not willing, they were shown an image instead (Appendix, Fig. S3.1) and asked to imagine eating the sample before rating their expected OL and emotional responses.

Next, to access the impact sharing environmental information had on the perception of the yoghurt, participants were shown a short (5 minute) video as a group. Given the broad nature of sustainability within the food industry, the video focused on the GHG emissions of a range of food categories (meat, dairy, veg) based on Life Cycle Assessment analysis. It also included a comparison of the estimated climate impact of PFD compared to CD. See the supplementary material for a more detailed breakdown of the video content. After watching the video, participants were asked again if they were willing to try PFD (yes/no). Similar to the Control condition, participants then tasted (or viewed images) of the yoghurt labelled as CD (CD-information sharing) and PFD (PFD-information sharing) in a randomised, balanced order, before rating emotional responses and OL. At the end of Session 2, participants were informed that none of the samples were PFD for ethical considerations and transparency. In summary, only a definition was provided during the control condition, whilst the information sharing condition related to both definition and sharing information through video.

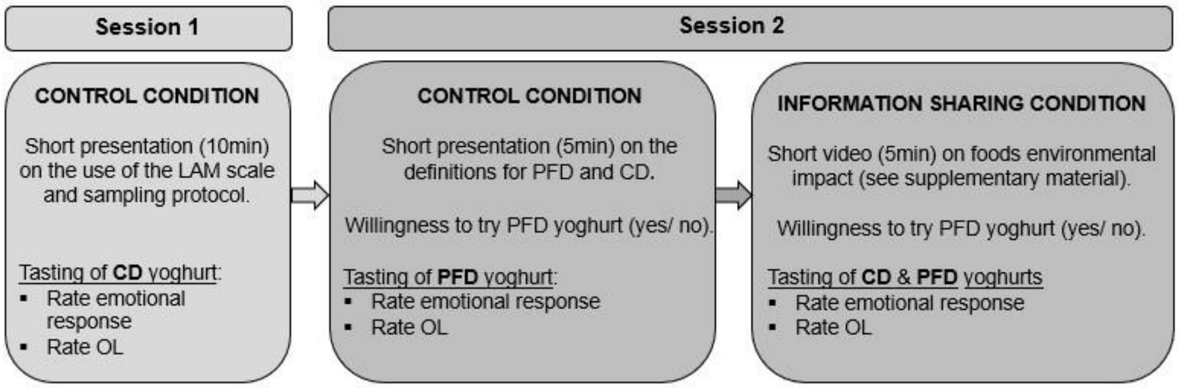

Fig 3.1 Flowchart of the study design procedure across the sessions. Please note that the session 1 CD yoghurt and the first part of session 2 PFD yoghurt relate to the control condition (definition only).

3.3 Data Analysis

Data was analysed using XLSTAT (Addinsoft, 2023) with a 5% significance level. Analysis of Variance (ANOVA) was carried out to examine differences in overall liking between the two yoghurts (CD, PFD). To understand significant changes in liking, post-hoc analysis was carried out using two-tailed paired sample t-tests on the two conditions (Control, Information sharing) for the two products (CD and PFD). Additional analyses were carried out across consumer segments (high neophobic, low neophobic) for both the FTN and FN groups. To understand how large the standardised mean differences were, effect size using Cohen's d_z was calculated and interpreted based on the following benchmarks; small (d= 0.2), medium (d= 0.5), and large (d= 0.8) (Lakens, 2013).

Contingency tables were used to tabulate the emotional response frequencies of the CATA data. To understand relationships between the products and emotional responses, correspondence analysis (CA) was conducted, and Cochran's Q test (with the Sheskin, 2011) procedure for multiple pairwise comparisons) was performed on each of the emotional terms to understand significant differences (5% level).

3.4 Results

3.4.1 Consumer willingness to try and acceptability of PFD.

All participants (n=62) were willing and consented to trying the PFD yoghurt in both conditions (control and information sharing), which indicates high acceptability, curiosity and trust in this novel technology. In addition, PFD yoghurts were liked moderately (M=71.62), which is not significantly different from CD (M=73.05) (p= 0.24).

3.4.2 Comparing the impact of information on the liking of yoghurts labelled as 'conventional dairy' and 'precision fermented dairy'.

When participants were given additional information through the video (environmental impact, PFD process), their liking for CD yoghurt decreased significantly (t (61) = 2.60, p= 0.031, d= 0.28), whereas PFD yoghurt's liking increased slightly (t (61) = -1.585, p= 0.085, d= -0.22) (Fig. 3.2). The trends observed indicate sharing this type of information impacts consumer acceptance slightly with a small effect size present (Lakens, 2013). See Appendix Fig. S3.2 for the mean change in overall liking.

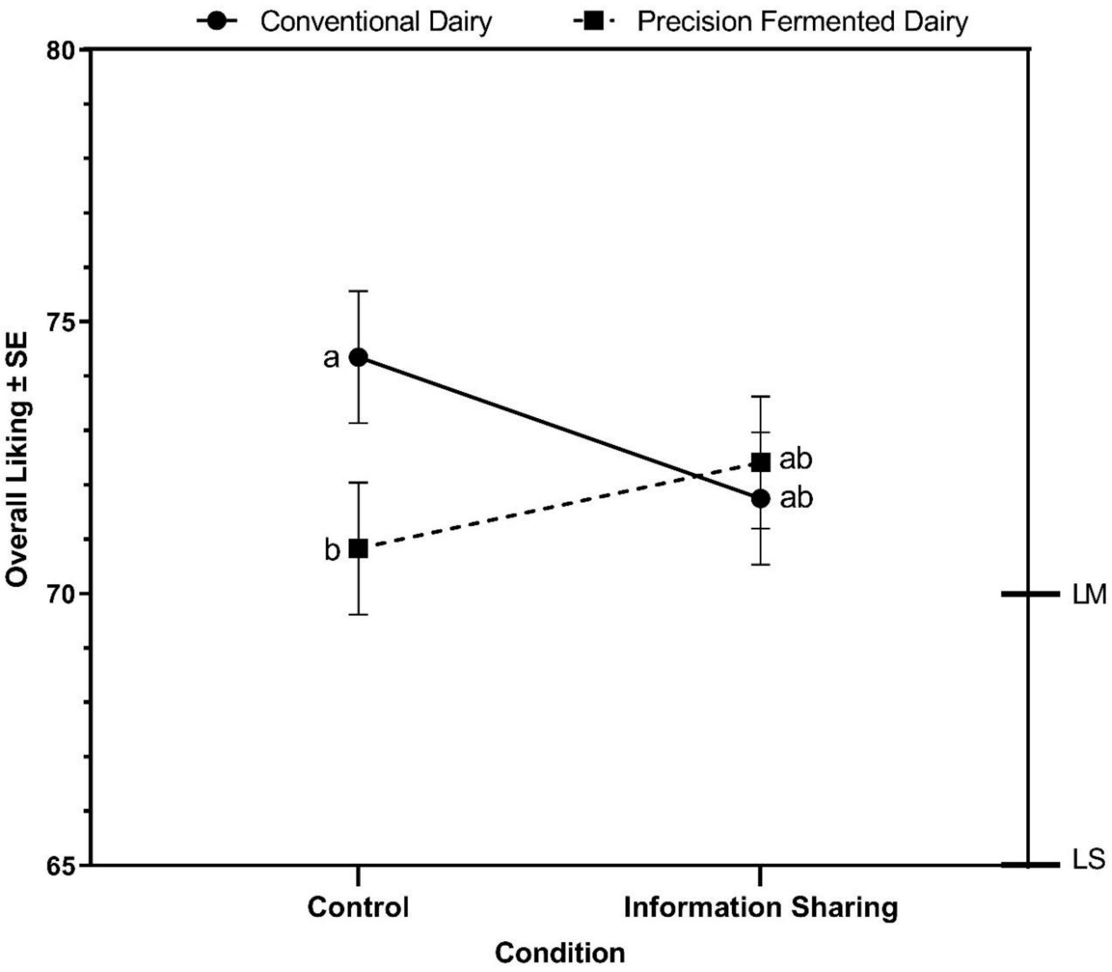

Fig. 3.2. Mean overall Liking ± SE for the conventional dairy and precision fermented dairy yoghurt in the control (definition only) and information sharing (definition and video) conditions. LS – Like Slightly, LM – Like Moderately. Different letters denote significant difference (p≤0.05) based on Tukey Honest Significant Difference (HSD) multiple comparisons test.

3.4.3 Comparing the impact of information on the emotional responses of yoghurts labelled as ‘conventional dairy’ and ‘precision fermented dairy’.

The CATA data relating to the twenty-five emotional terms were evaluated using Correspondence Analysis (CA), as presented in Figure 3. The biplot explained 87.94% of the variance, with the first dimension (F1) accounting for 63.29% and the second dimension (F2) accounting for 24.65%. F1 captured the majority of the variance, with emotions ranging from positive (*nostalgic*) to negative (*disgusted*), whilst F2 represents ‘*worried*’ to ‘*guilty*’.

The results of the Cochran’s Q test for each emotion, revealed significant differences ($p<0.05$) in frequencies among the four samples for five positive emotions (*adventurous*, *enthusiastic*, *free*, *interested* and n*ostalgic*) and one unclassified emotion (*understanding*). There were no significant differences for the negative emotions and the term ‘*aggressive*’ was not selected by any participant (Appendix, Table S3.4). In general, for each product, *‘pleasant’* and *‘good’* were the most frequently cited terms[7] (~72% and ~68%). The high frequency scores across products suggests an equally positive outlook.

The pooled data for the CD yoghurts was closely associated with positive terms and had higher citation frequency scores for the term ‘*nostalgic*’ (~36%) compared to the PFD yoghurts (~16%). This suggests participants feel comfortable and familiar with the sensory characteristics of CD yoghurts. In contrast, the PFD yoghurts had significantly higher ($p<0.0001$) frequency counts for the emotional terms, ‘*adventurous*’ and ‘*interested*’ (27.4%, 59.7%) compared to the CD yoghurts (~3.2% and ~23.4%).

As shown in Fig. 3.3, after sharing the information (environmental impact, PFD process), PFD yoghurt was associated with ‘*adventurous’* ($p<0.0001$), ‘*enthusiastic’* ($p= 0.025$), ‘*free’* ($p= 0.008$) and *‘understanding’* ($p<0.0001$) significantly more compared to the Control condition. The data suggests that sharing information has evoked more positive emotions, helped to educate participants about PFD and made them feel more understanding, adventurous and enthusiastic about the product. Therefore, sharing information has a much higher effect for PFD yoghurt (i.e., a more

[7] Frequently citied terms are calculated by the sum of the citation frequencies (%) for that emotional term, divided by the number of product categories (four).

sustainable product) compared to CD yoghurts. In contrast, for the CD yoghurts, sharing information had minimal impact on emotions, only making participants feel slightly '*guilty*' (p= 0.063). However, the changes in emotional responses are consistent with the small but potentially important differences observed for liking which further justifies the decision to interpret these changes as significant, despite being marginal.

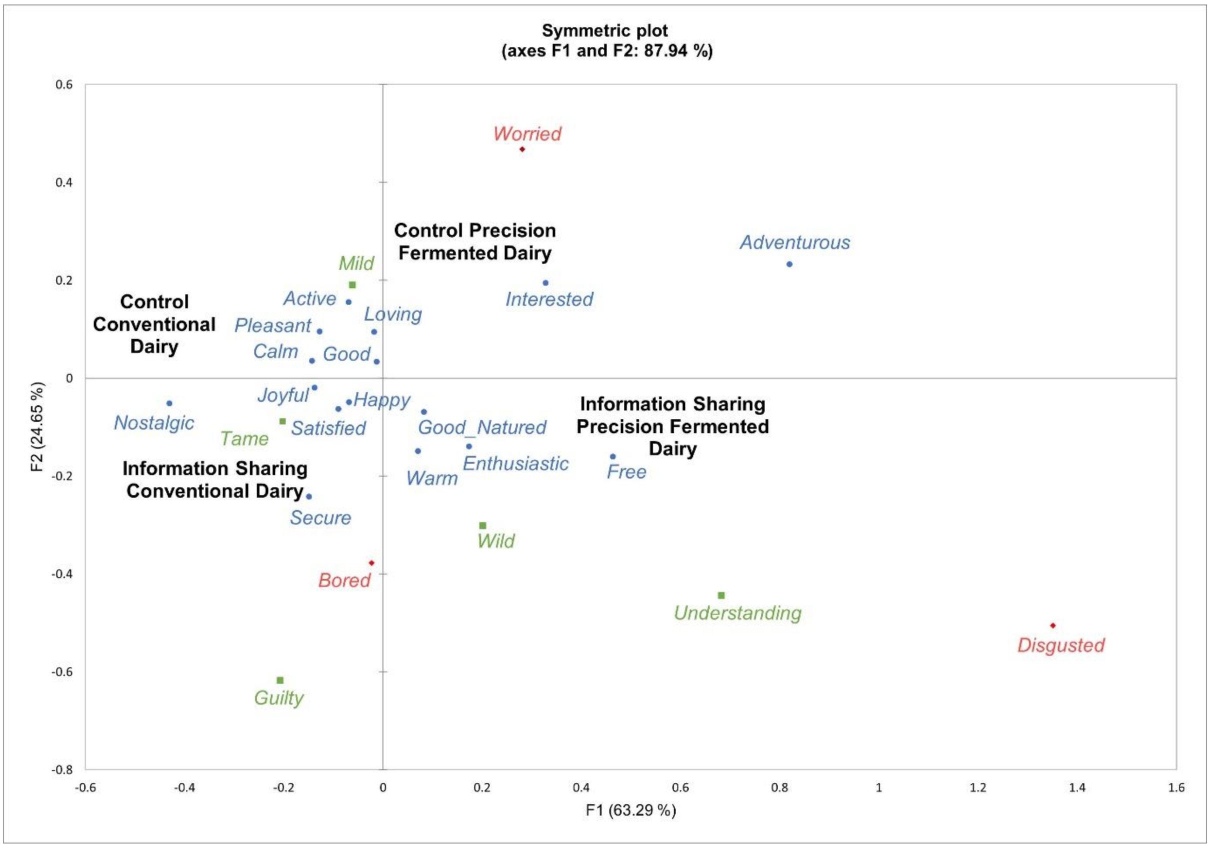

Fig. 3.3. Correspondence analysis biplot of the frequency of use of the CATA emotional terms for the evaluation of two yoghurts (CD and PFD) under two conditions (control and information sharing). Please note the products are in bold and the emotional terms are in italics with red (diamond)= negative words, blue (circle)= positive words and green (square) = unclassified

3.4.4 Comparing the impact of information on liking within the FN and FTN groups

Chi-square analysis found no associations between FN and FTN groups (p>0.05), although some overlaps between the neophobic groups were present, with some participants considered high in both FN and FTN (n=14, 23%), others low in both FN and FTN (n=12, 20%) but the majority were mixed (i.e., high in one category and low in the other) (n=34, 56%). Overall, there was no significant difference in liking between the two yoghurts (CD, PFD) for both the high and low FN and FTN groups ($p>0.05$) respectively. Therefore, results indicate neophobia has little influence on OL. After the information was shared, both the FN and FTN groups showed a decrease in OL for CD yoghurt and a slight increase in OL for the PFD yoghurt (Appendix, Figs. S3a-3d). The greatest mean decrease for the CD yoghurt was observed amongst the low FN group (Fig. S3.3a. M= 4.34) which was significant (p= 0.01, d= 0.48), whilst the greatest mean increase for the PFD yoghurt was observed amongst the high FN group (Fig, S3.3b. M= 2.54).

3.4.5 Comparing the impact of information on emotional response between FN and FTN groups.

Reviewing the six significant emotions (*adventurous*, *enthusiastic*, *free*, *interested*, *nostalgic* and *understanding*) among the high and low FN and FTN groups provided further insights (Appendix, Table S3.5). Results suggest, sharing information (environmental impact, PFD process) elicits different emotions dependent on the level (low, high) and type of neophobia (FN, FTN). For example, participants with high FN and FTN had a greater increase in citation frequency scores for the emotional term '*understanding*' (34.5% and 41.9%) between the control and information sharing PFD conditions compared to low FN and FTN participants (28.1% and 20.0%). Overall, the increase in citation frequencies was greatest for the high FTN and FN groups, suggesting sharing information has more of an effect on highly neophobic individuals (Fig. 3.4). Potentially, these groups are likely to be more open to changing their behaviour as a consequence of interventions using information sharing.

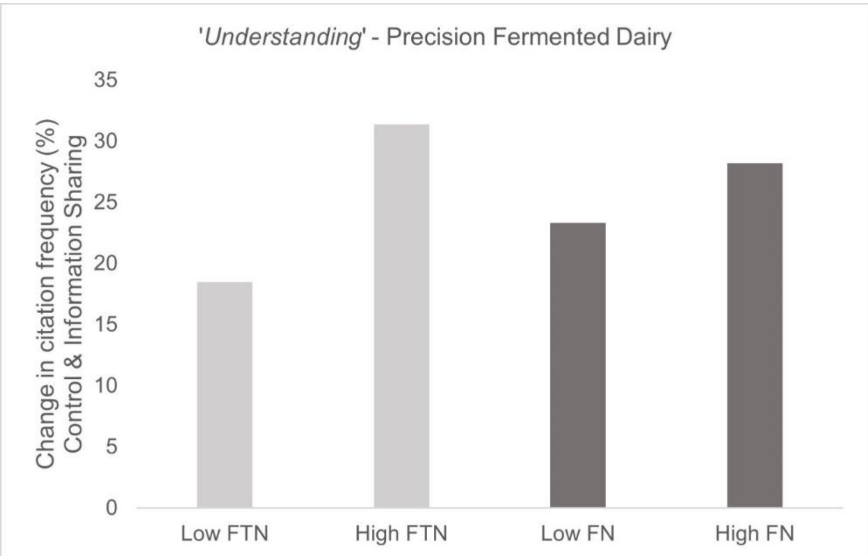

Fig. 3.4. Change in citation frequency (%) between high and low FN and FTN groups for the emotional term '*Understanding*' before and after information for the PFD yoghurt.

3.5 Discussion and considerations

All participants were willing to try the PFD yoghurt which supports findings from previous studies where consumers had a positive outlook towards this novel technology (Ford et al., 2023a; Kossmann et al., 2023). It also signifies an increase in acceptance compared to a previous survey among British consumers, where only an estimated two-thirds were willing to try precision fermented cheese (Zollman Thomas and Bryant, 2021). The higher acceptance observed in this study could relate to participant curiosity towards the taste of the product which is a key driver (Ford et al., 2023a). It could also relate to differing cohorts, as the majority of participants in our study were young and female which is a demographic associated with a greater willingness to try protein alternatives (Ford et al., 2023b). The past few years have also seen a boom in protein alternatives, which may have increased consumer awareness of the need for more sustainable products and/ or normalised novel alternatives.

Additional factors likely to influence acceptance include the product type, for example, yoghurt may be more accepted in the context of PFD compared to cheese. As yoghurt undergoes a fermentation process the method used for PFD may have seemed familiar, necessary and not risky. This may explain the little influence neophobia had on OL for the PFD yoghurt despite the mean average for FN being higher than other studies (Rabadán and Bernabéu, 2021). Previous research has found some consumers to be sceptical around the sensory appeal of PFD products (Ford et al., 2023a), so any fears may have subsided once a familiar product was tasted. Indeed, familiarity is known to reduce neophobia (Pliner and Hobden, 1992). Furthermore, a study reviewing PFD cheese found consumers perceived it as being equally safe compared to CD cheese, which arguably strengthens consumer trust and decreases neophobia (Zollman Thomas and Bryant, 2021). In contrast, it has been widely found that neophobia has a negative influence on the acceptance of cultured meat (Bryant et al., 2019; Hwang et al., 2020; Wilks et al., 2019). Therefore, it could be suggested that there will be fewer challenges regarding consumer acceptance towards PFD compared to some other novel technologies.

In general, participants moderately liked PFD yoghurts, which is similar in liking score with CD yoghurt. Therefore, results show promise that consumers will accept PFD products when available, provided the assumption that the precision fermented technology can mimic the sensory properties of CD. Following the provision of information (environmental impact, PFD process), the slight increase in liking and the positive emotions elicited for the PFD yoghurts compared to the decreased liking and somewhat '*guilty*' emotion for the CD yoghurts aligns with a previous study (Yang et al., 2020a). Furthermore, the additional insights gleaned from measuring emotional response agrees with prior suggestions that it is a more discriminatory method compared to liking (Yang et al., 2018). Additional studies have also found an increase in acceptance for sustainable products when information related to product composition was shared alongside a tasting (Bschaden et al., 2022; Grasso et al., 2022). In the context of cultured meat, information relating to personal benefits, meat quality and taste increased acceptance more than societal/ environmental benefits (Rolland et al., 2020). Findings therefore suggest that the content of the information shared is also important, and in the case of PFD, alternative information may further increase acceptance.

In terms of the format and type of information shared, for ethical reasons, a definition of PFD was provided which focused on the production method (Appendix, Table S3). Considering the effect of framing when describing novel technologies, this may have influenced OL scores. For example, research has found, focusing on the technological nature of cultured meat creates more negative consumer attitudes (Bryant and Dillard, 2019). By contrast, comparing cultured meat to conventional meat and focusing on the sensory appeal creates more positive consumer attitudes such as more natural, tasteful and familiar (Fidder and Graça, 2023). In the context of precision fermentation technology, research has found using claims that are framed as 'natural' or 'naturally' enhances consumer attitudes, especially when they align with the beliefs of the consumer (Banovic and Grunert, 2023). In addition, the name used can also influence consumer acceptance as shown in a study comparing the terms 'animal free meat', 'cultured meat' and 'lab grown meat' (Bryant and Barnett, 2019). Therefore, future study designs should consider how the novel technology is described and the name used. Currently, an alternative name used to describe and market products is 'animal-free' dairy (Broad et al., 2022; Kossmann et al., 2023; Slade and Zollman Thomas, 2023). The use of the word 'precision' in this study may therefore have elicited different connotations which further highlights the importance of semantics.

In contrast, during the information sharing condition, the explanation provided around the process of making PFD to some extent mirrored the definition provided during the control condition (See video - supplementary material). Therefore, the level of information on this topic between conditions may not have changed much. Additionally, the video also contained information pertaining to the predicted environmental benefits of PFD, with the narration; '*Life cycle assessment analysis comparing conventional dairy production with large-scale precision fermented dairy, estimated a reduction in GHG emissions by 35-65%*' (Mendly-Zambo, Powell, and Newman 2021). As sustainability is a multifaceted subject, alternative product factors may resonate more with consumers e.g., animal welfare, health benefits. Current literature highlights the significance of animal welfare in driving consumer acceptance for PFD (Ford et al., 2023a, Powell et al., 2023). Therefore, future studies would benefit from extending these findings to understand which type of information causes the greatest increase in OL for PFD. For example, messaging could pertain to improved food safety, being lactose free, having a similar functionality to dairy and reduced reliance on animals.

In relation to PFD cheese, previous research found different information treatments (animal welfare, environmental concerns, GMO, farmer existence) to have no significant influence on consumers' acceptance (Kossmann et al., 2023). Reasons for the lack of overall influence could relate to the fact that the study did not include a sensory tasting and was amongst German consumers who had a lower willingness to try compared to previous studies. Considering the importance of sensory appeal in driving acceptance for PFD amongst UK consumers (Ford et al., 2023a), future studies should review the influence of different types of information in a tasting context. It could be that certain PFD products exhibit greater barriers with regards to gaining consumer acceptance. For example, conventional cheese can exhibit a variety of flavour profiles, often influenced by the animals diet, therefore PFD cheese may face greater scepticism especially around sensory expectations compared to other PFD products.

In situations where information is lacking, to some extent consumer expectations and trust in products and food manufacturers becomes magnified. A recent study found lower levels of trust in relation to precision fermentation technology to be associated with higher levels of food technology neophobia (Banovic and Grunert, 2023). Therefore, sharing information should increase trust and reduce neophobia, especially considering neophobic individuals shifted their responses based on the information shared. As the emotional term '*understanding*' increased significantly in citation frequency amongst the high FTN and FN groups after sharing information (environmental benefits, PFD process), it supports the notion that these groups are particularly more susceptible to information. However, it is thought that although sharing information about the benefits of precision fermentation can improve consumer acceptance for this novel technology, it does not mitigate the effects of high technology neophobia (Banovic and Grunert, 2023). Instead, the suggestion is to encourage consumers not to categorise it as a new technology.

3.6 Limitations and future directions

A notable limitation relates to the small and predominantly female sample size. This is especially apparent when comparing the neophobia groups, therefore caution should be taken when drawing conclusions. However, including effect size within our calculations means that future studies will be able to estimate population sizes which will need to be larger in order to validate the findings. In relation to other novel technologies, such as cultured meat, previous research has found consumer willingness to try differs dependent on nationality, age and gender (Ford et al., 2023b) as well as dietary preference and level of FTN (Krings et al., 2022). In addition, males and older participants have been found to have higher levels of FN (Siegrist et al., 2013). Future studies should therefore explore how different socio-demographic and socio-cultural factors influence consumer acceptance towards a range of PFD products, with a more nationally representative sample. In addition, attention should also be given to the segmentation tactics applied to group consumers based on FN and FTN scores which varies across studies. Although there are many ways to segment consumers based on FN scores (Choe and Cho, 2011), the following popular segmentation method has been previously applied and deemed appropriate to allow for comparisons to be made (Yang et al., 2020a). However, it should be noted that using the median score may result in the neophobic groups not actually being neophobic. Future research would benefit from a more standardised approach to allow for comparisons to be made across the literature (Rabadán and Bernabéu, 2021). In particular, the use of two groups (low vs high) for FN and FTN may mask differences that could be captured by more groups (i.e., low, standard, high).

Another limitation relates to PFD yoghurt not being commercially available. Consequently, the results were based on the hypothetical assumption that CD and PFD will deliver similar sensory experiences. The yoghurts would therefore have remained the same in physical appearance and taste during evaluation. Although this has its benefits, in that it controls for the influence of sensory differences, assessing actual PFD products in future studies will provide a more accurate assessment of OL and emotional response. It will also provide clarity regarding the influence of neophobia on OL for PFD products.

Lastly, all participants consented to trying the PFD yoghurt, which meant it was not possible to determine the effect the video information may have had on changing non-consenters minds. The high consent could have been due to current knowledge regarding precision fermented dairy, which was not captured, but should be a consideration in future studies. Another point worth considering is the level of trust the participants placed in the researchers which may have led people to feel more confident in trying the product. It is also worth noting that the changes in consumer liking were observed over a short period of time and repeated exposure to the video could lead to incremental shifts in liking. Current longitudinal studies show sustainable food behaviours, such as eating less meat, increased overtime but general knowledge, especially around foods environmental footprints did not (Siegrist et al., 2015). Additionally, a more recent longitudinal survey found exposure to information about animal farming to be associated with changes to animal product consumption, although the predictive ability was low for the period of one year (Bryant et al., 2023). Therefore, longitudinal studies that capture whether sustainable behavioural changes are made and maintained (i.e., the adoption of PFD) over the period of a few years in response to specific information interventions (i.e., the environmental impact of PFD vs CD) will provide valuable insights.

3.7. Conclusion

To the best of our knowledge, this is the first study to investigate the influence of sharing information (environmental impact, PFD process) on consumer acceptance towards yoghurts labelled as PFD and CD. In general, the yoghurts were equally liked, however CD yoghurt was associated with the term ‘*nostalgic*’ compared to ‘*adventurous*’ and ‘*interested*’ for the PFD yoghurt. Providing information increased consumer liking slightly for the PFD yoghurt and evoked more positive emotions with participants feeling more '*understanding*', '*adventurous*' and '*enthusiastic*'. In contrast, sharing information had minimal impact on CD yoghurt with participants indicating a slightly '*guilty*' emotion. Results therefore indicate a positive trend between sharing information and increasing acceptance whilst highlighting the importance of measuring emotional response for gaining a deeper insight beyond OL. All the participants were willing to try the PFD yoghurt, regardless of their level of FN and FTN. Findings therefore suggest high acceptance and trust with the potential for fewer barriers towards consumer acceptance compared to other novel food technologies (e.g., cell-based meat). Additionally, sharing information had varying effects on emotional responses in groups with different levels of neophobia, with high FTN and FN individuals more *'understanding'* towards PFD after information. Overall, these preliminary results offer insights that will aid the design of future research exploring sensory appeal and acceptance of PFD products in a larger sample size. Currently, the results provide support for high consumer acceptance of PFD, which could contribute to a more sustainable food future.

Chapter 4

Applying regression tree analysis to explore willingness to reduce meat and adopt protein alternatives among Australia, China and the UK

Highlights:

- *Regression Tree analysis found country to be the most influential factor.*
- *Australia was the least willing to reduce meat, especially 35-55 years-olds.*
- *In contrast, UK females and Chinese males were the most willing to reduce meat.*
- *Willingness to adopt protein alternative categories differed between countries.*

Applying regression tree analysis to explore willingness to reduce meat and adopt protein alternatives among Australia, China and the UK

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Abstract

The increasing global demand for meat causes additional environmental and food security issues. Adoption of a healthy and sustainable diet through the reduction of meat consumption may represent one approach to tackle these problems. An online survey collected responses from meat-eaters in Australia (n=503), China (n=785) and the UK (n=489) to review the importance of considering cross-cultural and demographic differences when investigating meat-eating behaviour. The aim of this study was to understand meat consumption habits and the associations between consumers' willingness to reduce meat/ adopt protein alternatives (meat substitutes, edible insects, cultured meat), with the influence of age, gender and country. To aid interpretation and explore interrelationships between variables, regression tree analysis using the CHAID algorithm was used. Results found country to be the most influential factor in predicting changes to meat consumption and willingness to reduce meat/adopt alternatives. Overall, Australians, especially those aged 35-54, were significantly less willing to reduce and adopt alternatives compared to Chinese and UK consumers. Interestingly, Chinese males were more willing to reduce meat and adopt alternatives, whilst the opposite trend was found in the UK. Findings highlight the importance of considering cultural differences, age and gender when designing country specific meat reduction strategies. It also emphasises the need to introduce appropriate protein alternative categories that will help facilitate a dietary transition in a given country. Overall, regression tree analysis has proven to be a useful stats tool to help explain complex interrelationships (e.g., meat consumption with other psychographic behaviours) in the current study.

4.1 Introduction

Feeding the world in a more sustainable way is one of the biggest global challenges. The food system accounts for up to 37% of global anthropogenic greenhouse gas (GHG) emissions, with meat and dairy contributing to more than half of this percentage (Xu et al., 2021). Yet, global meat production is predicted to double by 2050 (FAO, 2019), partly in response to the growing population which is estimated to increase to around 11 billion by the end of the twenty first century (UN, 2021). Subsequently, this raises concerns for food security and further environmental degradation, such as high agricultural land and water use, deforestation, soil pollution, GHG emissions and biodiversity loss (IPCC, 2019).

To meet the United Nations (UN) sustainable development goals, which aim to keep global warming well below 2°C (aiming for 1.5°C), there is an urgent need to encourage consumers to practice more sustainable behaviours for personal and planetary health. As consumers' daily food choices have a significant impact on overall sustainable consumption, one solution to mitigate GHG emissions comes from the implementation of dietary behavioural change measures (UNEP CCAC, 2021). Consequently, several studies have identified the benefits of shifting towards more sustainable 'planetary' based diets which specifically reflect a reduction in red meat (Clark et al., 2019; Clark & Tilman, 2017; Rogelj, 2019; Rosenzweig et al., 2020; Springmann et al., 2018; Willett et al., 2019).

4.1.1 Cultural differences in meat consumption

Given the global need to reduce meat intake for sustainability reasons and considering meat consumption habits vary hugely across different countries, it is important to account for cultural differences and the subsequent influences on consumption habits (Jeong & Lee, 2021). Australia, China and the UK represent different meat consumption habits, with Australia having one of the highest per capita meat consumption rates in the world. Current estimates report 115Kg/year, comparatively higher than the UK (78Kg/year) and China (63Kg/year) (FAO, 2022). Although meat consumption in China is lower, the per capita meat consumption in China has grown substantially since 1961 (+60Kg), whereas meat consumption in Australia and the UK have been relatively stable, but unsustainably high over the past decades (Fig. 4.1).

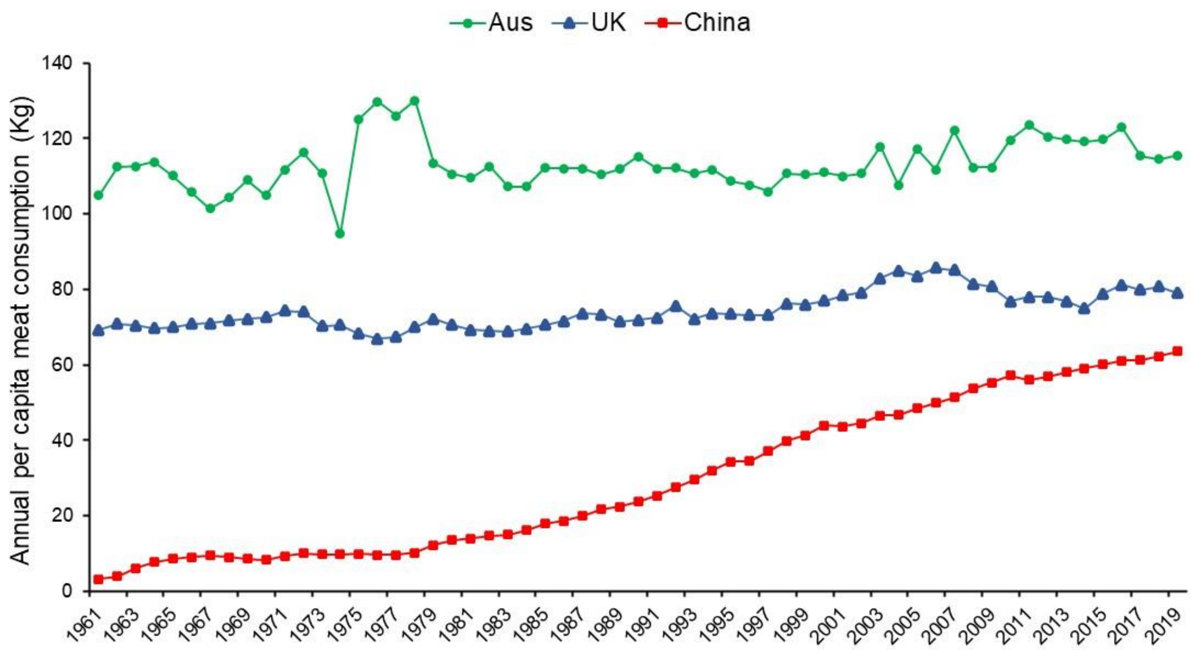

Fig. 4.1. Meat consumption: Kg per person per year by country (Australia, UK, China) from 1961-2019: Source: United Nations Food and Agricultural Organisation (FAO, 2022). Please note: Data excludes fish and other seafood sources.

Understanding meat-eating behaviour is highly complex, determined by a combination of socio-demographic and external factors, alongside socio-cultural differences. (Stoll-Kleemann & Schmidt, 2017). In the UK, millennials consistently consumed greater quantities of meat compared to other age groups (Stewart et al., 2021), whilst in Australia and China men consumed significantly more meat than women (Sui et al., 2017; Wang et al., 2022). In terms of willingness to reduce meat, gender is thought to be more influential compared to age (Hartmann & Siegrist, 2017). For example, research amongst consumers in Europe, Australia and the USA have found males to be less willing to reduce meat compared to females (Malek et al., 2019b; Neff et al., 2018; Prattala et al., 2007; Siegrist et al., 2015).

Although studies have been conducted in relation to consumers' willingness/ intention to reduce meat consumption in Australia (Cheah et al., 2020; Malek et al., 2019a, 2019b), China (Taufik, 2018) and the UK (Macdiarmid et al., 2016; Mylan, 2018), there is a lack of cross-cultural comparisons on this topic. Furthermore, there is still a limited understanding of the moderating role of gender and age on meat-eating behaviour (Kwasny et al., 2022).

To date, distinguishing between different meat-types has deepened our understanding of consumer segments (Malek et al., 2019b) and highlighted relationships with gender (Rosenfeld & Tomiyama, 2021). Consequently, it is important to consider the influence of socio-demographic factors alongside meat types, to provide insights on how best to implement and tailor country-to-country meat reduction strategies.

4.1.2 The role of protein alternatives

Another solution to reducing meat consumption relates to the substitution of animal protein with protein alternatives, which are thought to provide viable opportunities for consumers to adopt a more sustainable diet (Bonny et al., 2017). Specifically, this study focused on a mixture of protein alternatives, from the familiar meat substitutes (i.e., predominantly plant-based foods used to replace the role of meat), to the more novel edible insects, and cultured meat. The success of these protein alternatives largely depends on consumer acceptance and willingness to adopt products into current or future diets. Previous cross-cultural studies have compared plant-based meat substitutes, cultured meat and edible insects in the same study and included the UK amongst other countries; Spain, Brazil, Dominican Republic, Netherlands, Poland and Finland (Gómez-Luciano et al., 2019; Grasso et al., 2019). However, the focus was either on older consumers or willingness to purchase rather than willingness to adopt. Additional cross-cultural studies including either Australia, China or the UK amongst other countries have focused just on one protein alternative (Bekker et al., 2017; Bryant et al., 2019; Gasteratos & Sherman, 2018; Hartmann et al., 2015; Hoek et al., 2011; Lensvelt & Steenbekkers, 2014; Siegrist & Hartmann, 2020; Verbeke et al., 2015). Additionally, the role of gender and age on consumer acceptance of protein alternatives has evidently provided mixed results (Onwezen et al., 2021). Therefore, further cross-cultural research comparing meat reduction alongside willingness to adopt protein alternatives in countries with differing meat consumption habits is required to provide further clarity.

Quantitative research methods, particularly online surveys, offer an efficient way to measure and provide insights, albeit self-reported, from a large pool of consumers. Existing cross-cultural surveys related to this topic have mainly employed Analysis of Variance (ANOVA) to review variation between and within countries (Bryant et al., 2019; Gómez-Luciano et al., 2019; Hartmann et al., 2015). However, ANOVA ideally requires data to have normal distribution and homogeneity of variance, which is often difficult to obtain when reviewing cross-cultural survey data of convenience sample. Furthermore, it's challenging for ANOVA to demonstrate complex factor interactions. Therefore, an appropriate statistical technique that manages unstructured data and interactions between variables, whilst providing an easily interpretable output needs to be explored.

4.1.3 Regression Trees with CHAID

Regression Trees are a form of decision tree and are a popular statistical machine learning method that construct prediction models from data (Loh, 2011; Breiman et al., 1984). Regression trees are frequently applied within the fields of health care and medicine (Podgorelec et al., 2002; Sut & Simsek, 2011) and have also been used to predict food demand (Bozkir & Sezer, 2011). Recently, they have been applied within sensory and consumer science, to review factors influencing wine consumption (Jovanović et al., 2017) and factors associated with taste responsiveness (Yang et al., 2020b).

Interpreting data from unstructured surveys can be challenging when interactions exist between variables making it hard to equate the weighting of variables and determine contributions. Utilising regression trees can therefore provide a powerful tool in which to break down the complex interrelationships of numerous variables whilst being high in accuracy and visually intuitive (de Ville, 2013). However, caution must be taken to avoid overfitting data, especially in large data sets where smaller splits become statistically significant. One solution is the application of the Chi-squared Automatic Interaction Detector (CHAID) algorithm proposed by Kass (1980), which studies the strongest associations between the dependent variable and numerous potential predictor variables. Benefits include its appropriateness for dealing with a range of dataset sizes (n=25 – 1800), although performance is thought to improve as sample sizes increase (n=>1000) (Şata & Elkonca, 2022). It also allows for flexibility towards data type which can be inputted as nominal, ordinal or interval data (de Ville, 2013). In general, '*no type of distribution of independent variables is assumed a priori'* (Díaz-Pérez and Bethencourt-Cejas, 2016).

Outputs generate a tree with the target field located at the top (e.g., willingness to reduce). This ‘root node’ contains all participant responses which then unfolds in a stepwise fashion into data subsets (nodes) with the most influential variables ‘branching’ first. Branching occurs for subgroups that contain significantly higher or lower predicted scores to the average after applying binary logistic regression (Antipov & Pokryshevskaya, 2010). In other words, it identifies the predictor variable that best discriminates the dependent variable. It then continues to branch into new nodes based on the variables that best discriminate that subgroup. Overall, it identifies variables that influence the target dependent variable the most and how they differ. The algorithm tries to prevent overfitting by only splitting when significant associations are evident (Shanthi, 2019). It also permits the analyst to specify the minimum number of observations to allow for a split, providing a certain level of control over the algorithms output.

4.1.4 Study objectives

Given the complexity of meat-eating behaviour, this study aimed to apply regression tree analysis with the CHAID algorithm to explore the influence of age, gender and country on current meat consumption habits, changes to meat and meat substitute consumption and willingness to reduce meat. Further analysis explored consumers’ willingness to adopt three protein alternatives with differing levels of familiarity (meat substitutes, edible insects, cultured meat). Based on the cultural differences discussed in relation to the volume of meat consumed per person per capita, and the influences of age and gender on consumption habits, the hypothesis was that willingness to reduce meat and adopt protein alternatives will differ between countries. The findings contribute to existing literature on cross-cultural meat-eating behaviour, whilst providing insights to the wider food industry regarding consumer acceptance of protein alternatives.

4.2 Materials and Methods

An online consumer survey was designed and administered through Jisc online surveys, certified to ISO/IEC 27001 standard (JISC®, 2022). Before being disseminated, the survey was modified to reflect differences in demographic data between countries (e.g., ethnicity, income, and education brackets). The UK and

China surveys were approved by the University of Nottingham's Faculty of Medicine and Health Sciences Ethics Committee (UK Ref. number: 89-0820; China Ref. number: 154-0121), and the Australian survey was approved by the Human Research Ethics Committee at the University of Adelaide (Ref. number: H-2021-022). Before answering any questions, consumers were asked to give their consent to take part in this research. Upon completion of the questionnaire, participants had the option to be entered into a voluntary prize draw by providing their e-mail address.

4.2.1 Study design and participants

Responses were collected independently from the UK, Australia, and from the city of Shanghai in China from October 2020 to June 2022. Shanghai was chosen as the primary city to be comparable in education levels and population size with the UK and Australia. A total of 2,504 responses were collected, however non-meat eaters n= 460 (Australia n = 123, China n= 161, UK n= 176) and invalid responses n= 987 (Australia n= 25, China n= 946, UK n= 16) were removed. This left a total of 1,777 valid meat-eater responses (Australia n= 503, China n= 785 and the UK n= 489). The invalid responses related to participants whose dietary preferences did not match their personal meat consumption habits and or whose response time was too short (<15 minutes). No missing data was obtained as the survey platform prevented respondents from proceeding to the next section until all questions were answered. It is also worth noting that the responses were based on location and not length of time spent in certain countries.

The questionnaire was developed in English and pilot tested in the UK (n=13) and Australia (n=5) to help refine the flow, interpretation, relevance of questions and to remove any errors. The translation of the survey from English into Chinese was conducted via a three-step process; 1) Initial translation into Chinese 2) Back-translation into English 3) Final review and translation. The reviewed survey was piloted in China (n=12) to reduce misunderstandings and ensure lingual coherence. The online survey link was shared and promoted across various social media platforms applicable in each country and through existing email contact lists. Initial skews towards female participants in all three countries resulted in the use of targeted Facebook Ads to recruit more male participants in the UK and Australia, with a market research agency (Credamo, China) utilised in China.

4.2.2 Questionnaire design

This questionnaire formed part of a larger survey collecting data in relation to; motivations to reduce meat and adopt protein alternatives, consumers' perceptions of sustainable diets and the environmental impact of food alongside personality traits and meat attachment. For the current paper, only consumers' responses on their current consumption habits and general willingness to reduce meat and adopt protein alternatives were reviewed.

Key demographic characteristics (age, gender, ethnicity/race, education level, household income) were collected in the first part of the survey (Table 4.1). Three age categories were used to represent young, middle and older consumers similar to a study by Malek et al. (2019b). Following this, information relating to consumption habits and willingness to reduce meat consumption and to adopt meat substitutes, edible insects and cultured meat were collected as detailed below. Seven-point Likert scales were used throughout for choice-based questions to ensure consistency and to avoid confusion.

4.2.3. Meat consumption habits

Participants were first asked to identify their dietary preference from a list of options (omnivore, flexitarian, vegan, vegetarian, pescatarian), with definitions to avoid misinterpretations. Omnivores and flexitarians were grouped as meat eaters, and vegans, vegetarians and pescatarians were grouped as non-meat eaters and removed from the analysis for this study.

Meat and meat substitute consumption habits in the last 12 months were captured through self-reported consumption frequencies. Participants were asked, "*Please select the option below which best represents your consumption habits in the last 12 months*", with the options, '*do not consume* (1)', '*less than once per month'*, '*1-3 times per month'*, '*once per week'*, '*2-3 times per week'*, '*4-6 times per week*' and '*everyday* (7)'. The category options included; beef, lamb, chicken, pork and meat substitutes.

To prevent any ambiguity, definitions for the terms 'meat'[8] and 'meat substitutes'[9] were provided with reminders available during evaluation.

To capture changes to consumption habits over the last 3 years, consumers were asked, "*please select the option below which best represents how your consumption habits have changed over the last 3 years*", with the options, '*never consumed (1)'*, '*completely removed*', '*a lot less'*, '*slightly less'*, '*about the same'*, '*slightly more'* and '*a lot more (7)'.*

4.2.4 Willingness to reduce meat and adopt protein alternatives

Initially participants were asked "*How willing are you to reduce the foods listed below in order to follow a sustainable diet?*", foods listed included; beef, lamb, chicken and pork. The subsequent willingness questions were accompanied by short passages on the benefits of reducing meat, consuming meat substitutes, edible insects and cultured meat (Appendix S4.1). Questions were prefaced with the following statements; "*How willing are you to reduce your meat consumption in the next year for sustainability or environmental reasons?*", "*How willing are you to consider using meat substitutes as a replacement to meat in the next year?*", "*How willing are you to consider adopting edible insects into your future diet if products become more readily available?*" and "*How willing are you to consider adopting cultured meat into your future diet if products become more readily available?*". Willingness questions were presented on a fully labelled 7-point scale with the anchors 'extremely unwilling (1)' to 'extremely willing (7)'. It is acknowledged that meat substitutes and alternatives can cause confusion, however, this was minimised by giving detailed explanations (see footnotes) throughout the survey.

[8] **Meat** refers to both red and white meat (e.g., beef, lamb, pork, chicken). Examples of meat from other animals can include turkey, goat, game birds, rabbit etc. Meat also includes unprocessed meat (e.g., chicken breast, steak etc) or processed meat (e.g., sausages, bacon, ham, salami, pates, canned meat, chicken nuggets etc).

[9] **Meat substitutes** are products that are protein-containing foods that are primarily vegetable based and are frequently used to replace the function of meat as a meal component. Meat substitutes are often made up of pea protein, soya (tofu), mycoprotein (Quorn), jackfruit or animal-like proteins produced by yeast extract and are often designed to imitate meat in taste, texture, and appearance. They can therefore take the form of burgers, sausages, chicken strips, ham slices etc. They are predominantly used in hot meals and can make up components of ready-made meals.

Table 4.1
Socio-demographic characteristics of the sample (n=1,777) expressed as (%) within each country sub-sample.

	Australia n= 503	China n= 785	UK n=489
Gender			
Male	39.6	50.8	40.9
Female	58.1	48.2	58.1
Other/prefer not to say	2.4	1.0	1.0
Age (years)			
18 - 34	23.0	65.9	52.9
35 - 54	34.6	14.8	18.4
55 - 65+	41.8	19.4	28.3
Prefer not to say	0.6	0	0.4
Education			
No qualification	0.8	0.1	1.0
Some secondary school	8.7	1.9	16.2
Technical/ trade/ diploma/ vocational training	28.8	19.9	18.6
Completed University graduate (Bachelor's degree)	35.8	63.8	34.4
Completed Postgraduate/ Doctorate degree	25	13.4	28.0
Prefer not to say	0.8	0.9	1.8
Dietary preference			
Omnivore	87.5	74.4	78.9
Flexitarian	12.5	25.6	21.1

4.2.5 Statistical analysis

Scores for willingness to reduce meat and adopt protein alternatives were segmented into willing and unwilling categories. The willingness category combined consumers who scored 'slightly', 'moderately' and 'extremely' willing to reduce/adopt. A similar way of collapsing the original scale into categories has been conducted in previous literature and allows for necessary comparisons to be made (Gómez-Luciano et al., 2019; Malek et al., 2019b). Pearson Chi-Square for cross tabulation was then used to explore the associations between countries (Australia, China, UK) based on the willingness categories.

Regression Tree analysis with the CHAID algorithm was conducted to further explore the associations between age, gender and country with; current meat consumption, changes to meat and meat substitute consumption, willingness to reduce meat consumption and willingness to adopt protein alternatives. Due to the number of factors, non-parametric analysis was very limited. Therefore the consumption habits, which used categorical frequency scales was treated as quantitative (e.g., a mean score of 4.2 would reflect the category 'once per week'). To aid interpretation the corresponding scale labels are noted under the relevant figures. XLSTAT version 2022.2.1 (Addinsoft, Paris, France) was used to run the regression tree analyses with descriptive statistics (M= mean predicted score, N= number of pooled participant responses, % = sample population) applied to describe the data. To prevent overfitting, the minimum number of observations to allow for a split was set at 5%. Additional tree parameters included a 5% merge threshold, 5% significance with Bonferroni correction to consider the multiple comparisons and a maximum tree depth of 3.

4.3 Results

4.3.1 Current meat consumption habits

Regression Tree analysis was applied to understand the influence of age, gender and country on self-reported consumption habits for different types of meat (beef, lamb, chicken, pork) (Fig. 4.2). The most influential factor was product category, as identified by the first split. Overall, chicken had the highest consumption frequency score (M=4.2), followed by pork (M=4.1), beef (M=3.7) and lamb (M=3.0). Country was the next most influential factor, with China predicted to consume significantly more pork (M=4.7) compared to Australia (M=3.7) and the UK (M=3.3). In particular, young Chinese consumers aged 18-34 consumed more pork (M=4.8) compared to other age groups and countries. In contrast, Australia consumed significantly more beef (M=4.7) and lamb (M=3.6), compared to the UK and China who were grouped together (M=3.4 and M=2.7). In particular, Australians aged between 35-54 consumed the most beef (M=5.5) and the most lamb (M=3.9) compared to other age groups. In general, the amount of chicken consumed was similar between all three countries. However, in Australia and the UK, males were predicted to consume more chicken (M=4.4) than females, but in China it was consumers aged 18–34 (M=4.3) compared to consumers aged 35-65+.

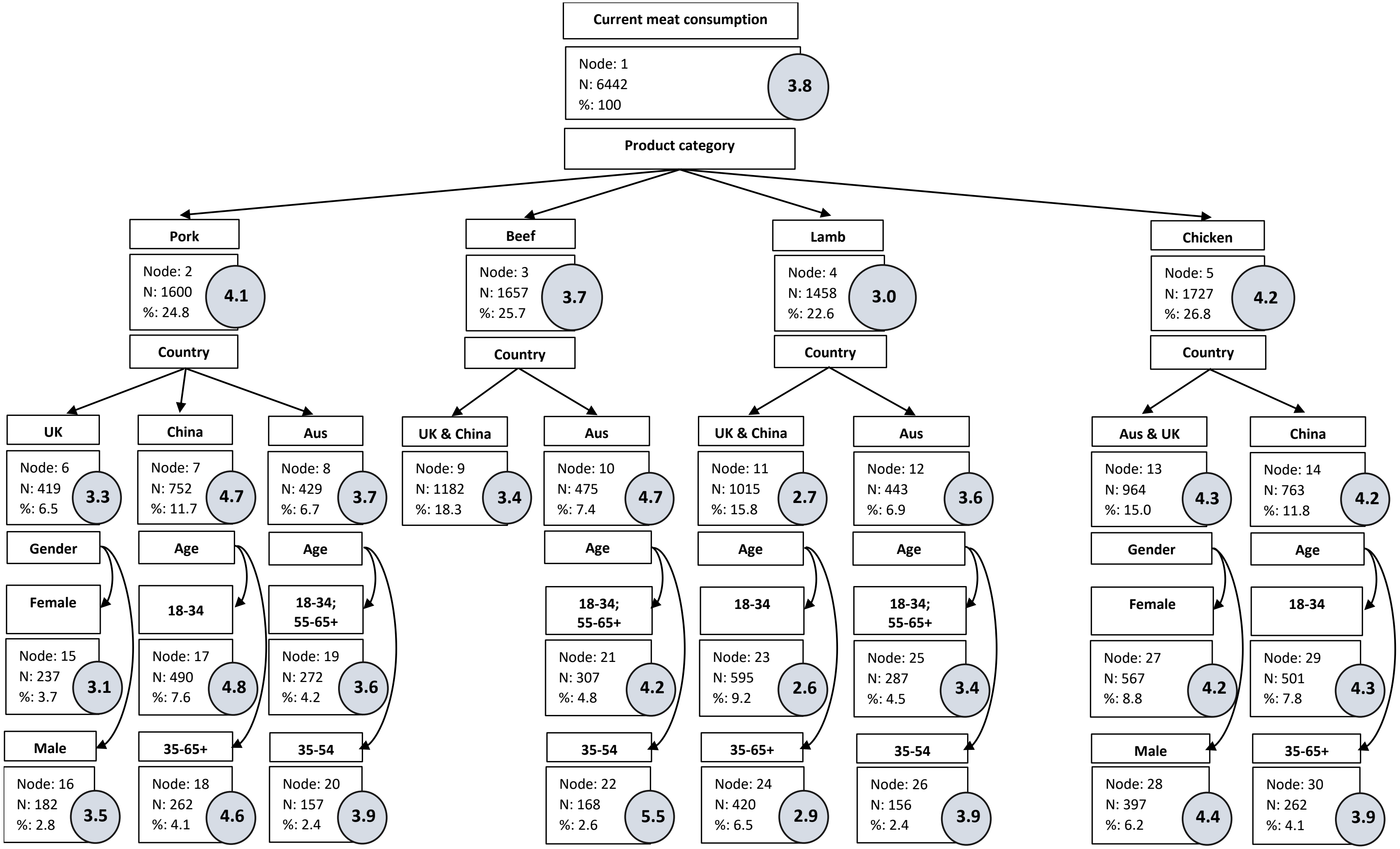

Fig. 4.2. Regression tree generated for current meat consumption habits (beef, lamb, chicken, pork) with country, age, gender and product category as independent variables. Please Note: N= number of pooled participant responses, %= sample population. The predicted mean values are based on the original scale: 1= 'do not consume', 2= 'less than once per month', 3= '1-3 times per month', 4= 'once per week', 5= '2-3 times per week', 6= '4-6 times per week', 7= 'Everyday'.

4.3.2 Changes to meat consumption habits

Looking at the self-reported changes to consumption habits over the past three years for different types of meat (beef, lamb, chicken, pork), as shown in Fig. 4.3, country was the most influencing factor, with the UK having the lowest mean value (M=4.3), indicating a significantly greater reduction in meat, compared to China (M=4.5) and Australia (M=4.9). Product category was the next influential factor for China and the UK, with beef, lamb and pork in the UK and lamb in China the most reduced (M=4.1). Chicken was not reduced much for both UK and China (M=4.7 and 4.9). Interestingly, for all types of meat, females reduced significantly more compared to males in the UK. However, in China, it's males who reduced lamb significantly more (M=3.9), compared to females (M=4.2). For Australia, age was the next influential factor, with 35–54-year-olds increasing consumption of all types of meat, with beef reflecting the highest score (M=5.7).

4.3.3 Changes to meat substitute consumption

Reviewing changes to meat substitute consumption, country was the most influential factor with the UK increasing consumption (M=5.5) followed by China (M=5.2) (Fig.4.4). In contrast, Australia was predicted to have decreased consumption (M=4.5), scoring significantly lower compared to both China and the UK. Age was the next influential factor in both the UK and Australia. In the UK, younger consumers (18-34) increased consumption the most (M=5.7), whilst in Australia consumers aged 35-54 decreased consumption the most (M=3.8). In China, gender was the next most influential factor, with males increasing their meat substitute consumption significantly more (M=5.3) than females (M=5.1), although the difference in absolute values is small (0.2).

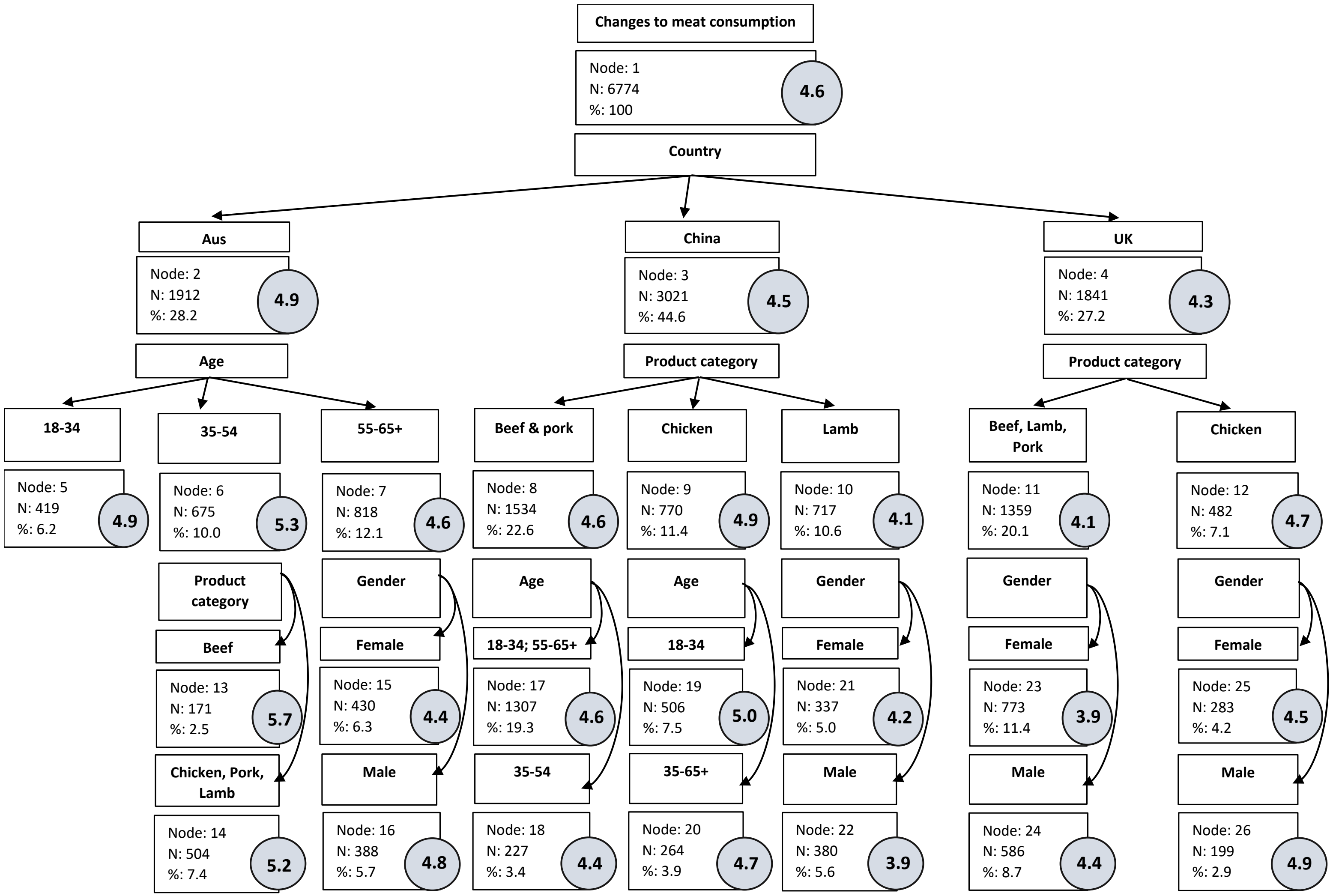

Fig. 4.3. Regression tree generated for changes to meat consumption (beef, lamb, chicken, pork) with country, age, gender and product category as independent variables. Please Note: N= number of pooled participant responses, %= sample population. The predicted mean values are based on the original scale: 2= 'completely removed', 3= 'A lot less', 4= 'slightly less', 5= 'about the same', 6= 'slightly more', 7= 'A lot more'. Consumers who scored 1 = 'never consumed' were removed from the analysis.

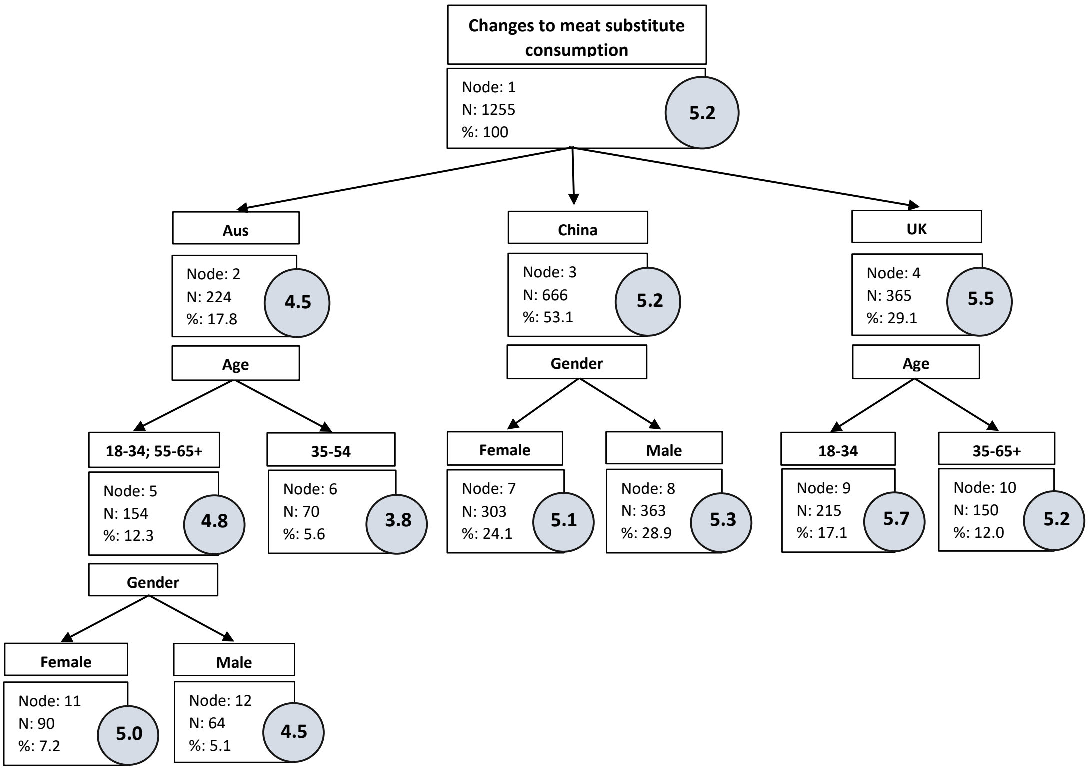

Fig. 4.4. Regression tree generated for changes to meat substitute consumption with country, age and gender as independent variables. Please Note: N= number of pooled participant responses, %= sample population. The predicted mean values are based on the original scale: 2= 'completely removed', 3= 'A lot less', 4= 'slightly less', 5= 'about the same', 6= 'slightly more', 7= 'A lot more'. Consumers who scored 1 = 'never consumed' were removed from the analysis.

4.3.4 Willingness to reduce meat

Chi-square analysis showed significant differences in the number of consumers willing to reduce meat consumption in the next year for sustainability or environmental reasons between countries (X^2 (2) = 517.41, p = < 0.001; Cramer's V effect size = 0.38). A greater proportion of consumers in China (70.4%) and the UK (66.7%) were willing to reduce compared to consumers in Australia (38.2%) (Fig.4.6).

Regression tree analysis on willingness to reduce by meat type (beef, chicken, lamb, pork) were explored (Fig. 4.5). Willingness scores were included as dependent variables and age, gender, country and meat type were included as independent variables. Results showed that country was the most influential factor, as identified by the first split. The UK was significantly more willing to reduce meat overall (M=4.8), compared to China (M=4.6) and Australia (M= 3.2). Gender was the next influential factor for the UK, with females significantly more willing to reduce (M=5.3) compared to males (M=4.1, neutral). For UK females, lamb had the highest willingness score (M=5.7), followed by beef and pork (M=5.4) and chicken (M=4.5). For UK males, 18–34-year-olds are generally more willing to reduce all meat types (M=4.9) compared to 35-65+ year-olds (M=3.8). For China, product type was the next influential factor, with consumers significantly more willing to reduce lamb (M= 5.2), followed by beef and pork (M=4.4) and chicken (M=4.2). Gender was the next influential factor, with males significantly more willing to reduce all meat types than females. For Australia, age was the next influential factor, with 35–54-year-olds significantly less willing to reduce any meat type (M=2.4), compared to 18-34 and 55-65+ year olds (M=3.6). For all age groups, males were the least willing to reduce all meat types. In particular, males aged 35-54 were very unwilling to reduce (M=2.2).

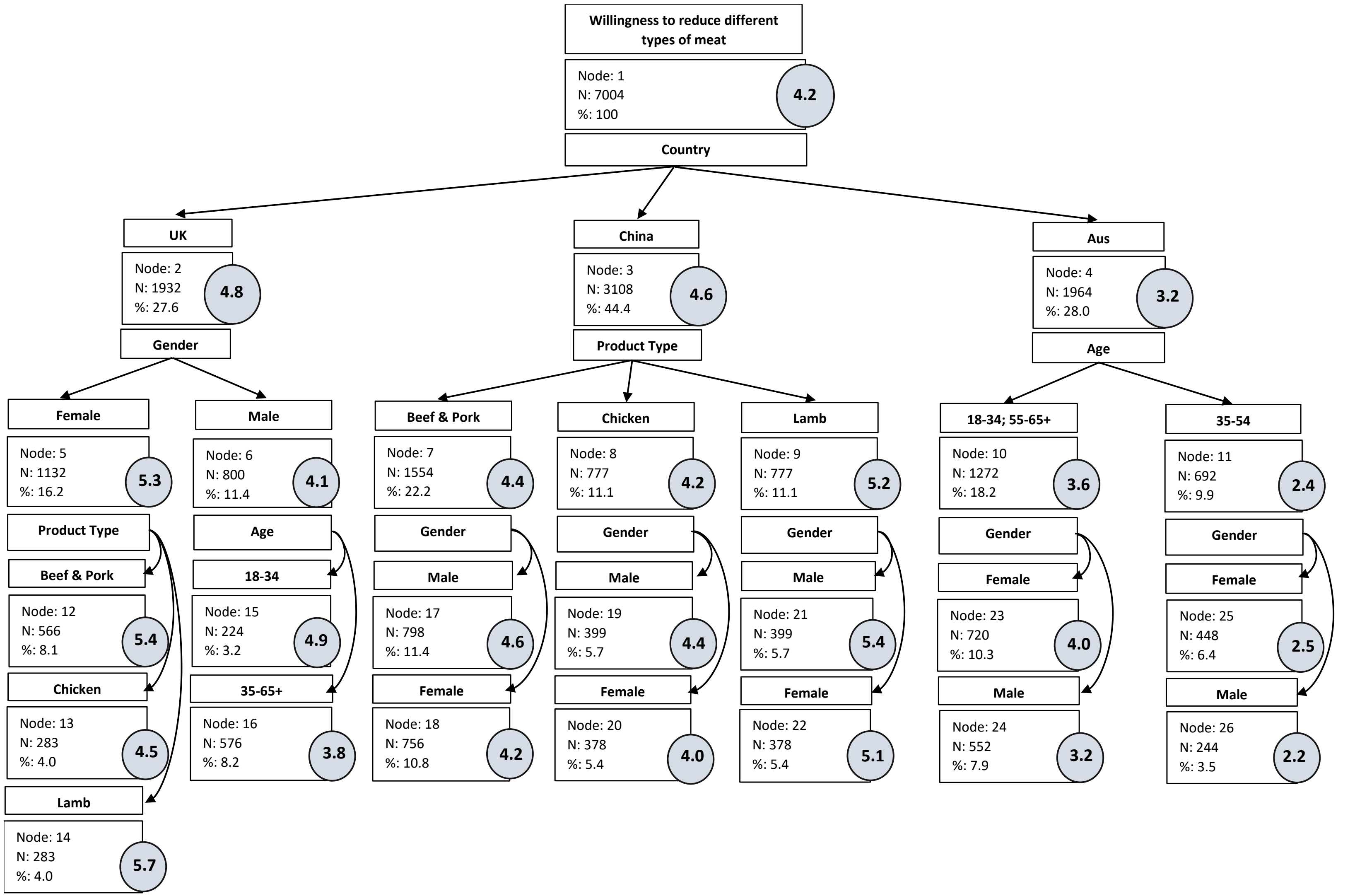

Fig. 4.5. Regression tree generated for willingness to reduce meat by type (beef, lamb, chicken, pork) with country, age, gender and meat type as independent variables. Please Note: N= number of pooled participant responses, %= sample population. The predicted mean values are based on the original scale 1-7, (1= ‘extremely unwilling’, 4= ’neutral’, 7= ‘extremely willing’).

4.3.5 Willingness to adopt protein alternatives

Reviewing willingness to adopt protein alternatives, chi-square analysis found a significant country*protein alternative interaction ($p < 0.001$) as shown in Fig 4.6. Overall, a significantly higher proportion of consumers in the UK (68.7%) and China (65%) were willing to consider using meat substitutes compared to Australia (32.1%). For edible insects, the UK (51.7%) and Australia (45.5%) were significantly more willing to adopt than China (32.2%). For cultured meat, the UK (64.2%) and China (62.7%) were significantly more willing to adopt than Australia (39.0%).

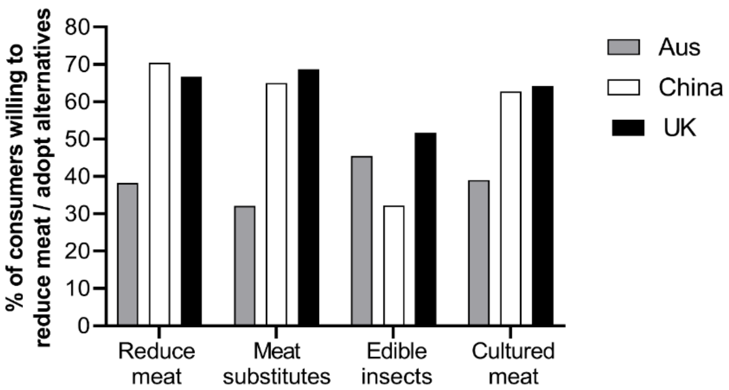

Fig. 4.6. Meat-eaters willingness to reduce meat and willingness to adopt three protein alternatives between countries. **Please note**: % values reflect the combined scores for consumers who scored 'slightly', 'moderately' and 'extremely' willing to adopt.

Regression tree analysis on willingness to adopt the three protein alternatives (Fig. 4.7) identified country to be the most influencing factor, with the UK having the highest willingness score (M=4.6), significantly greater than China (M=4.3) and Australia who were relatively unwilling overall (M=3.4). For the UK, age was the next influential factor, with consumers aged between 18-34 significantly more willing (M=5.0) compared to those aged 35-65+ (M=4.0). In particular, 18–34-year-olds were more willing to adopt meat substitutes and cultured meat (M=5.3) than edible insects (M=4.4). For China, the type of protein alternative was the next influential factor, with meat substitutes and cultured meat having a higher willingness score (M=4.7) compared to edible insects (M=3.4). Gender was the next influential factor for all protein alternatives, with males having significantly higher willingness scores than females. For Australia, age was the next influential factor, with 35–54-year-olds having the lowest willingness score (M=2.9), significantly lower compared to 55-65+ (M=3.5) and 18–34-year-olds (M=3.9). A further split was only identified for 35–54-year-olds who had a higher willingness score for edible insects (M=3.9) compared to meat substitutes and cultured meat (M=2.4).

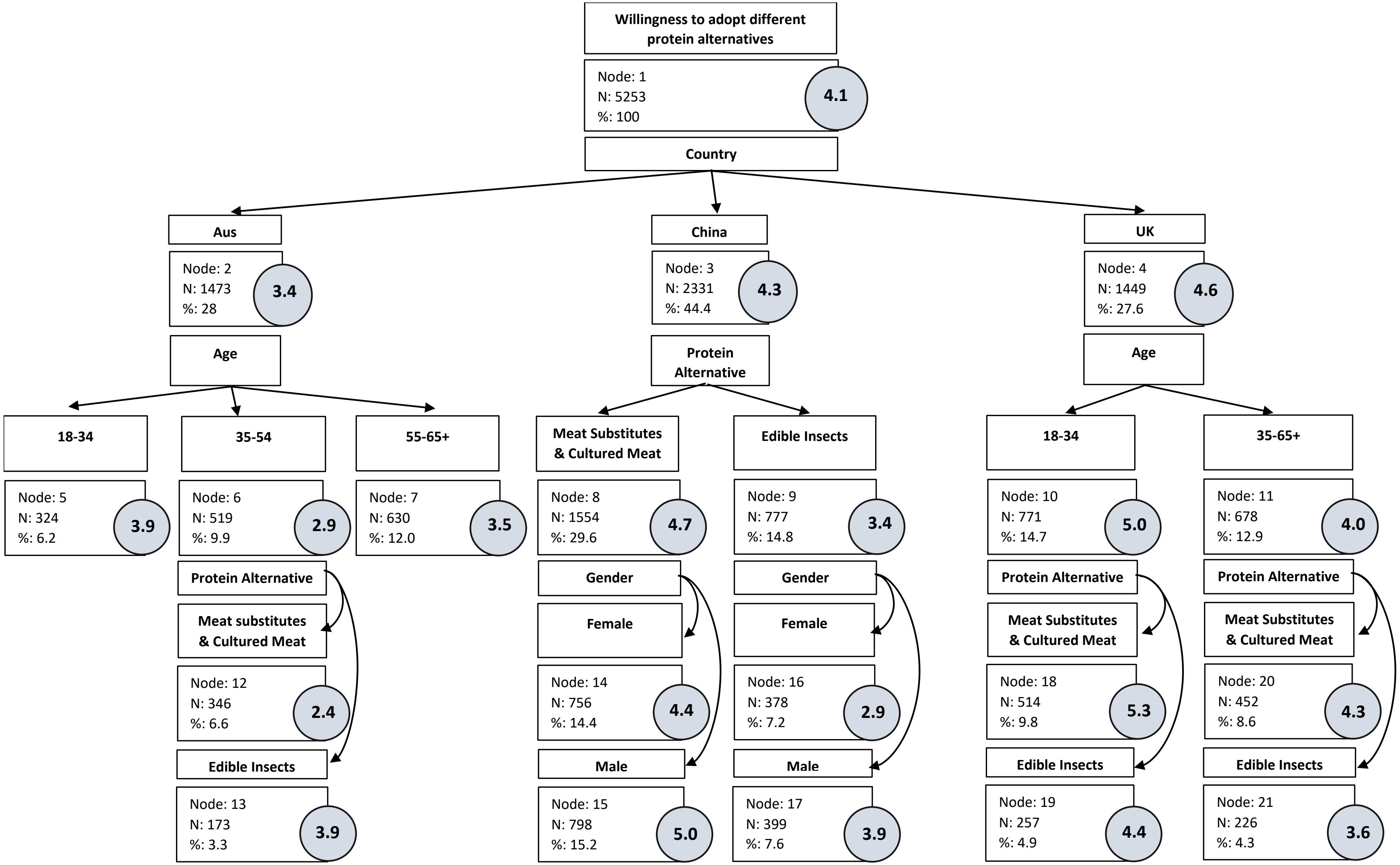

Fig. 4.7. Regression tree generated for willingness to adopt different protein alternatives with country, age, gender and protein alternative as independent variables. Please Note: N= number of pooled participant responses, %= sample population. The predicted mean values are based on the original scale 1-7, (1= 'extremely unwilling', 4= 'neutral', 7= 'extremely willing').

4.4 Discussion

To the authors' knowledge, this is the first study to apply regression tree analysis to explore the influence of age, gender and country on current/ changes to meat consumption, willingness to reduce meat and willingness to adopt three protein alternatives (meat substitutes, edible insects, cultured meat). Findings therefore provided new evidence and insights into the underlying factors influencing meat consumption and protein alternative adoption between the three countries differing in their consumption rates.

4.4.1 Willingness to reduce meat

Country proved to be the most influential factor, highlighting the importance of considering cultural differences. In general, consumers in China and the UK represent a greater potential to follow a more sustainable diet being significantly more willing to reduce meat and adopt meat substitutes and cultured meat compared to Australian consumers (Fig 4.6), which agrees with previous findings where a lower willingness to reduce meat intake was observed in Australia (Malek et al., 2019b), compared to higher percentages in both the UK (*Eating Better*, 2020) and China (Phelps, 2018).

A difference in willingness scores for the meat categories was also found, with consumers in the UK more willing to reduce beef and pork than Chinese and Australian consumers. Differences may partially relate to the availability of products between countries (FAO, 2022), but also demonstrate how culturally embedded consumption habits can be. For example, beef was the most frequently self-reported meat consumed in Australia compared to pork in China. Beef production is a huge industry in Australia, known for its high quality, and supported by positive consumption campaigns (WinterBeef, 2021). Whilst in China, the consumption of meat with a preference for pork is rapidly becoming part of social norm (Bu et al., 2021). Subsequently, the lower willingness to reduce in Australia may relate to consumption culture where eating meat is arguably part of the 'Aussie' identity and lifestyle e.g. the centrality of the barbecue (Bogueva et al., 2017). Whilst in China, meat is representative of social and economic development (Wellesley et al., 2015).

4.4.2 Willingness to adopt protein alternatives

UK and Chinese consumers have a relatively higher willingness to adopt meat substitutes than Australian consumers. The self-reported increase in the consumption of meat substitutes in the UK is reflective of the range of products available in supermarkets, restaurants and fast-food outlets which continue to grow (IFIC, 2020). Whilst in China, tofu consumption is just as much part of daily eating habits, making meat substitution more familiar (Phelps, 2018) and likely to further increase acceptance (Hoek et al., 2013; Jeong & Lee, 2021). Although the market for plant-based foods in Australia is growing, the lower acceptance could relate to the perception that meat substitutes are unnecessary (Hoek et al., 2017) with a lack of Australian brands (Bogueva et al., 2022).

Interestingly, although meat substitutes had a higher preference, a similar number of consumers in China and the UK were also willing to adopt cultured meat. This is in contrast to previous findings showing larger differences between the same alternatives when comparing willingness to purchase (Gómez-Luciano et al., 2019; Slade, 2018) and acceptance to consume (Grasso et al., 2019). Reasons for the similarity in willingness scores observed in this study could relate to the belief that cultured meat has the potential to mimic the role of meat within a meal, especially from a sensory perspective (see framing, Appendix S4.1). Such functionality is a known motive for consumer acceptance towards meat substitutes (Elzerman et al., 2013; Ford et al., 2023a). Moreover, similar scores could relate to social desirability bias, especially when reviewing a hypothetical product. As cultured meat is a novel product, which few have tried, consumers are rating willingness based on their taste expectations. In contrast, for meat substitutes, willingness scores are based on previous experiences. Therefore, these high scores reflect previous experiences with meat substitutes and the assumption that cultured meat will taste very similar to meat. Overall, considerations should also be given to the psychographic behaviours of the different cohorts. For example, Gómez-Luciano et al. (2019) found that for some countries, an increase in the perception of healthiness, safety and nutritiousness of cultured meat and or plant-based proteins increased the probability of purchase intention.

The significantly higher willingness to adopt cultured meat in China and the UK compared to Australia is contradictory to a previous cross-cultural study, which identified little differences in acceptance between the same three countries (Siegrist & Hartmann, 2020). Arguably this could be attributed to descriptors and scales used, as well as the decision on whether to share alleged benefits of cultured meat with consumers which may increase acceptance (Mancini & Antonioli, 2019; Zhang et al., 2020b). However, the findings do support alternative studies, where over 50% of European based consumers are willing to try cultured meat (Mancini & Antonioli, 2019; Weinrich et al., 2020) as well as growing acceptance in China (Bryant et al., 2019; Liu et al., 2021; Zhang et al., 2020b). Although willingness to adopt cultured meat in Australia was significantly lower than the UK and China, compared to previous research involving Australian consumers, the percentage score was either slightly higher or comparative (Bogueva & Marinova, 2020; Garcez de Oliveira Padilha et al., 2021). Reasons for the lower willingness to adopt in Australia could relate to concerns over masculinity and the belief that eating cultured meat would betray the nations pride in producing good quality animal meat (Bogueva & Marinova, 2020).

For edible insects, interestingly, Australian consumers were significantly more willing compared to consumers in the UK and China, which is in contrast to previous cross-cultural research comparing Asian and Western consumers (Hartmann et al., 2015). It is also contradictory to the belief that Chinese consumers would be more accepting based on a long history of consumption. However, the consumers represented in this study are from Shanghai where edible insects do not form part of traditional dishes compared to other provinces (e.g. Yunnan) in China (Feng et al., 2018). A previous study reviewing willingness to consume edible insects amongst Australian consumers reported a higher percentage (56.2%) (Hopkins et al., 2022), whilst a study amongst UK consumers found a lower percentage (25.9%) (Circus & Robison, 2019). Therefore, there is slight ambiguity perhaps due to differing demographics and question formats which future research should consider.

4.4.3 The influence of age, gender and country on willingness to reduce meat and adopt protein alternatives

All the regression trees identified country as being the most influential factor when predicting willingness scores for meat reduction and protein alternatives. For each country, gender and age groups were also influential as identified by the additional splits.

4.4.4 Australia

The lower willingness to reduce meat amongst 35–54-year-olds in Australia could be partially attributed to the finding that this age group had the highest self-reported meat intake and also increased meat over time. Previous research supports the finding that younger Australian's aged <35 tend to be willing to eat meat-free most of the time (Malek et al., 2019b). In comparison, consumers aged 35-54 may be less concerned about money, therefore the price of meat, which can limit younger consumers meat intake may be less of a concern (Ford et al., 2023a). Additionally, this age group may lead busier lifestyles where the concept of cooking meat-free may seem time consuming to some individuals (Kemper, 2020). In addition, recent findings have identified non meat-reducers to be less accepting of future foods, such as plant-based substitutes and cultured meat (Kemper et al., 2023). The higher willingness to adopt protein alternatives amongst younger consumers aged 18–34 is consistent with previous findings reviewing Australians acceptance of cultured meat (de Oliveira Padilha et al., 2022) and edible insects (Wilkinson et al., 2018). However, it should be noted that the overall predicted willingness scores in this study for the younger age bracket was <4 indicating a slight unwillingness to adopt in general.

4.4.5 UK

For the UK, gender is a more dominating factor in predicting meat consumption habits, with males predicted to consume significantly more meat, whilst reducing meat intake the least. This is perhaps to be expected as the notion that men consume more meat is well recognised and has been linked to numerous factors including; genetic differences (Çınar et al., 2022), masculinity (Rosenfeld & Tomiyama, 2021) higher meat attachment (Graça et al., 2015a) and a lower importance for healthy lifestyles (Nakagawa & Hart, 2019). Previous research with UK consumers also identified gender differences which played a bigger role than age groups (Horgan et al., 2019). However, analysis of trends in UK meat consumption using the National Diet and Nutrition Survey found no gender differences (Stewart et al., 2021). This could be due to the results being expressed as a proportion of energy intake. Further exploration into the extent to which gender differences influence meat consumption in the UK are therefore needed to provide clarity. However, the higher acceptance amongst younger UK consumers is in alignment with previous findings with European consumers reviewing meat substitutes, edible insects and cultured meat (Bryant & Sanctorum, 2021; Detilleux et al., 2021; Mancini & Antonioli, 2019; Schösler et al., 2012; Verbeke, 2015). It also supports the notion that younger consumers are the most likely to reduce meat intake and or go meat-free (FSA, 2020), which partially explains why they are the biggest consumers of plant based meat substitutes (Alae-Carew et al., 2022).

4.4.6 China

The higher willingness to reduce meat amongst Chinese males contradicts previous findings which showed females to be more inclined to practice sustainable behaviours, including meat reduction (Chan et al., 2017). However, gender and age have been found to influence meat purchases, with females preferring to purchase beef more than males (Zhang, 2018). The differences observed could also relate to consumers coming from Shanghai as research has identified urban consumers to have healthier dietary preferences compared to rural consumers (Wang et al., 2022). Further research is required to explore the influence of gender on meat consumption amongst Asian consumers as findings could highlight a lower level of meat attachment and masculinity. Currently, gender differences have been identified when reviewing the meat-masculinity link between ethnic groups including the Chinese Dutch (Schösler et al., 2015).

In relation to protein alternatives, the higher willingness to adopt plant-based meat substitutes amongst Chinese males supports the increase in self-reported consumption. It also supports the higher purchase intent amongst males compared to females (Yaxin et al., 2020). Yet findings contradict research conducted with European consumers where females are often more accepting (Onwezen et al., 2021; Siegrist & Hartmann, 2019). However, for edible insects, the opposite trend is consistently observed amongst European consumers which supports the higher willingness amongst Chinese males (Grasso et al., 2019; Kröger et al., 2022; Sogari et al., 2019; Tuccillo, 2020). In general, research reviewing gender influences on the acceptance of meat substitutes and edible insects amongst Chinese consumers is lacking compared to cultured meat. In support of the findings, a study with urban Chinese consumers identified younger males to have a higher predicted level of acceptance for cultured meat (Zhang et al., 2020b). However, alternative research has identified no significant influence with gender (Wang & Scrimgeour, 2022). The differences observed could relate to the various mix of urban cities reviewed, which when compared, vary in their economic development. Income is potentially an important factor to consider as those on higher incomes are predicted to be the most positive and accepting (Wang & Scrimgeour, 2022). China is a complex country to study due to numerous provinces, varying cuisines and levels of economic development. Therefore, further research that considers the impact of socio-demographic factors is required to bring clarity and alignment to findings as customising meat reduction strategies by province may be required.

4.5 Other considerations

The recruitment method relied on convenience sampling and resulted in a bias towards female participants in the Australian and UK sample sets as well as a higher proportion of educated consumers in all three countries and a higher proportion of younger consumers in China. In addition, the Chinese sample is taken from Shanghai where eating habits are known to differ from other provinces in China. Considering the varying cuisines, to some extent sampling just from Shanghai allowed for an element of control when reviewing consumption habits. Overall, the results should not be generalised to all Australian, Chinese, and British consumers but interpreted with caution. However, achieving representative samples in cross-cultural research is challenging considering the added differences between country demographics (Ares, 2018; Reynolds et al., 2003). Therefore, regression tree analysis served as an appropriate exploratory tool to understand whether the findings were attributed to demographic variations whilst accounting for unbalanced samples in sub-categories.

In terms of alternative decision tree algorithms, a paper by Yang et al. (2023) provides a comprehensive overview of how the CHAID algorithm compares to alternative algorithms, namely the Classification and regression tree (CART) and the Iterative Dichotomiser (ID3). In summary, the CHAID algorithm was found to have the greatest detection accuracy (92.3%) compared to the CART (85.7%) and ID3 (69.1%) algorithms (Yang et al., 2023). This is partially related to the application of 'pre-pruning' in the branch method before tree division and generation (i.e., removing nodes that do not add further information) which is thought to make it more stable and less likely to overfit. By comparison, if the CART algorithm was applied, because it is a binary tree, variables are likely to appear multiple times making the importance of certain factors harder to interpret (Yang et al., 2023). Therefore, future studies should consider applying the CHAID algorithm especially for large data sets and for continuous scales which the ID3 algorithm cannot process. However, it is worth noting that as data categories increase (e.g., age, gender, meat type) accuracy can decrease, especially when comparing the CHAID to the CART algorithm (Yang et al., 2023).

Although measures were put in place to remove invalid survey responses, future research would benefit from including additional approaches to improve the data quality. Examples include adding in a trap question early on in the questionnaire and capturing participant engagement/interest through validated scales (Jaeger & Cardello, 2022). Though this study compared consumption frequencies with dietary preferences as a screening tool to remove invalid responses, it is also worth noting that the consumption frequencies were self-reported and potentially open to miscalculation. The same could be observed for the gender categories listed which did not allow for within-gender heterogeneity. Therefore, analysing the data simply based on binary differences may have oversimplified and overlooked the wider role of gender conformity which is also known to influence meat consumption (De Backer et al., 2020; Rosenfeld & Tomiyama, 2021).

In addition, the wording of the willingness questions mentioned, ‘for sustainability or environmental reasons’ or ‘in order to follow a sustainable diet’. Therefore, findings may not capture consumers who are willing to reduce meat for other reasons (i.e., personal health, price, animal welfare, food safety etc). In general, this may have influenced the results but provides an opportunity for future research to gain deeper insights into alternative motives. Likewise, the brief explanations given for the protein alternatives which mentioned sustainability benefits may have influenced consumers’ opinions. Previous research highlights the effect of framing, especially in relation to cultured meat, on consumers’ willingness and subsequent perceptions (Bryant & Barnett, 2019; Siegrist et al., 2018). Furthermore, the translation of the term ‘cultured meat’ into Chinese ‘人造肉’, which is thought to literally translate to ‘man-made meat’ (Liu, et al., 2021), may have resulted in a different linguistic equivalence especially considering the novelty of this concept which may impact responses. Just like in English, cultured meat has many variations (e.g., lab-grown, cell-based, in-vitro, clean meat) however, the translation of 'cultured meat' was deemed most appropriate and consistent compared to the alternative definitions.

Consideration must also be given to the time frame in which the surveys were disseminated across Australia, China, and the UK during the Covid-19 pandemic. Lockdown provided more time and flexibility to consider food purchases and to cook meals from scratch at home (Borsellino et al., 2020; Filimonau et al., 2021; Murphy et al., 2020), with many purchasing food online (Chen et al., 2021; Ellison et al., 2021). These lifestyle changes have reportedly driven consumers towards more sustainable and healthier food choices (Di Renzo et al., 2020; Murphy et al., 2020; Rodríguez-Pérez et al., 2020; Wang et al., 2020). An increase in organic food sales has also been noted, especially amongst UK consumers (Askew, 2021). Motives behind such changes are thought to be related to a greater awareness of the link between health and nutrition, with evidence amounting to a possible long-term shift towards more plant-based and reduced meat diets (Attwood & Hajat, 2020).

4.6 Conclusion

The differences observed meet the study objectives by highlighting how cultural factors can inherently influence consumption habits and willingness to reduce meat intake and adopt protein alternatives. Findings also provide further insights regarding the influence of age and gender in predicting trends in consumption habits. Regression tree analysis with the CHAID algorithm proved to be a useful tool to explain the complex interrelationships being visually intuitive and statistically robust. In general, the global landscape of sustainable food consumption is ever-changing, and it is important for future research to take a holistic approach to understand the role reduction and substitution play in the diet. These findings highlight the need for country specific meat reduction strategies, tailored to specific subgroups, whilst emphasising the need to introduce appropriate protein alternative categories that are going to help facilitate a dietary transition. In other words, edible insect products may be more suited to supporting a protein transition amongst consumers in Australia, whilst cultured meat and plant-based meat substitute products are likely to have more success amongst consumers in the UK and China. To summarise, the UK is the most willing to reduce meat and adopt protein alternatives. In particular, UK females are the most willing to reduce meat and younger consumers are most willing to adopt alternatives. For China, males are the most willing to reduce meat/ adopt alternatives, whilst Australia is the least willing to reduce meat/ adopt alternatives, specifically 35–55-year-olds. Further analysis should consider other psychographic behaviours (e.g., personality traits, meat attachment and knowledge of products) to segment markets and to provide additional insights.

Chapter 5

Comparing motivations and barriers to reduce meat and adopt protein alternatives amongst meat-eaters in Australia, China and the UK

Highlights

- *Motives for meat reduction and protein alternative adoption relate to food safety and the environment.*
- *Regression tree analysis found the magnitude of motivational importance differed across countries.*
- *Australians had the greatest proportion of extremely unwilling responses, especially towards meat reduction and meat substitute adoption.*
- *Meat reduction barriers relate to the perception it is necessary for health.*
- *Protein alternative barriers relate to the belief products are; Unhealthy, Unnecessary, Unsustainable, Unsafe, Unnatural and Unappealing.*

Comparing motivations and barriers to reduce meat and adopt protein alternatives amongst meat-eaters in Australia, China and the UK

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Abstract

Motivations are central in determining consumer food choices and provide insights regarding barriers to change. Given the global need to transition towards more sustainable protein consumption patterns, understanding cross-cultural motivations is important. The present research aimed to address this knowledge gap by reviewing motivations to reduce meat and to adopt meat substitutes, edible insects and cultured meat amongst meat-eating consumers in Australia, China and the UK (n=1,777). An online survey captured the importance of key motivations via closed-ended statements, with barriers to change collected via open-ended questions for extremely unwilling consumers. Results found food safety and environmental benefits to be the most important motives for meat reduction and protein alternatives adoption. Chinese and UK consumers were more motivated by these factors compared to Australian consumers who had the greatest proportion of consumers unwilling to reduce based on the belief meat consumption is necessary for health reasons. Relative differences in motivational importance were also apparent by protein alternative type. In general, the greatest proportion of unwilling responses amongst Australians (n=245) related to the use of meat substitutes, whilst for Chinese (n=160) and UK consumers (n=97) it related to edible insects. Overall, six key themes were identified amongst extremely unwilling consumers, with the protein alternatives being perceived as; Unhealthy, Unnecessary, Unsustainable, Unsafe, Unnatural and Unappealing. The prominence of themes differed between countries and across protein categories, but the perception that alternatives were unnecessary was a communal theme. Overall, the findings provide interesting insights and recommendations to support country-specific protein transitions.

5.1 Introduction

Total global food demand is expected to increase by up to 56% by 2050 (Van Dijk et al., 2021). Predominantly this is driven by growing populations alongside economic development and urbanisation. Subsequently, it is expected that there will be a greater demand on animal proteins causing further environmental pressures with regards to deforestation, water pollution and Greenhouse Gas (GHG) emissions (Steinfeld et al., 2006). Increasing food production whilst minimising environmental damage, ensuring food security and addressing public health issues therefore present some of the biggest global challenges moving forward.

Mitigative solutions relate to a reduction in meat consumption and including a wider variety of non-animal protein sources (Clark & Tilman, 2017; Willett et al., 2019). Additionally, there is a need to consume meat from more sustainable sources such as Carbon Neutral Beef which is produced using regenerative agricultural techniques. In summary, this farming practice is an alternative method for producing food that has the potential to reduce and or provide a net positive environmental and social impact (Newton et al., 2020). Through mimicking the earth's natural cycles, this form of agriculture has numerous benefits (e.g., improved soil health, greater carbon sequestration, reduced GHG emissions).

Additionally, the inclusion of a wide range of protein alternatives are needed to meet differing consumer needs. For example, this could be in relation to affordability, availability, nutritional needs, varying cuisines and palates. Potential protein alternatives include plant-based meat substitutes, edible insects and cultured meat which eliminate or reduce the need to breed, raise and slaughter animals and therefore alleviate the environmental pressures associated with traditional animal agricultural practices (Kim et al., 2020; Parodi et al., 2018). Examples of protein alternatives include plant-based meat substitutes which often incorporate a variety of ingredients (e.g., pea or soy protein, mycoprotein, seitan, tempeh) and are frequently processed into products that mimic the appearance, taste and texture of meat (Tso et al., 2020). Currently, the plant-based meat market has seen huge global growth which is projected to rise 24.9% between 2023 to 2030 from USD $4.4 billion in 2022 (Grand view Research, 2023). However, this forecast is not always supported by current news which has observed a continued decline in plant-based sales since 2021 with nearly a 21% decrease in volume sales over a 52-week period (Wilson, 2023).

Alternatively, a potential novel source of protein are edible insects. Although edible insects are consumed by several hundreds of millions of people (Van Huis et al., 2022), they are less prevalent within western societies (Van Huis et al., 2013). However, the past decade has seen increased attention focused on the promotion of insects as human food (Van Der Weele et al., 2019). This is partially due to their similar nutritional value and health benefits to meat, but much lower environmental impact than meat (Van Huis & Rumpold, 2023). For example, although the nutritional composition of insects varies greatly between species (Payne et al., 2016a) some do have favourable nutrient profiles when compared with meat (Payne et al., 2016b). Furthermore, insects emit less greenhouse gas emissions and require less land, especially in the case of mealworms compared to beef (Kim et al., 2020; Oonincx & De Boer, 2012).

By comparison, cultured meat, which utilises future food technology to grow animal cells *in vitro*, is also gaining traction as a future protein alternative. The rapid development of technologies means that products are likely to become available to the public soon (Lee et al., 2020). However, before cultured meat becomes available on the market, there are still many challenges to overcome such as technological difficulties and high costs associated with scalability (Deliza et al., 2023; Treich, 2021). Overall, it is thought the substitution of meat with protein alternatives will play a contributing role in achieving sustainable global food production goals (Kozicka et al., 2023; Moruzzo et al., 2021; Nobre, 2022). However, the success of this dietary transition depends on consumers changing their consumption habits.

5.1.1 Consumer motivations and barriers to reduce meat and adopt protein alternatives.

Motivations are central in determining consumer food choices and provide insights with regards to prominent barriers to change. Key food related motivations include; price, food safety, sensory appeal, convenience, animal welfare, environmental and health benefits (Lindeman & Väänänen, 2000; Steptoe et al., 1995). In general, the top motivations for reducing meat consumption are reported to be health benefits, animal welfare and environmental/ sustainability concerns (Cheah et al., 2020; Graça et al., 2019). Conversely, the barriers can relate to a belief that meat is indispensable in a balanced diet (Font-i-Furnols & Guerrero, 2022). Meat-eaters can also demonstrate meat-related cognitive dissonance associated with animal welfare issues (Rothgerber, 2020) and have lower environmental concerns around meat reduction (De Boer and Aiking, 2022). Additional barriers towards meat reduction include a general attachment to meat (Ford et al., 2023a; Graça et al., 2015a) which is often linked to the justifications that eating meat is natural, normal, necessary and nice (Piazza et al., 2015).

For plant-based meat substitutes, motivations can relate to moral and ethical factors as well as the convenience and ease of cooking as a replacement to meat (Graça et al., 2019; Onwezen et al., 2021). Sensory appeal is also a prominent motive, but the processes involved in creating products that mimic meat can create negative consumer perceptions around unnaturalness and subsequent concerns related to health and safety (Ford et al., 2023a; Varela et al., 2022). In addition, although meat substitutes are often marketed under the pretence of being beneficial for the environment and health, partially due to the role they play in replacing meat in the diet, it is not guaranteed that consumers will agree with this (Hartmann et al., 2022).

For edible insects and cultured meat, similar motivations and barriers are apparent with potential environmental and health benefits being key drivers for acceptance, whilst food neophobia and concerns around food safety reduce acceptance (Onwezen et al., 2021). Additionally, for edible insects, disgust remains a prominent psychological barrier preventing consumers from eating insects (Russell & Knott, 2021; White et al., 2023). In contrast, negative perceptions around naturalness and concerns around affordability are additional barriers for cultured meat (Bryant & Barnett, 2020; Pakseresht et al., 2022; Siddiqui et al., 2022).

Overall, there is a baseline level of understanding of the motivations and barriers towards meat reduction and protein alternatives. Considering a recent meta-review found motivation to be an important domain for driving and supporting the protein transition (Onwezen & Dagevos, 2023), it continues to be an important area to explore especially as food trends and consumer needs evolve. However, the relative importance placed on food choice motives are known to vary across cultures (Markovina et al., 2015; Torán-Pereg et al., 2023) and by protein alternative category (Hartmann & Siegrist, 2017; Onwezen et al., 2021; Tso et al., 2020). Predominantly this is due to cultural differences in meat consumption and variations in the familiarity with protein alternatives (Font-i-Furnols, 2023). Currently, there is little understanding as to how the magnitude of motivations differs across protein alternative categories and by cultural backgrounds. As this is of considerable importance when developing strategies to encourage protein transitions it highlights gaps in future research.

5.1.2 Research gaps, strategy and study aims

It is known that meat consumption varies by country (Font-i-Furnols, 2023). For example, currently, China is the world's largest consumer of pork, with rapid economic development leading to a general increase in other types of meat (Wang, 2022). Conversely, Australia has one of the highest per capita meat intakes in the world, increasing red meat consumption by 12Kg between 2020 compared to 2019 (Font-i-Furnols, 2023) . By contrast, UK consumption is lower, but the Committee on Climate Change has made it a priority to encourage a 20% reduction in meat consumption by 2030 in order to meet carbon reduction targets (CCC, 2021).

The present study follows on from previous research (Ford et al., 2023b) reviewing meat-eaters willingness to reduce meat and to adopt protein alternatives amongst consumers in Australia, China and the UK. Findings reflected cultural variations in meat consumption rates, willingness to reduce different types of meat and willingness to use/adopt protein alternatives. Specifically, Australians were predicted to be less willing to reduce meat and to use/adopt meat substitutes and cultured meat and more willing to try edible insects. In contrast, consumers from the UK and China were more willing to reduce meat and to use/adopt meat substitutes and cultured meat but less willing to try edible insects (Ford et al., 2023b). Therefore, as future protein transitions are likely to be culturally specific it is important to understand the motivations and barriers behind these results.

Although an increasing number of papers have reviewed consumer acceptance towards meat reduction and plant-based meat substitutes (Graça et al., 2019; Onwezen et al., 2021), edible insects (Florença et al., 2022; Van Huis & Rumpole, 2023) and cultured meat (Pakseresht et al., 2022; Siddiqui et al., 2022), there is still a lack of cross-cultural studies comparing product related motivations including comparisons across protein alternatives. As consumer responses can vary considerably dependent on the protein alternative type (plant vs insect vs cultured proteins), it is important to understand such differences (Onwezen & Dagevos, 2023). Furthermore, the majority of research has focused on willing consumers, yet it is equally important to study the extremely unwilling consumers to understand barriers. In understanding the barriers, we can develop evidence-based actions for supporting the protein transition (e.g., informing, framing, nudging, (dis) incentivising) (Onwezen & Dagevos, 2023). Findings can inform social marketing campaigns aiming to promote sustainable protein consumption.

Open-ended questions have been used widely in surveys and allow consumers to be open and free in their opinions. Previously, this data collection method has been applied to food-related consumer studies (Ares et al., 2014; Jaeger et al., 2023; Spinelli et al., 2017; Vidal et al., 2022), including consumers' perceived representation, impact and rationales around meat consumption (Graça et al., 2015b). It has also been applied in a cross-cultural context (Aguirre et al., 2019). It is therefore a popular tool to collect a range of in-depth, unprompted consumer opinions within the field of sensory and consumer research.

Considering the variation in consumption patterns between the three countries in this study, it is hypothesised that the countries will not be homogenous in their motivations to reduce meat consumption and to adopt alternatives. Therefore, findings will provide interesting insights between two western countries with differing meat consumption habits and a non-western country. Specifically, the present study aims to extend current findings and contribute to new knowledge by addressing the following study objectives:

1) To understand and compare the most important motivations across countries in relation to; reducing meat consumption and adopting meat substitutes, edible insects and cultured meat.
2) To explore the underlying reasons across countries for being extremely unwilling to reduce meat and to try/ adopt meat substitutes, edible insects and cultured meat.

5.2 Materials and Methods

An online consumer survey was designed and administered through Jisc online surveys, certified to ISO/IEC 27001 standard (JISC®, 2022). Details pertaining to the development of the questionnaire, participant recruitment and sample demographics have previously been published (Ford et al., 2023b). The UK and China surveys were approved by the University of Nottingham's Faculty of Medicine and Health Sciences Ethics Committee (UK Ref. number: 89-0820; China Ref. number: 154-0121), and the Australian survey was approved by the Human Research Ethics Committee at the University of Adelaide (Ref. number: H-2021-022). Before answering any questions, consumers were asked to give their consent to take part in this research. Data was collected between October 2020 – June 2022 throughout Australia (n= 503) the UK (n= 489) and just within the city of Shanghai in China (n=785). The surveys were circulated in each country separately to allow the recruitment advertisement and participant information sheet to specifically require participants to currently reside in either the UK or Australia. Participants also had to give consent of their residency before completing the survey. For the Chinese survey, a market research agency (Credamo, China) was utilised to ensure only consumers from the city of Shanghai were recruited. A back translation process from English to Chinese and back into English was applied by two native Chinese speakers (authors YZ & QY).

5.2.1 Questionnaire design

This questionnaire formed part of a larger survey which collected data in relation to a variety of topics (e.g., consumers' perceptions of sustainable diets, current meat intake, willingness to reduce meat, personality traits, meat attachment). For the current paper, general motivations to reduce meat consumption and to adopt protein alternatives are evaluated. Additionally, open-ended responses from consumers who scored ‘extremely unwilling’ in response to meat reduction and the adoption of protein alternatives are reviewed. Findings therefore follow on from a previously published paper by the authors reviewing consumer willingness (Ford et al., 2023b). Key demographic characteristics were collected and are presented in the Appendix (Table S1).

5.2.2 Willingness to reduce meat and adopt protein alternatives

Consumers were asked about their willingness to reduce meat and their willingness to use meat substitutes[10] in the next year. Consumers were then asked about their willingness to try and/ or adopt edible insects and cultured meat in future diets. The questions were presented using a 7-point scale with the anchors ‘extremely unwilling (1)’ to ‘extremely willing (7)’(Ford et al., 2023b). Consumers who scored ‘extremely unwilling’ in response to reducing meat and adopting the three protein alternatives were not asked about their motivations on the premise that they were not motivated to reduce meat and adopt alternatives and could skew the results. Therefore, motivational data was not available to analyse for consumers who scored extremely unwilling (score 1).

5.2.3 Motivations

The remaining participants who scored 2 – 7 on the willingness scale were asked about their motivations to reduce meat consumption and eat and or try protein alternatives. Therefore, the total number of participants (n=1,777) who completed the motivational data for each question were as follows; To reduce meat consumption Aus: = 286, China = 759, UK = 435; To use meat substitutes: Aus = 258, China = 752, UK = 427; To adopt edible insects: Aus = 376, China = 625, UK = 392; To adopt cultured meat: Aus = 311, China = 752, UK = 435.

[10] **Meat substitutes** were defined as: ‘products that are protein-containing foods that are primarily vegetable based and are frequently used to replace the function of meat as a meal component. Meat substitutes are often made up of pea protein, soya (tofu), mycoprotein (Quorn), jackfruit or animal-like proteins produced by yeast extract and are often designed to imitate meat in taste, texture, and appearance. They can therefore take the form of burgers, sausages, chicken strips, ham slices etc . They are predominantly used in hot meals and can make up components of ready-made meals’.

Motivations were captured throughout the questionnaire with the anchors 'extremely unimportant (1)' to 'extremely important (7)'. Participants were provided with a list of seven motives (health benefits, convenience, sensory appeal, price, animal welfare, food safety, environmental benefits) adapted from the Food Choice Questionnaire (Steptoe et al., 1995) and Ethical Concern Subscale (Lindeman & Väänänen, 2000). Consumers were asked, "*How important are the following factors in your decision to reduce your overall meat consumption*?". Using the same set of motives, consumers were then asked, "*How important are the following factors in motivating you to eat and or try meat substitutes?*". The questions were repeated for edible insects and cultured meat.

5.2.4 Reasons behind extremely unwilling

For those who scored 'extremely unwilling', these participants were asked to '*please provide a reason as to why you are extremely unwilling to; reduce your meat consumption in the next year for sustainability or environmental reasons; to consider using meat substitutes as a replacement to meat in the next year; to consider adopting edible insects/ cultured meat into your future diet'.* The number of participants who scored 'extremely unwilling' to each individual open-ended question are presented in Table 5.1.

5.3 Data analysis

5.3.1 Motivations to reduce meat and adopt protein alternatives

Regression tree analysis with the CHAID algorithm was applied to explore the associations between country and motivations with; meat reduction and protein alternative adoption. The data was analysed using XLSTAT version 2022.2.1 (Addinsoft, Paris, France). The dependent variable related to the motivation scores for reducing meat intake and adopting protein alternatives, whilst the independent variables related to country, motivation category and protein alternative type. To interpret the data, the predicted mean value scores are based on the original 7-point scales, with N = number of pooled participant responses and % = sample population. For this analysis, consumers who scored extremely unwilling were excluded.

5.3.2 Reasons for being extremely unwilling

The responses to the four open-ended questions were collected and analysed using the qualitative analysis software Nvivo, 20. The Chinese responses were translated into English by the author YZ. Thematic analysis (TA) following an inductive coding process was then applied using the guidelines of Braun & Clarke. (2022). After the familiarisation and coding stage, an initial framework matrix of themes was generated by the author, HF which was reviewed and developed by the rest of the authors. The open-ended responses could be assigned to more than one theme. In close alignment with the principles of quantitative content analysis (Krippendorff, 2018), the frequency of themes was calculated based on the number of times each consumer provided a response within a theme. Similar approaches have been presented in previous research (Aguirre et al., 2019; Jaeger et al., 2023). Verbatim responses are provided to clarify and support the chosen themes.

5.4 Results: Motivations

5.4.1 Motivations to reduce meat intake

For the strength of motivations to reduce meat, the different motivational categories were more influential compared to country differences, as identified by the first split (Fig.5.1). Factors were grouped together when there was a significant result and therefore a significant relationship between variables based on the Pearson's chi-squared test of independence. Overall, food safety and environmental benefits were grouped together as the most important factors (M= 5.7) followed by health benefits (M= 5.5), sensory appeal and price (M= 5.3), animal welfare (M=5.1) and convenience (M=4.9). Therefore, all of the factors are somewhat important to consumers, scoring between 'slightly' and 'moderately' important. Additional splits found country differences to be apparent for all the motivational factors excluding health benefits. For food safety and the environmental benefits, consumers in the UK and China (Shanghai) found these factors significantly more important (M= 5.7) compared to consumers in Australia (M= 5.4). Australian consumers additionally found environmental benefits to be more important (M= 5.6) than food safety (M= 5.2). For sensory appeal and price, consumers in the UK scored higher (M=5.5) compared to

Australian and Chinese consumers (M= 5.1). For animal welfare, UK consumers found this to be more important (M= 5.6) compared to Australian consumers (M= 5.1) who also scored higher than Chinese consumers (M= 4.7). Lastly, for convenience, this factor was more important for consumers in China and the UK (M= 5.0) compared to Australian consumers (M= 4.7).

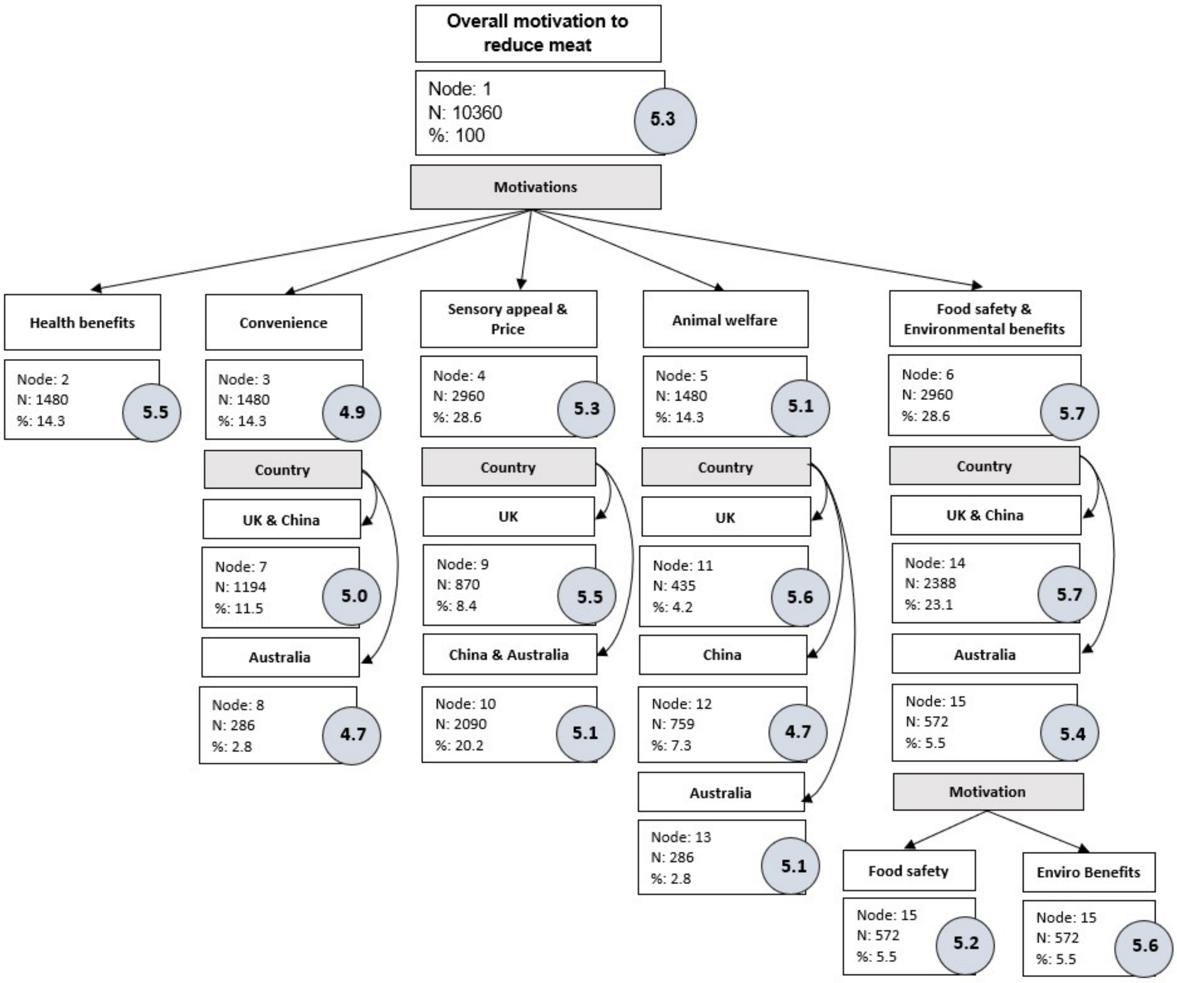

Fig. 5.1. Regression tree generated for motivations to reduce meat consumption with country and the seven motivation categories as independent variables. Please note: N = number of pooled participant responses, % = sample population. The predicted mean value scores are based on the original scale: 1 = Extremely unimportant, 2 = Moderately unimportant, 3 = Slightly unimportant, 4 = Neutral, 5 = Slightly important, 6 = Moderately important, 7 = Extremely important. Consumers who scored extremely unwilling to reduce meat were excluded leaving; Aus = 286, China = 759, UK = 435.

5.4.2 Motivations to use and or adopt protein alternatives.

For the strength of motivations to use and /or adopt protein alternatives, the motivational categories were the most influential factor, followed by country and protein alternatives. Overall, food safety and the environmental benefits which were grouped together were the most important factors (M= 5.7) followed by sensory appeal (M= 5.6), health benefits (M= 5.4), price (M= 5.3), convenience (M=5.0) and animal/

insect welfare (M= 4.9) (Fig. 2). All motivational categories identified significant country differences.

For the environmental benefits, UK and Chinese consumers found this to be more important (M= 5.8, M= 5.9) respectively compared to Australian consumers (M= 5.4). Similar importance was placed on the environmental benefits of each protein alternative for UK consumers, with Australian consumers finding no significant difference. However, Chinese consumers found the environmental benefits to be more important for cultured meat (M= 6.0) compared to edible insects and meat substitutes (M= 5.6).

A similar trend was observed for convenience, with Chinese and UK consumers scoring this as significantly more important (China: M= 5.2, UK: M= 5.1) compared to Australian (M= 4.6) consumers. Overall, Australians were the only consumers to show a reasonably large mean difference between the protein alternatives. Specifically, convenience was more important for cultured meat and meat substitutes (M= 5.8) compared to edible insects (M= 4.4).

For food safety, Chinese consumers found this to be a more important factor (M= 5.9) compared to UK (M= 5.6) and Australian consumers (M= 5.4). In particular, Chinese consumers felt it was more important for edible insects and meat substitutes (M= 6.1) compared to cultured meat (M= 5.6). By comparison, Australian and UK consumers found food safety to be equally important across protein alternatives. Chinese consumers also scored the health benefits significantly higher (M= 5.6) compared to Australian and UK consumers (M= 5.2). However, all groups found small mean differences between protein alternative type.

In terms of sensory appeal, UK consumers found this to be more important (M= 5.9) compared to Chinese and Australian consumers (M= 5.5, M= 5.4) respectively. However, all countries found the importance of sensory appeal to be similar or equal across protein alternative types. In addition, UK consumers also found price to be significantly more important (M= 5.6), compared to Chinese (M= 5.2) and Australian (M= 5.1) consumers. However, all three countries found it to be more motivational in relation to cultured meat and meat substitutes, compared to edible insects with the biggest mean difference observed amongst Australian consumers (0.4).

Lastly, for animal/ insect welfare, this factor was the least important overall but had the biggest mean difference between protein alternative types. Overall, it was more motivating for cultured meat and meat substitutes (M= 5.1) compared to edible insects (M= 4.3). For cultured meat and meat substitutes, UK consumers scored welfare higher (M= 5.6) compared to Australian (M= 5.1) and Chinese (M= 4.9) consumers. Whereas for edible insects, Chinese consumers rated welfare higher (M= 4.6) compared to UK (M= 4.3) and Australian (M= 3.9) consumers.

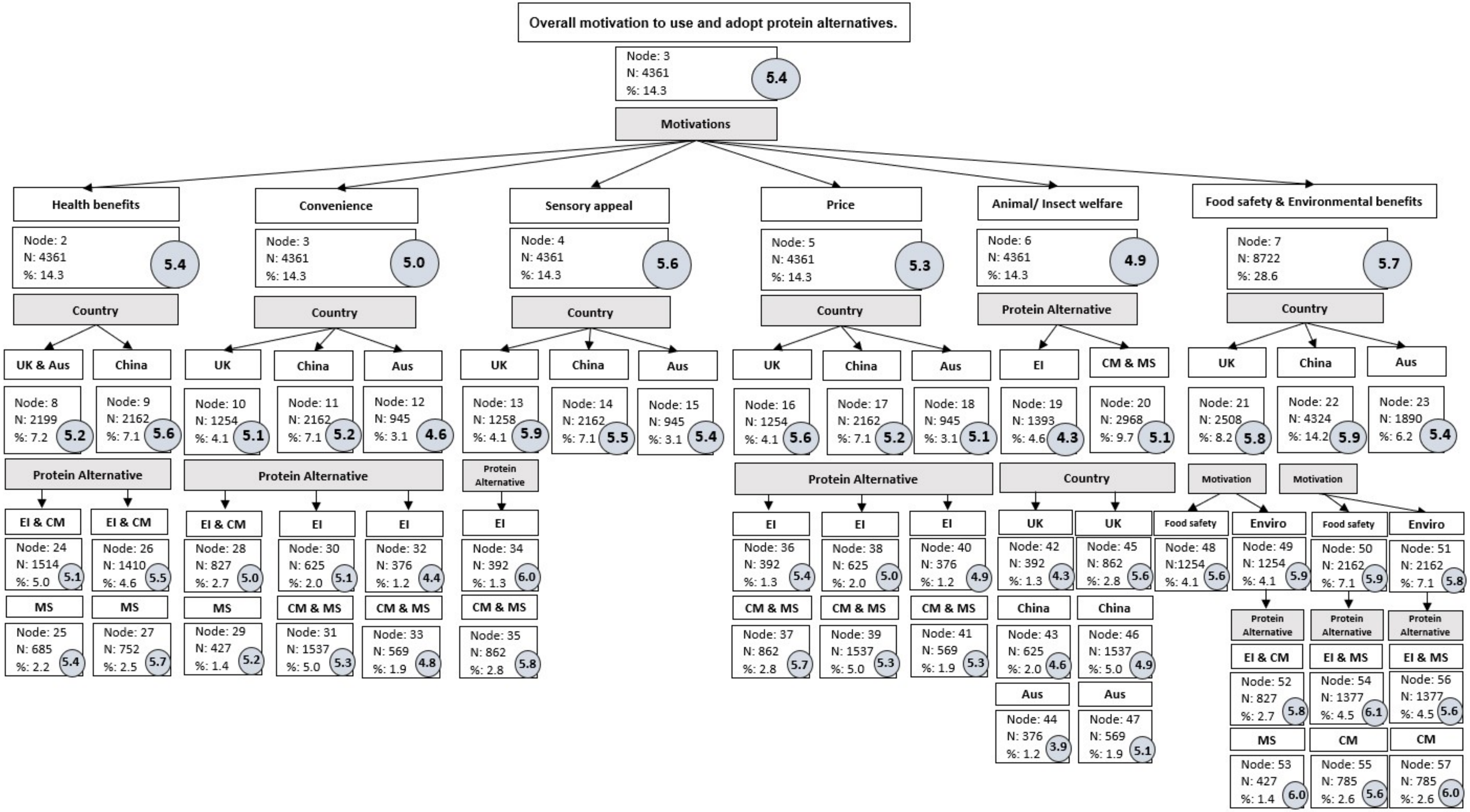

Fig. 5.2. Regression tree generated for motivations to use/adopt meat substitutes, edible insects and cultured meat with country, the seven motivations and protein alternative categories as independent variables. Please note: N = number of pooled participant responses, % = sample population. The predicted mean value scores are based on the original scale: 1 = Extremely unimportant, 2 = Moderately unimportant, 3 = Slightly unimportant, 4 = Neutral, 5 = Slightly important, 6 = Moderately important, 7 = Extremely important. Consumers who scored extremely unwilling to adopt were excluded leaving the final totals; MS (Meat substitutes): Aus = 258, China = 752, UK = 427; EI (Edible insects): Aus = 376, China = 625, UK = 392; CM (Cultured meat): Aus = 311, China = 752, UK = 435.

5.5. Results: Barriers

5.5.1 Barriers towards meat reduction and adoption of protein alternatives

In total, 1,300 open-ended responses were collected for the meat reduction and protein alternative questions, with all extremely unwilling consumers leaving a comment. The Pearson chi-square statistic found a significant ($p < 0.0001$) difference in the proportion of extremely unwilling consumer responses across countries and by category (i.e. meat reduction, meat substitutes, edible insects, cultured meat) (Table 5.1).

Overall, Australian participants had the greatest proportion of consumers supplying unwilling responses compared to Chinese and UK consumers. Australians were most unwilling to adopt meat substitutes (n=245, 72%), reduce their meat consumption (n=217, 73%) or adopt cultured meat (n=192, 69%) with the lowest proportion of unwilling responses relating to edible insects (n=127, 33%). By comparison, the greatest proportion of unwilling responses for Chines and UK consumers related to adopting edible insects (n=160, 42%; n=97, 25%) and the lowest responses related to reducing meat consumption (n=26, 9%; n=54, 18%), respectively. It should be noted that the Chinese participant responses were considerably shorter which highlights potential cross-cultural differences in responding to open-ended questions.

Table 5.1
Cross tabulation between extremely unwilling responses and country

Extremely unwilling	**Total (n=1,777)**	**Australia (n=504)**		**China (n=785)**		**UK (n=489)**	
	n	**n**	**%**	**n**	**%**	**n**	**%**
To reduce meat consumption	297	**217 (>)**	73.1	**26 (<)**	8.8	54 (<)	18.2
To use meat substitutes	340	**245 (>)**	72.1	**33 (<)**	9.7	62 (<)	18.2
To adopt edible insects	384	**127 (<)**	33.1	**160 (>)**	41.7	**97 (>)**	25.3
To adopt cultured meat	279	**192 (>)**	68.8	**33 (<)**	11.8	54 (<)	19.4

Note: Bold values are significantly different according to Fisher's test for significance (0.05) (i.e., if the actual value is lower (<) or higher (>) than the theoretical value for each cell). Please note: the number of responses is representative of consumers who scored '1' on the willingness scale (e.g., in total 297 consumers out of 1,777 were extremely unwilling to reduce meat consumption, the majority (n=217) were from Australia).

5.5.2 Extremely unwilling to reduce meat consumption.

Applying thematic analysis revealed six themes: Meat consumption is necessary for health reasons; Meat consumption is not environmentally damaging, other factors are; Meat is normal, nice and better than alternatives and Meat can be produced and consumed sustainably (Table 5.2). In addition, two themes were created grouping together the comments from consumers who disagreed with the information and who gave an emotional response.

Table 5.2
Extremely unwilling consumers (%) who mentioned the different themes in relation to meat reduction.

Theme	Topics	Total	Aus	China	UK
Meat consumption is necessary for health reasons	Meat improves health and wellbeing, is a complete source of nutrients, essential for dietary needs.	35.4	43.3	19.2	11.1
	Protein alternatives provide insufficient nutrition and can lead to negative health consequences.	12.8	16.1	7.7	1.9
Meat consumption is not environmentally damaging, other factors are	Current meat production and consumption is sustainable, meat is not the problem.	14.1	14.7	11.5	13.0
	Other factors are also an issue; food waste, food miles, packaging, burning fossil fuels, international travel, plant-based foods.	15.8	20.3	7.7	1.9
	Others responsibility, up to the producers not the consumers, individual change won't make a difference.	5.7	3.7	11.5	11.1
Meat consumption is normal, nice and better than alternatives	It is natural and normal; humans have evolved to eat meat.	10.8	12.0	0.0	11.1
	Enjoy, like eating meat, meat tastes good.	13.1	6.5	42.3	25.9
	Do not like vegetables or processed alternatives.	9.4	10.6	11.5	3.7
Meat can be produced and consumed sustainably	Regenerative agriculture is the way forward.	17.8	23.0	0.0	5.6
	Eating locally produced, high welfare sustainable meat in moderation is the solution.	12.5	11.5	3.8	20.4
Disagree with information	Disagree, biased view presented.	20.2	24.0	0.0	14.8
	Climate change is not real.	3.7	4.1	0.0	3.7
Emotional response	Defensive or angry: my diet, my choice.	10.8	9.7	7.7	16.7
	Others are behind the need to change: vegans, vegetarians, big food companies, politics, the privileged, people of power.	7.7	7.8	0.0	11.1

Please note: Australia, n=217, (73%); China, n=26, (9%); UK, n=54, (18%); Total, n=297 (100%). The % values in the table reflect the proportion of consumers who mentioned that theme within each country (e.g., for Australia, out of the 73% (n=217) of extremely unwilling consumers, 43.3% mentioned meat consumption was necessary for health reasons).

The most frequently mentioned theme for being extremely unwilling to reduce meat intake related to meat being necessary for health reasons (Aus: 59.4%; China: 26.9%; UK: 13%).

Australian consumers mentioned this more frequently compared to Chinese and UK consumers. Consumers found meat to be '*the healthiest human food on the planet'* and therefore an essential nutritional source. In comparison, protein alternatives were found to be nutritionally inadequate and likely to cause negative health consequences. Subsequently consumers mentioned the inclusion of meat in their diet as being vital in helping address various physical and mental health issues (obesity, pre-diabetes, depression), as well as autoimmune and dietary deficiencies (digestive issues, anaemia). Example responses from each country are shown below:

"*Meat is vital to health. I have reversed several health conditions by embracing animal products.*" (Australia, Female, 25-34)

"*To ensure nutritional intake.*" (China, Male, 25-34)

*"I want to stay healthy by consuming readily digestible amino acids, bioavailable vitamins and minerals provided by meat, which are not available from plants." (*UK, Male, 65+)

The second most frequently mentioned theme related to the perception that meat consumption is not environmentally damaging but other factors are (Aus:38.7%; China: 30.7%; UK: 26%). Consumers in all three countries felt meat reduction was unnecessary when current production and consumption is and can be sustainable. Therefore, meat was perceived to not be a problem. In particular, Australian consumers felt that the production of plant-based foods is more cause for concern referencing the environmental damage and pressure caused through mono-crop agriculture. Subsequently, a larger proportion of Australians mention other factors (20.3%) compared to Chinese (7.7%) and UK (1.9%) consumers. Other factors mentioned included the burning of fossil fuels and the emissions associated with cars and flights, whilst Chinese consumers mentioned the impact of food waste and excessive packaging. The belief that others were more accountable, whether that be the food producers or people around the world who are increasing their meat intake was mentioned more frequently by UK and Chinese consumers (~11%) compared to Australian consumers (3.7%).

"*I would like to see people reduce their impact on the environment by flying less, using their cars less & consider their impact on the environment.*" (Australia, Female, 55-65)

"*The environmental impact of food waste and excessive packaging may be far greater than the impact of meat production*." (China, 18-24, Female)

"*I do not believe that I as one person can change anything - the pressure to make the industry more sustainable should be on producers not on consumers*." (UK, Female, 18-24)

Another frequently mentioned theme related to meat consumption being normal, nice and better than alternatives (Aus: 29.1%; China: 53.8%; UK: 40.7%). Interestingly, a higher proportion of Chinese (42.3%) and UK (25.9%) consumers mentioned this compared to Australian consumers (6.5%). Instead, for Australians the emphasis was more on meat being natural and normal and linked to our ancestral needs. This theme was also mentioned by some UK consumers but was not stated by Chinese consumers. A dislike of vegetables and processed meat-free alternatives was also mentioned more frequently by Australian (10.6%) and Chinese consumers (11.5%) compared to UK consumers (3.7%).

"*We have come from cave man, our brains grew, we evolved eating meat and fat*." (Aus, Female, 35-54)

"*I have money, love to eat meat*". (China, Female, 18-24)

"*I both like meat and believe humans are designed to eat meat*". (UK, Male, 55-65)

The final key theme related to the perception that meat can be produced and consumed sustainably (Aus: 34.5%; China: 3.8%; UK: 26%). The premise that meat can be produced sustainably was predominantly mentioned by consumers in Australia (23%) and a few in the UK (5.6%) but was not mentioned by Chinese consumers. The main topic related to regenerative farming practices which were perceived to be a better solution compared to meat reduction and were thought to underpin a sustainable diet. Consumers described the process of regenerative farming, highlighting how animal agriculture typically utilises non-arable land, sequesters carbon, replenishes soil. Examples of how to consume meat sustainably were more frequently mentioned amongst UK consumers (20.4%) compared to Australian (11.5%) and Chinese (3.8%) consumers. Factors related to eating meat in moderation, from local butchers, produced ethically, from regenerative farm practices, with minimal food waste (e.g., eating nose to tail).

"Regenerative farming to provide a sustainable diet requires ruminants not monocropping. A majority of the land for ruminants cannot be cropped and cannot feed the world with a plant-based diet." (Australia, Male, 45-54)

"I have not caused waste in my meat consumption." (China, Female, 18-24)

"Eating more, but higher welfare and more locally produced meat, helps to support local farmers and drive down the price compared to less sustainable products." (Female, UK, 45-54)

In total, 20.2% of consumers stated that they disagreed with the statement that accompanied the question (Appendix I – Statement A). The majority of consumers were Australian (24%) and from the UK (14.8%) whilst no Chinese consumers explicitly disagreed. Overall, only a few were climate change deniers (3.7%). It was very apparent when reviewing the responses that a proportion of consumers across all three countries were also defensive and or angry (10.8%) towards the suggestion of reducing meat consumption. For some consumers, there was a sense of 'it's my diet, my choice', and subsequently a feeling of being constrained, controlled, and told what to do. For some Australian (7.8%) and UK (11.1%) consumers there was a perception that others are behind the need to reduce meat intake, notably non-meat-eaters such as vegans and vegetarians. It was also believed that big pharmaceutical and food companies, political agendas, the privileged and people of power would likely benefit from the transition.

*"Absolute rubbish being perpetuated on society by vested groups and vegans." (*Australia, Female, 55-65*)*

*"This vegan push is best culturally insensitive, really racist and at worse genocide through malnutrition." (*Australia, Male, 45-54*)*

"*Let me ask you, have you reduced it yourself?*" (China, Male, 25-34)

"*Like to eat meat, unwilling to be constrained.*" (China, Male, 25-34)

"*All you bloody tofu eaters need to leave meat eaters alone.*" (UK, Male, 45-54)

"*I believe in freedom of choice, and I like meat*". (UK, Male, 55-65)

5.5.3 Extremely unwilling to eat and or try protein alternatives

Overall, five key themes were identified; Unhealthy, Unnecessary, Unsustainable, Unsafe and Unappealing. For meat substitutes and cultured meat, an additional theme relating to Unnaturalness was also identified. The most frequently mentioned themes differed across countries and by protein alternative.

5.5.4 Meat Substitutes

The most frequently mentioned themes amongst Australian consumers related to meat substitutes being unhealthy and unnatural (~35.5%). Whilst the perception that meat substitutes are unnecessary was the most mentioned theme amongst Chinese (39.4%) and UK (40.4%) consumers (Table 5.3).

Table 5.3
Extremely unwilling consumers (%) who mentioned the different themes in relation to being extremely unwilling to use meat substitutes.

Theme	Topics	Total	Aus	China	UK
Unhealthy	Unhealthy, nutritionally inadequate, toxic, meat is essential.	30.3	36.7	18.2	11.3
Unnatural	Unnatural & highly processed, fake food, artificial, full of additives/chemicals.	26.8	34.3	6.1	8.1
Unnecessary	Enjoy and prefer real meat, whole foods, meat consumption is necessary and normal.	20.6	18.0	36.4	22.6
	There are sustainable options for eating meat, regenerative farming, self-sufficiency, meat is not the culprit.	4.7	3.3	3.0	11.3
	Other ways to be meat-free, vegetables, grains, tofu, beans.	4.1	4.1	0.0	6.5
Unsustainable	Environmentally damaging, worse for the environment compared to livestock farming, large carbon footprint, food miles, supports monocropping.	15.0	16.7	0.0	14.5
Unsafe	Unsafe, not fit for human consumption, too many chemicals, toxic.	4.7	4.1	15.2	1.6
Unappealing	Unappealing, do not like them, do not want them.	2.9	0.4	3.0	12.9
	Negative sensory appeal; taste is not good, bland, boring, unable to replicate real meat.	5.3	1.2	24.2	11.3
Disagree with information	Disagree, biased view presented.	15.3	17.1	0.0	16.1
Others are behind the change	Gives power/ control to big food companies to make profit, people of power, vegetarians and vegans.	4.7	4.5	3.0	6.5

Please note: Australia, n=245,(72%); China, n=33, (10%); UK, n=62, (18%); Total, n= 340 (100%). The % values in the table reflect the proportion of consumers who mentioned that theme within each country (e.g., for Australia, out of the 72%, (n=245) of extremely unwilling consumers, 36.7% mentioned meat substitutes were unhealthy).

Unhealthy: A larger proportion of Australians (36.7%) mentioned meat substitutes were unhealthy compared to Chinese (18.2%) and UK (11.3%) consumers. Meat substitutes were especially perceived as being nutritionally inadequate and in some cases, detrimental to health compared to conventional meat which was believed to contribute to good health. This was partially related to the processed nature of products, with some concerns around the different chemical ingredients included and the low bioavailability of nutrients in products. The quantity of substitutes that need to be consumed in order to match the nutritional value of meat was also questioned. The negative effects of meat substitutes were associated with an increased risk of developing diabetes, high blood sugar levels, obesity, anaemia as well as being triggering for conditions such as fibromyalgia, IBS, Chron's disease, hives and allergy problems (soy).

"*Because it's unhealthy, full of oestrogen mimicking soy and highly inflammatory seed oils.*" (Australia, Female, 35-44)

"Moderate meat intake contributes to good health." (China, Male, 25-34)

"*As an athlete, I don't feel the nutritional content is as good as consuming meat.*" (UK, Female, 18-24)

Unnatural: A larger proportion of consumers in Australia (34.3%) compared to the UK (8.1%) and China (6.1%) commented on meat substitutes being highly processed and unnatural labelling them as '*fake*' and '*full of harmful additives / awful chemicals / unnatural ingredients*'. References to being high in salt / preservatives, containing pro-inflammatory ingredients and high oestrogen concentrations were also made.

Unnecessary: Meat substitutes were perceived to be unnecessary when there is 'real' meat available. Many therefore questioned why there is a need to replace meat with 'fake' foods that mimic meat. The enjoyment gained from meat was frequently mentioned by Chinese (36.4%) and UK consumers (22.6%), more than Australian consumers (18%). However, only Australians gave the reasoning that meat consumption is 'normal' and part of our evolution and ancestral needs. Subsequently, instead of consuming meat substitutes, alternative options were mentioned such as 'less but better meat' (local, high welfare, regeneratively farmed). These options were more apparent to consumers in the UK (11.3%) compared to Australian and Chinese (~3%) consumers. Some from the UK and Australia also commented on alternative whole food ingredients which can be utilised instead of meat substitutes when going meat-free (grains, vegetables, legumes).

"*I don't understand why when there are legumes etc. we would need to eat a meat substitute.*" (Australia, Female, 65+)

"*Can't find a substitute as the meat tastes fantastic*." (China, Female, 18-24)

"*The solution is to source sustainable meat in small quantities, local, fed with local food. Less meat but better meat both for the environment and animal welfare*." (UK, Female, 18-24)

The themes unappealing, unsafe and unsustainable were less frequently mentioned but the responses were closely linked to the themes previously mentioned. A summary of the output with corresponding quotes can be found in the Appendix.

5.5.5 *Edible insects*

Overall, the most frequently mentioned theme by all consumers related to the unappealing nature of edible insects (Table 5.4).

Table 5.4
Extremely unwilling consumers (%) who mentioned the different themes in relation to being extremely unwilling to adopt edible insects.

Theme	Topics	Total	Aus	China	UK
Unappealing	Unappealing, unacceptable, not interested, do not like, psychological barrier, food neophobia, apprehension, aversion, creepy, disgusting, disturbing, gross, scary, queasy, revolting.	76.3	53.5	92.5	79.4
	Negative sensory appeal, unpleasant appearance, aesthetically unappealing, taste revolting, unpalatable, boring, fishy, crunchy, bitty residue.	10.2	6.3	11.9	12.4
	Not a food source, eat real food, not their place in the food chain, do not want to eat my foods food.	3.9	3.9	4.4	3.1
Unnecessary	We have plentiful sources of meat/ protein to meet future population needs, would not be able to replace meat, happy with current diet, no need to eat insects.	7.3	15.7	1.3	6.2
	There are better alternatives, real meat, sustainable meat produced through regenerative agriculture, vegetarian and vegan food.	7.8	13.4	0.6	12.4
	Insects are more plausible as animal and fish food.	1.0	1.6	0.0	2.1
Unsafe	Dirty, unhygienic, pesticides, vermin, not sanitary, dirty unknown health effects, vectors for disease.	3.9	4.7	2.5	5.2
Unhealthy	Nutritionally inadequate especially compared to meat, insufficient fat levels, not a complete protein.	1.8	3.9	0.6	1.0
	Allergic to shellfish, medical condition.	1.0	2.4	0.0	1.0

Unsustainable	Insects are important to the environment, pollinators, ecology, would create an unbalance, regenerative agriculture is more sustainable.	1.3	2.4	0.6	1.0
	Welfare, insects have feelings too, sentient beings, killing the same but on a larger scale.	2.3	0.8	1.3	6.2
Disagree with information	Disagree, imaginary problem, biased statement.	1.0	1.6	0.0	2.1
Agenda pushed by others	Gives power to others, green lobby, political/ alternative agenda, politicized narrative, fascist plan, elite fraudsters.	1.8	3.1	0.0	3.1

Please note: Australia, n=127,(33%); China, n=160, (42%); UK, n=97, (25%); Total, n= 384 (100%). The % values in the table reflect the proportion of consumers who mentioned that theme within each country (e.g., for Australia, out of the 33%, (n=127) of extremely unwilling consumers, 53.5% mentioned edible insects were unappealing).

Unappealing: For many, the thought of consuming edible insects was disgusting, fear inducing and made some feel queasy. The unappealing nature was most frequently mentioned by Chinese consumers (92.5%) followed by UK (79.4%) and Australian (53.5%) consumers. The psychological discomfort towards insects was partly based on the unpleasant appearance and negative taste/texture experiences or perceptions. Subsequently, a few also stated that edible insects should not be considered as food.

"*I can't stand them living let alone as a meal*." (Australia, Male, 65+)

"*I'm scared of bugs, even if it's not made to look like a bug, but if it says it's a bug, it's still unpalatable*." (China, Female, 18-24)

"*No sensory appeal. The time I tried a bar with cricket flour in it tasted horribly fishy*." (UK, Female, 35-44)

Unnecessary: A larger proportion of Australians mentioned edible insects were unnecessary (15.7%) compared to UK (6.2%) and Chinese consumers (1.3%). In general, consumers felt there was no need for edible insects when there are plentiful sources of meat which can be produced sustainably through regenerative agriculture. Others were satisfied with their current diet and felt no real need to add edible insects. In particular, UK consumers mentioned they would rather stick to plant-based sources of protein.

"*I eat the natural Human diet. Meat, and meat-based food. Insects eat insects.*" (Australia, Male, 45-54)

"*It's not primitive. There's no need to eat insects.*" (China, Male, 55-65)

"*There is no need, we can produce adequate volumes of protein to meet the needs of the future population*." (UK, Male, 65+)

The remaining themes, unsafe, unhealthy and unsustainable were less frequently mentioned and the output is summarised in the appendix. Compared to the other alternatives, few consumers disagreed with the statement presented in the Appendix S4.1 (statement C).

5.5.6 Cultured meat

The top theme identified amongst UK and Australian consumers related to the perception that cultured meat is unnatural (42.6%, 33.9%), whilst for Chinese consumers the top theme related to the unappealing nature (i.e. scared, uncomfortable with the thought) of cultured meat (33.3%) (Table 5.5).

Table 5.5
Extremely unwilling consumers (%) who mentioned the different themes in relation to being extremely unwilling to adopt cultured meat.

Theme	Topics	Total	Aus	China	UK
Unnatural	Unnatural & processed, fake foods Frankenstein food.	33.0	33.9	12.1	42.6
Unappealing	Unappealing, do not like the thought, food neophobia; disgusting, weird, repulsive, revolting, wrong, unacceptable, dangerous, won't eat it.	13.6	10.9	33.3	11.1
	Negative sensory appeal.	2.9	1.6	15.2	0.0
Unnecessary	Nothing wrong with current meat consumption, too old to change, won't be available for a while.	3.9	5.2	0.0	1.9
	Humans have always eaten meat; we have evolved to eat meat.	2.2	3.1	0.0	0.0
	There are better alternatives, unprocessed foods, real meat, reduced meat, sustainable meat produced through regenerative agriculture.	21.5	20.8	18.2	25.9
Unsustainable	Environmentally damaging, high carbon emissions, does not allow for regenerative agriculture, energy intensive, process requires huge resources; plastic, water, land, electricity, storage, transportation, less efficient, high dependence on monocrops to feed the cells.	14.7	20.8	9.0	1.9
	Unethical, does not support/ will destroy the farming community, does not address animal welfare issues/ animals still being used.	5.4	4.2	9.0	13.0
	Unaffordable, inaccessible.	3.2	2.1	12.1	1.9
Unsafe	Unsafe, harmful, still experimental, unknown side effects, untested, will make us sick, food safety, hygiene.	8.6	8.3	12.1	7.4
Unhealthy	Unhealthy, cannot match conventional meat for nutrition.	8.6	11.5	6.1	0.0

Disagree with information	Disagree, biased view presented.	9.3	9.9	0.0	13.0
Gives power to others	Gives power/ control/ profit to others, pharmaceutical companies, big food industries, the wealthy, privileged, corporate controlled society.	7.9	7.8	0.0	13.0

Please note: Australia, n=192, (69%); China, n=33, (12%); UK, n=54, (19%); Total, n= 279 (100%). The % values in the table reflect the proportion of consumers who mentioned that theme within each country (e.g., for Australia, out of the 69%, (n=192) of extremely unwilling consumers, 33.9% mentioned cultured meat was unnatural).

Unnatural: Cultured meat was perceived as unnatural and processed with some labelling it as '*Frankenstein food'* especially amongst UK (42.6%) and Australian (33.9%) consumers compared to Chinese consumers (12.1%). In particular, the thought of food produced in a lab acted as a psychological barrier.

"Feel sick psychologically." (China, Female, 55-65)

"I won't eat anything unnatural. The concept is absolutely revolting to me."
(Australia, Female, 45-54).

"*Nothing made in a laboratory should ever grace a plate of food.*"
(UK, Male, 45-54)

Unappealing: The unnatural perception of cultured meat was closely associated with unappealing, which was mentioned more amongst consumers in China (33.3%) compared to the UK (11.1%) and Australia (10.9%). In addition, a greater proportion of Chinese consumers (15.2%) mentioned negative sensory perceptions compared to Australians (2.9%), with UK consumers not mentioning this topic. Specifically, there was a concern that cultured meat would taste and look different and lack the subtle flavours induced by food sources.

"It can only be made palatable by adding unhealthy food."
(Australia, Male, 55-65)

"Haven't tried it, but I think artificial meat is similar to cheating your senses."
(China, Female, 18-24)

"Artificial items destroy the qualities of the meat itself and will not have the characteristics of natural meat."
(China, Male, 25-34)

Unnecessary: Similar to the comments made around meat substitutes, consumers felt that cultured meat is not needed when there are better alternatives available. Specifically, consumers mentioned the consumption and enjoyment of consuming real, authentic meat and whole food alternatives most frequently amongst consumers in the UK (25.9%) followed by Australia (20.8%) and China (18.2%). UK consumers also mentioned another option would be the reduction or complete removal of meat rather than consuming cultured meat. In contrast, Australian consumers mentioned the role of regenerative agriculture in producing meat sustainably which was perceived as a more viable route compared to making meat in a lab using *'mad science'*. Australians were also the only group of consumers (3.1%) to mention the notion that humans have always eaten meat and it is therefore an evolutionary need.

"*I don't see the point in creating Frankenstein meat when we could concentrate on healthy and sustainable animal farms and stop destroying so much land by planting million-acre mono-crops to grow food that leads to obesity and increased risk such as CVD.*" (Australia, Female, 45-54)

"*I prefer to eat real natural meat.*" (China, Male, 18-24).

"*I think I'd rather just be a vegetarian than eat meat that was cultured / developed in a laboratory*." (UK, Female, 35-44).

The remaining themes, unsustainable, unsafe and unhealthy are reported in the appendix. Included are the responses from those who disagreed with the information and who felt the concept of cultured meat gives power to big food industries, pharmaceutical companies and wealthy individuals.

5.6 Discussion: Barriers

The discussion firstly reviews country differences in relation to the extremely unwilling responses and the key reasons behind the consumer responses. Key differences in motives across the protein alternatives for each country are then discussed and recommendations in relation to practical implications provided. It is worth noting that the current findings cannot be generalized to UK, Australian and Chinese (Shanghai) consumers. Future research should recruit a more nationally representative data set and should require consumers to affirm the duration of their residency in a given country. In addition, the comparatively brief responses to the open-ended questions from Chinese consumers could suggest the findings are less data rich compared to Australian and UK consumers. One suggestion could be to encourage participants to "write as much as you can" (Jaeger & Cardello, 2022).

5.6.1 Extremely unwilling responses country differences

The higher proportion of extremely unwilling responses from Australian consumers, highlights a greater resistance towards meat reduction and protein alternative adoption compared to Chinese and UK consumers as observed previously (Ford et al., 2023b). Specifically, Australians were extremely unwilling to adopt plant-based meat substitutes more than the other alternatives. This contradicts previous research which suggests overall, that plant-based meat tends to be favoured more than cultured meat and edible insects (Circus & Robison, 2019; Gómez-Luciano et al., 2019; Grasso et al., 2019; Heijnk et al., 2023; Motoki et al., 2022). By comparison, the higher proportion of extremely unwilling responses for edible insects compared to the other alternatives for Chinese and UK consumers aligns with these findings. One reason for the greater resistance amongst Australians could be due to a larger preference for whole grains and legumes compared to more processed forms of plant-based meat substitutes (Estell et al., 2021). The barriers discussed below provide further insights into the main reasons driving this response.

5.6.2 Barriers to reduce meat intake and adopt protein alternatives

The top three themes given by extremely unwilling consumers to not reduce meat and adopt protein alternatives are provided in Table 5.6. These key barriers are used as guidance for the structure of the discussion.

5.6.3 Meat consumption is not environmentally damaging, other factors are

The notion that other factors (i.e., food waste, food miles, packaging, burning of fossil fuels, international travel) are more environmentally damaging compared to meat consumption supports findings amongst a nationally representative Australian sample (Rattenbury & Ruby, 2023). These authors reported that despite an increase in awareness, consumers may still view meat as less environmentally damaging compared to other factors (e.g., public transport, renewable resources, recycling). However, previous research has claimed that meat and dairy production contributes a similar level of emissions compared to the transport sector despite many consumers perceiving the transport industry to be a bigger contributor (Bailey, 2014). In general, it is thought that what we choose to eat has far greater impact on the environment compared to food miles and packaging based on estimates that more emissions are produced during the production of meat and subsequent changes in land (i.e. deforestation required for animal feed) (Poore & Nemecek, 2018; Ritchie, 2020). However, this also simplifies the complexity of the topic, with environmental emissions varying by numerous factors (e.g., meat type, production method). Either way, the importance of what we choose to eat supports the sentiment many of the unwilling to reduce meat consumers felt. Specifically, the consumer focus should be on how meat is produced not a reduction of meat. In other words, '*it's not the cow, it's the how'* (Rodgers & Wolf, 2020).

Table 5.6. Top 3 themes mentioned by extremely unwilling consumers for each protein type across countries.

Barriers	Australia	China	UK
To reduce meat	1. Necessary for health reasons 2. Meat is not environmentally damaging 3. Meat can be produced and consumed sustainably	1. Meat consumption is normal, nice & better than alternatives 2. Meat is not environmentally damaging 3. Necessary for health reasons	1. Meat consumption is normal, nice & better than alternatives 2. Meat is not environmentally damaging 3. Necessary for health reasons
To use meat substitutes	1. Unhealthy 2. Unnatural 3. Unnecessary	1. Unnecessary 2. Unappealing 3. Unhealthy	1. Unnecessary 2. Unappealing 3. Unsustainable
To adopt edible Insects	1. Unappealing 2. Unnecessary 3. Unhealthy	1. Unappealing 2. Unsafe 3. Unnecessary & Unsustainable	1. Unappealing 2. Unnecessary 3. Unsustainable
To adopt cultured meat	1. Unnatural 2. Unnecessary 3. Unsustainable	1. Unappealing 2. Unsustainable 3. Unnecessary	1. Unnatural 2. Unnecessary 3. Unsustainable

5.6.4 Meat can be produced and consumed sustainably

Following on from the above points, some consumers felt the current depiction of meat being environmentally damaging, ignores the potential benefits of regenerative agriculture. Regenerative agriculture formed the basis of the reasoning behind the belief that '*meat can be produced and consumed sustainably*'. Australian consumers were especially knowledgeable on this topic mentioning it more frequently compared to Chinese and UK consumers. This could be in response to the bushfires in Australia, in which farmers were directly impacted which subsequently made the need for supportive and sustainable farming practices more pertinent. The higher awareness amongst consumers for this practice is likely due to Australia having one of the biggest communities of advocates promoting the natural role of ruminant animals in protecting the farming environment (Cusworth et al., 2022). Overall, these findings bring into question whether a greater level of resistance to meat reduction would also be present in other countries like China and the UK if awareness of these sustainable farming practices were more apparent and / or products produced through this method were more available.

Although regenerative agriculture offers a sustainable prospect for producing and consuming meat, which is recognised in the recent Intergovernmental Panel on Climate Change report (IPCC, 2019), it is thought to only make up a small proportion (less than 1%) of the total meat market (Friedrich, 2021). It also faces barriers towards adoption, such as it is an expensive process for farmers to transition towards (e.g., upfront costs, lack of resources) which comes with its own social stigma and fear around change (Kenny & Castilla-Rho, 2022). Subsequently, for consumer demand to increase, it will require consumers to be willing to pay more for 'clean and green' meat or for alternative cost reducing strategies to be put in place with support from government, food distributors, supermarkets and wider communities (Kenny & Castilla-Rho, 2022). In addition, regenerative farming practices vary by location, for example, a comparable strategy called 'Agriculture Green Food Development' is applied in China. Similarly, products labelled as 'green' or 'organic' are thought to be associated with higher costs but also greater levels of mistrust due to food safety scandals (Xu et al., 2020). Consequently, a middle ground between the environmental benefits of reducing meat intake and producing affordable, efficient and safe meat from sustainable practices is required. Ultimately, if consumers are motivated by the environmental benefits, whether that be associated with meat intake, reduction or consuming only sustainably grown meat, a certain level of disruption to meat production and consumption practices are required.

5.6.5 Protein alternatives are unsustainable & unnecessary

The unnecessary nature of all protein alternatives was a commonality between countries amongst extremely unwilling consumers. This theme links closely with the stance that meat can be produced and consumed sustainably, and protein alternatives are comparatively unsustainable. Consumers were less concerned about the potential unsustainable nature of edible insects compared to plant-based meat substitutes and cultured meat. Of the few consumers concerned, references related to changing the balance of the environment and ecology. Indeed, the challenges associated with the sustainable production of edible insects have been highlighted (Lange & Nakamura, 2023). As there is a risk that collecting edible insects can threaten essential ecosystems (i.e., pollination, composting, pest control) (Losey & Vaughan, 2006). Alternatively, insect farming can prevent the risks of collecting insects outside of their regenerative capacity (van Huis, 2013). In addition, a few extremely unwilling consumers commented on the sentient nature of edible insects, especially amongst UK consumers. This could be related to the UK government formally recognising animals as "sentient beings", although this does still not include edible insects (DEFRA, 2022). In general, there are a lack of welfare regulations in place for insect farming despite falling under the category of "farmed animals" within EU regulations (Delvendahl et al., 2022). New research reviewing consumer awareness and perceptions of welfare issues related to edible insects, especially in comparison to welfare and meat are required.

A stance frequently mentioned by Australian and UK extremely unwilling consumers was that meat substitutes and cultured meat are not a sustainable alternative to conventional meat. Meat substitutes were associated with the negative effects of mono-cropping, which were perceived as being harmful to soil and detrimental to long-term food security. However, it is argued, that despite a few exceptions (e.g., nuts, poultry), on the basis of protein content, growing crops for human feed is more efficient and environmentally friendly (e.g., less GHG emissions, reduced land use and lower eutrophication) than growing crops for livestock feed (Breewood & Garnett., 2023; Poore & Nemecek, 2018). Therefore, a counterview is that a reduction in meat production and subsequent consumption would reduce demand for pasture and arable land (Breewood & Garnett., 2023). Nevertheless, it seems consumers with greater awareness of monocropping are more resistant to change their behaviour.

In relation to cultured meat, the environmental benefits are largely determined by how the released land from livestock production is used (Treich, 2021). Unwilling consumers mentioned the resources required to set up factories and distribution networks would likely result in high land use and emissions. However, it has been suggested that cellular agriculture production sites could be set up closer to populated areas, reducing the need for transport (Post et al., 2023). Overall, a conclusion often provided to address conflicting views relates to a reduction in animal sourced foods, alongside mixed sustainable farming practices (grass-fed livestock, regenerative agriculture). This way the same land can potentially be maximized to accommodate for crops, grazing and fallow periods (Breewood & Garnett., 2023).

5.6.6 Meat consumption is necessary for health reasons and protein alternatives are unhealthy

Health appeared to be a substantial barrier for meat reduction and adoption of meat substitutes and cultured meat. Consumers were extremely unwilling to reduce meat based on it being a nutritional necessity in the diet; a known rationalization for meat consumption (Piazza et al., 2015). This perception was closely associated with the belief that plant-based alternatives provide insufficient nutrition. Meat is one of the most nutritious sources of food on the planet; rich in iron, zinc and Vitamin B12 (Godfray et al., 2018). It is therefore justifiable that extremely unwilling consumers object to changing their current meat diets which are, in their view, perfectly healthy. However, it is also believed that these nutrients can be obtained from a wider range of foods, although this is more feasible in high income countries (Godfray et al., 2018).

By comparison, the unhealthy perception of protein alternatives was a barrier, especially for meat substitutes which was mentioned the most by Australian consumers. In reality, processed plant-based meat substitutes are often high in sodium, saturated fats and possess inadequate sources of protein compared to conventional meat (Nezlek & Forestell, 2022; Santo et al., 2020). Subsequently, it has been observed that Australians tend to have high expectations for plant-based meat alternatives, demanding similar levels of iron and B12 to conventional meat (Estell et al., 2021). However, the reported health benefits of meat substitutes are both complex and inconclusive (Gastaldello et al., 2022) and at best speculative for cultured meat (Santo et al., 2020). Reported concerns include questions around cultured meats' nutritional quality (i.e. iron absorption, micronutrient benefits) (Chriki & Hocquette, 2020; Deliza et al., 2023). Nonetheless, these concerns may be counterbalanced by the potential to control and adjust cultured meat's fat composition allowing for healthier sources to be promoted (Chriki & Hocquette, 2020). Encouragingly, research has found edible insects to have a host of health benefits, namely prebiotic properties, improved gut health and prevention of cardiovascular disease, diabetes, cancer and high blood pressure (Van Huis & Rumpold, 2023). Although further research is required to establish these claims, health benefits may be an attribute for which edible insects can gain superiority over other protein alternatives.

5.6.7 Meat consumption is normal & nice, alternatives are unnatural & unappealing

The belief that meat is normal and nice is a well-known justification applied by meat eaters (Piazza et al., 2015). The enjoyment gained from eating meat and the inadequate taste of vegetarian diets have been previously observed as a major barrier to change (Kemper, 2020; Rosenfeld & Tomiyama, 2020). In particular, meat eaters are more likely to select that they liked the taste of meat compared to meat reducers (Kemper et al., 2023). Interestingly, the narrative that meat consumption is 'normal' and part of our ancestral needs was more embedded amongst Australian and UK consumers compared to Chinese consumers. This suggests cultural backgrounds impact consumers' relationship and rationalisation around meat, which are strongly linked with meat traditions (Leroy & Praet, 2015).

By comparison, the unappealing nature of edible insects has been widely cited and is closely linked with food neophobia and expected negative sensory perceptions (Onwezen & Dagevos, 2023; Van Huis & Rumpold, 2023). Conversely, unnaturalness was closely associated with the perception of highly processed foods, which were full of additives and chemicals in the case of meat substitutes and fake, ‘Frankenstein’ foods for cultured meat. Indeed, previous research found the biggest barrier against the possible consumption of processed meat substitutes to be unnaturalness which was intertwined with lack of trust (Varela et al., 2022). In addition, the unnatural perception of cultured meat is commonly observed (Bryant & Barnett, 2020; Pakseresht et al., 2022) and thought to be higher amongst consumers high in mistrust and fear (Wilks et al., 2021). To overcome this barrier, focusing on the unnatural nature of other conventional food has increased acceptance of cultured meat (Bryant et al., 2019).

5.6.8 Defensive and emotional responses

The belief that others, in particular non-meat eaters are behind the need to change is a common defensive mechanism observed based on the perception that this consumer group can appeal self-righteous and a threat to moral identities (Piazza et al., 2015). Extremely unwilling consumers may therefore feel more inclined than meat reducers to protect their meat-eating identity. For example, more resistant meat-eaters anticipate more vegetarian stigma (Rosenfeld & Tomiyama, 2020). Overall, the defensive and emotionally charged responses, especially for meat reduction, suggest extremely unwilling consumers can be hard to engage with. It also highlights the sensitive nature of this topic which is taken into consideration when recommending strategies to support a protein transition.

5.7 Discussion: Motivations

5.7.1 Motivations to reduce meat intake and adopt protein alternatives.

The relative importance of the food choice motives varied across countries and by protein alternative type. Considering the multiple variables involved (country, motive, protein type), the top three most important motives in each country (Table 5.7) and mean score differences ≥ 0.4 in the regression trees (Fig.5.1, 5.2) are discussed.

Specifically, these relate to environment, health, food safety, animal welfare, sensory appeal and price. For Chinese consumers, the top three motives were the same across categories (environmental benefits, food safety, health benefits). However, for UK and Australian consumers, the motivations differed, with the exception of the environmental benefits which were consistently in the top three across categories.

Table 5.7. Top 3 motives mentioned by consumers for each protein type across countries.

Motives	Australia	China	UK
To reduce meat	1. Environmental benefits 2. Health benefits 3. Food Safety	1, 2. Environmental benefits & food safety 3. Health benefits	1, 2. Environmental benefits & food safety 3. Animal welfare benefits
To use meat substitutes	1. Food safety, environmental benefits, sensory appeal & health benefits.	1. Food safety 2. Health benefits 3. Environmental benefits	1. Environmental benefits 2. Sensory appeal 3. Price
To adopt edible Insects	1. Food safety, environmental benefits & sensory appeal	1. Food safety 2. Environmental benefits 3. Health benefits	1. Sensory appeal 2. Environmental benefits 3. Food safety
To adopt cultured meat	1, 2, 3. Food safety, environmental benefits & sensory appeal	1. Environmental benefits 2. Food safety 3. Health benefits	1, 2. Environmental benefits & Sensory appeal 3. Price

***Please note**: 1,2,3 means no difference between the top three motives.*

5.7.2 Environmental benefits

Despite the environmental benefits being rated as one of the most important factors, previous research has found it to have a weak influence on meat consumption attitudes (Hartmann & Siegrist, 2017; Sanchez-Sabate & Sabaté, 2019). In particular, the lack of environmental concern associated with meat consumption has been observed amongst consumers in Australia (Hoek et al., 2017; Lea & Worsley, 2008), China (Happer & Wellesley, 2019) and the UK (Macdiarmid et al., 2016). However, in recent years this trend is starting to change amongst consumers in all three countries supporting current findings (Cheah et al., 2020; Ford et al., 2023b; Malek et al., 2019a; Wang, 2022). This is partially in response to increased attention around the meat-climate relationship often accessed through online news articles or conversations

(Bryant et al., 2023). Lived experiences associated with climate change (e.g., poor air quality in China, Bushfires in Australia, Flooding in the UK) are also likely to bring greater attention towards environmental changes.

Previous research has also recognised the environmental benefits to be a prominent motive with regards to the adoption of protein alternatives (Nguyen et al., 2022; Onwezen et al., 2021). Yet, when making comparisons across alternatives, it is interesting to find this factor was of equal or similar importance amongst consumers in Australia and the UK, respectively. This perception is somewhat valid considering preliminary estimates show cultured meat to have similar GHG emissions when compared with plant-based processed products (Tuomisto, 2019). However, it is likely that consumers have a low awareness of the differing environmental impacts of food. For example, consumers are thought to have a lack of knowledge for estimating the environmental impact of meat compared to other foods (Hartmann et al., 2022; Siegrist & Hartmann, 2019).

By comparison, Chinese consumers found the environmental benefits to be more important in the context of cultured meat. Findings support a previous study amongst consumers from Shanghai which found that environmental concerns are a strong driver for the adoption of cultured meat (Wang & Scrimgeour, 2022). However, results suggest there may be more pressure on cultured meat to prove its environmentally friendly status compared to other alternatives amongst Chinese consumers (Wang & Scrimgeour, 2022). A review of the prospects of cultured meat in China predicted a reduction in its environmental impacts including lowered GHG emissions and land use if substituted for conventional meat (Sun et al., 2015). However, it also noted that the energy usage would be higher compared to current Chinese pork production with large scale production posing a risk to biodiversity through a reduced need for grassland (Sun et al., 2015). Seemingly, further research on the overall environmental benefits of cultured meat when products are scaled up and how this impacts consumer acceptance is required.

5.7.3 *Food safety*

The importance of food safety in China has been frequently observed as a prominent motive partly due to various food safety scandals (Wang, 2022). As a result, Chinese consumers are willing to pay more for products with food safety attributes, especially pork (Yang & Fang, 2021). However, in the UK and Australia, the high scores may be a response to the pandemic which was ongoing at the time of data collection. Subsequently, consumer views on the safety of the food chain are likely to be heightened, including fear around zoonotic viruses (Krishnamoorthy et al., 2023). Findings therefore signify a shift in motivations amongst western consumers. By contrast, consumers who were unwilling to reduce meat did not show any concerns around the food safety of meat which suggests a level of trust in the meat they consume.

Regarding protein alternative type, food safety was of equal importance amongst Australian and UK participants despite each type of alternative having distinct food safety challenges associated with anti-nutrients, microbial risks and allergens (Banach et al., 2022). Conversely, Chinese consumers rated food safety attributes as the most important motive for edible insects which has previously been observed as a key concern (Liu et al., 2019) Interestingly, Chinese consumers found food safety to be less important for cultured meat compared to the other alternatives. This may relate to the sterile conditions used for cultured meat production implying a lower level of predicted contamination (Lee et al., 2020; Zhang et al., 2020a). However, as production systems become upscaled challenges associated with contamination are likely to arise (Deliza et al., 2023). Furthermore, the extent to which the more ethical ‘immortalized’ animal cells express oncogenes, which are known to have tumorigenicity, is a current gap in knowledge (Soice & Johnston, 2021).

5.7.4 Health benefits

Health benefits were equally important across countries for meat reduction, scoring in the top three for Chinese and Australian consumers. However, for the protein alternatives, they were more important to Chinese consumers. To some extent differences between countries are expected, as healthy food choices are influenced by variations in cultural exposures related partly to socio-economic status and upbringings (Enriquez & Archila-Godinez, 2022). Yet, when comparing across protein alternative type, little differences were observed within each country suggesting health is of equal importance. This could be due to the scarce number of studies reviewing the effect of long-term substitution of meat with plant-based meat substitutes, edible insects and cultured meat (Tso et al., 2020).

Health concerns have previously been considered important for meat reduction amongst Australian (Bogueva et al., 2017; Malek et al., 2019a; North et al., 2021), Chinese (Taufik, 2018; Wang, 2022) and UK consumers (Clonan et al., 2015; Eating Better, 2022; Mylan, 2018). This is likely due to positive perceptions that a reduction of excessive meat intake is beneficial in preventing and or addressing various diseases (e.g. cancer, heart disease, Crohn's disease, nutritional deficiencies) (Cheah et al., 2020). Similarly, the importance of health benefits for motivating protein alternatives is likely due to the supportive role they play in meat substitution. For example, substituting a high meat diet with plant-based meat substitutes is thought to provide health benefits namely a lower risk of cardiovascular disease (Guasch-Ferré et al., 2019). However, estimates are based on high-quality plant protein sources (e.g., legumes, soy, nuts).

5.7.5 Sensory appeal

This factor was predominantly important for Australian and UK consumers across all protein types. Indeed, numerous studies support this finding and highlight its importance for repeat consumption (Onwezen & Dagevos, 2023). In particular positive taste expectations are important for plant-based meat substitutes (Ford et al., 2023a), especially when products can be perceived as inferior in taste compared to a conventional meat (Michel et al., 2021). However, of all the alternatives, cultured meat is thought to replicate the sensory characteristics of meat the most (Post et al., 2023). However, for edible insects and cultured meat, due to the lack of commercially available products, taste is often based on predicted perceptions. In some instances, this raises expectations. For cultured meat this may be achievable as a study found consumers considered the taste of a burger labelled as 'cultured' to be slightly better, despite it being the same as the conventional burger product (Rolland et al., 2020). However, outside of a tasting context, cultured meat is thought to be less tasty compared to conventional meat (Mancini and Antonioli, 2019) with general low sensory expectations (Bryant and Barnett, 2020).

By comparison, for edible insects, one sensory study on a commercially available edible insect burger found consumer acceptance to be low, especially when compared to a beef burger (Schouteten et al., 2016). However, another study found liking for a pizza with mealworms to increase compared to perceived expectations (Ventanas et al., 2022). Indeed, familiarity is thought to increase acceptance of insects as food (Onwezen et al., 2021; Van Huis & Rumpold, 2023). Therefore, it is important that consumers have a positive first sensory experience, and in some cases, if products are indistinguishable from their conventional counterpart.

5.7.6 Price

Only UK consumers rated price within the top three important motives in relation to meat substitutes and cultured meat. Previous research has noted the importance of cost as a barrier for UK consumers wanting to consume sustainable food (FSA, 2021; Whittall et al., 2023). A brief overview of products from one UK retailer concludes that despite some meat being cheap, it is estimated that comparatively, meat substitutes are never the cheapest option (Ritchie, 2023). For cultured meat, price as a motive is understandable as one of the biggest challenges facing the cellular agricultural industry, is scaling at an affordable cost (Post et al., 2023). Although price was important to Australian and Chinese consumers, when traded-off against other attributes (e.g., health benefits and food safety) price is not as significant. Findings suggest consumers may be willing to pay a higher price if products are healthy and safe to consume. Indeed, research amongst Australians has indicated a higher willingness to pay a price premium for certain plant-based products (Estell et al., 2021).

5.7.7 Animal/Insect welfare

Although Animal / insect welfare had a lower level of overall motivation for meat reduction and protein alternative adoption compared to the prior factors discussed, it is worth noting that it had the biggest difference in mean scores between countries and protein alternative categories. Findings therefore suggest this is an important motive to consider when tailoring protein transition strategies. For meat reduction, UK consumers found animal welfare notably more important in comparison to Australian and Chinese consumers. The observed cultural differences are understandable based on differing country related animal welfare standards and practices. For example, pre-slaughter stunning, a humane animal welfare practice, is conducted by law in Australia and the UK, but is not routinely applied and mandated in China (Sinclair et al., 2023). Additionally, Chinese consumers stated they felt more comfortable watching the slaughtering processes compared to Australian and UK consumers (Sinclair et al., 2023).

The reduction or complete removal of animal involvement for meat substitutes and cultured meat is of more importance compared to the welfare of insects, especially for Australian and UK consumers. This suggests that the welfare principles may differ across vertebrates and invertebrates, and is thought to relate to phylogenetic distance, which is greater between humans and insects compared to humans and animals. The greater the phylogenetic distance, the less humans are thought to apply anthropomorphism (i.e. project humanlike characteristics to non-human agents) (Delvendahl et al., 2022; Wang & Basso, 2019).

5.8 Practical implications and future research

A meta-analysis by Onwezen & Dagevos. (2023) highlighted the need to explore across alternatives and include cross-cultural comparisons, including consumers outside of western high-income countries. Our research has contributed to addressing this knowledge gap with findings reinforcing the need for country specific protein transitions as previously stated (Ford et al., 2023b). In particular, key recommendations are provided for food producers/ marketers and policy makers to compliment the growing body of reviews suggesting strategies to reduce meat consumption (Harguess et al., 2020; Onwezen, 2022) and encourage the sustainable consumption of plant-based meat substitutes, edible insects and cultured meat (Onwezen et al., 2021; Pakseresht et al., 2022; Van Huis & Rumpold, 2023).

Previous motives in relation to meat reduction and protein alternative adoption mention the importance of health, sustainability and animal ethics (Onwezen & Dagevos, 2023). However, our study also highlights the importance of food safety as a motive for change, which is likely heightened since the pandemic. Therefore, intervention strategies that inform consumers of the safety of products could positively influence consumer acceptance towards cultured meat, edible insects and meat substitutes (Bryant & Barnett, 2020b; Tso et al., 2020; Van Huis & Rumpold, 2023). Moreover, as food safety is a personal benefit, it is likely to be more persuasive (Onwezen & Dagevos, 2023). Overall, as awareness around food safety, environmental and health benefits increases, there is a need to map changes to consumer acceptance overtime which is currently lacking (Tso et al., 2020).

The environmental benefits were equally motivating across countries for the different protein categories. Therefore, despite observed differences across countries for willingness to reduce meat/ adopt alternatives (Ford et al., 2023b), the main underlying motive towards changing behaviour is similar. Informing consumers of the environmental benefits of protein alternatives can positively influence acceptance (Weinrich, 2019), including through more informative packaging (e.g., lower carbon footprint) (Holenweger et al., 2023). Currently, there is a need for intervention strategies to increase awareness on the environmental impact of food, especially for enhanced protein alternative acceptance (Onwezen & Dagevos, 2023).

Conversely, the extremely unwilling responses bring into question whether the behaviours of these consumers could ever be shifted. Nevertheless, some general suggestions across countries include; challenging the narrative that meat is a necessity in the diet by promoting the health benefits of plant-based foods, being transparent about the sustainable nature of the land being farmed for plant-based foods (i.e., the extent of monocropping) to reduce scepticism; promoting the sentiment that ‘every change makes a difference’ in instances where consumer feel other sectors are more damaging. For the protein alternatives, the perception that they were unnecessary was a communal belief across countries. One solution to tackling this negative perception is to provide an alternative frame. For example, a counter narrative could be the unnecessary pain and suffering animals currently endure which could be alleviated by protein alternatives (Katz-Rosene et al., 2023). Replacing animal sourced protein with a variety of alternative protein sources will be necessary to reduce GHG emissions, mitigate the climate crisis and to maintain global food security (Katz-Rosene et al., 2023; Willett et al., 2019).

5.8.1 Strategies to implement in Australia

Of the three countries, Australians had the greatest proportion of extremely unwilling consumers, especially towards meat reduction and meat substitute acceptance. Findings therefore suggest a greater resistant to changing behaviour likely due to meat consumption being deeply embedded within Australian cultural norms (Sievert et al., 2022). Although meat reduction may not be imminent, there is potential for Australian consumers to transition towards consuming meat only from sustainable sources. In particular, the interest extremely unwilling consumers revealed in supporting regenerative agriculture should be taken advantage of. Future research should better understand whether this is a viable option for the average consumer and the possible barriers consuming only regeneratively famed meat poses for the individual (e.g., higher cost, limited availability). Considerations should also be given towards the wider implications of promoting regeneratively farmed meat on the meat industry and environmental, public health goals. Currently, it’s thought that meat reducers are more likely to report changes towards purchasing more sustainable meat products (e.g., Australian produced, Certified Humane, Organic) compared to committed meat eaters (Malek et al., 2019b).

For Australians who are to some extent willing to change, the health benefits of meat reduction and meat substitutes needs to be promoted. Arguably, for plant-based meat substitutes to be a success, they need to be healthy and or nutritionally comparable to conventional meat. In addition, sensory appeal was particularly applicable to Australian consumers across the alternatives. For plant-based meat substitutes, exploring which composition and recipe is most preferred could highlight the best avenues to proceed with. For example, a study amongst French consumers found Mycoprotein to be the most preferred, mostly due to texture (Cordelle et al., 2022). Likewise, for edible insects, understanding which sensory attributes drive consumer acceptance will be key. Especially considering consumers are more willing to adopt edible insects, compared to meat substitutes and cultured meat (Ford et al., 2023b). Therefore, this indicates a great potential in Australia to promote edible insects as suitable protein alternatives. However, a number of factors influence the sensory profile of insects (e.g., product type, processing, species, packaging, storage) which need to be better understood (Mishyna et al., 2020; Wendin & Nyberg, 2021). Currently, it is thought Australians are more likely to consume insects when hidden and unrecognizable within a product or mixed into a dish (Wilkinson et al., 2018).

5.8.2 Strategies to implement in China

For Chinese (Shanghai) consumers, food safety continues to be an important motive, especially for protein alternatives, such as edible insects. A study by Liu et al. (2019) recommended implementing effective government policy to ensure the production of edible insects follows strict safety guidelines. In addition, trust in the government's food safety regulations is also relevant for cultured meat (Zhang et al., 2020b). In the context of meat substitutes, safety in the ingredients used is likely to be imperative. China has a long history of consuming a variety of meat substitutes e.g., tofu, therefore the greater familiarity is likely to enhance consumer trust, with consumers thought to be more open to products, which could be further promoted (Wang, 2022).

Overall, messaging campaigns that positively promote the hygienic conditions edible insects are farmed under and the sterile conditions cultured meat is produced in could re-assure consumers and increase acceptance. Additionally, further highlighting the food safety risks associated with intensive farming practices provides a counter narrative that could accelerate behavioural change. Lastly, the high proportion extremely unwilling consumers perceiving edible insects as unappealing should be explored. In particular, more research reviewing strategies to counter food neophobia towards insects is required (Onwezen & Dagevos, 2023). Some solutions include culinary education programmes, collaborative and innovative marketing strategies from policy makers and private business (Liu et al., 2019).

5.8.3 Strategies to implement in the UK

For UK consumers, the importance of price as a motive for meat substitute and cultured meat acceptance should be explored. Most likely this is reflective of the ongoing cost of living crisis. However, understanding consumers' willingness to pay towards alternatives could help understand expectations and consumer acceptance. Currently it is thought that UK consumers are willing to purchase plant-based meat substitutes the most (approx. 58% of consumers) and cultured meat the least (approx. 20%) (Gómez-Luciano et al., 2019). Yet, when compared to hybrid and beef burgers, UK consumers were least willing to purchase plant-based burgers (Grasso et al., 2022). However, it is thought that in promoting the perceived benefits of cultured meat, consumers may be willing to pay a price premium (Rolland et al., 2020). Furthermore, price incentives such as subsidies have been successful in increasing the adoption of alternatives, but greater research is needed (Onwezen & Dagevos, 2023; Taufik et al., 2019). Ultimately, protein alternatives will need to not just be price competitive, but ideally cheaper than conventional meat.

In addition, sensory appeal was also important to UK consumers across the alternatives. As mentioned for the Australian consumers, future research should better explore which sensory attributes consumers seek and or prefer within each of the protein alternative categories. Despite technological advancements in replicating the taste and texture profiles of meat products, challenges still remain (Tso et al., 2020). However, it is recommended that companies focus on taste and texture as the main attributes influencing liking (Sogari et al., 2023). It may be that food developers need to create different recipes and blends to meet a variety of consumer needs.

5.9 Conclusion

Overall, our findings add to the existing knowledge regarding the importance of product related motivations in driving change towards a protein transition. Importantly, this study has compared motives for meat reduction alongside a range of protein alternatives within a cross-sectional context. The most important motivations for meat reduction and protein alternative adoption, irrespective of cultural backgrounds, relates to environmental benefits and food safety. This is reflective of current concern around climate change and our post-pandemic status. It also signifies the inclusion of these factors alongside health benefits which has been a long-standing motive. However, these motivational factors are equally contested as barriers to change, especially in terms of being negative to health and the environment.

Findings also provide a novel insight into extremely unwilling consumers mindsets, which are currently an under-explored consumer group. The emotional and sometimes angry and defensive responses given towards the concept of reducing meat consumption and being willing to adopt protein alternatives indicates the sensitive nature of this topic. It also highlights that perhaps many of the unwilling consumers overlooked the sentiment of the question which was focused on meat reduction and not a complete removal of meat. Therefore, it is important to communicate the need to take a balanced approach and the supportive role of alternatives when encouraging protein transitions. In particular, the type of protein alternative needs to be considered on a country basis (Ford et al., 2023b), and the appropriate motivations leveraged to increase acceptance.

Chapter 6

Meat Attachment: Exploring differences associated with age, gender and personality traits. A cross-cultural study

Highlights:

- *The Meat Attachment Questionnaire (MAQ) had good model fit and high validity across countries.*
- *Australian consumers scored significantly higher in overall meat attachment followed by Chinese and UK consumers.*
- *The MAQ dimensions, hedonism and affinity, scored the highest in all three countries.*
- *High meat attachment was associated with males with low neuroticism scores in the UK, consumers aged 34-54 with low neuroticism scores in Australia and females with high neuroticism scores in China.*

Meat Attachment: Exploring differences associated with age, gender and personality traits. A cross-cultural study

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Abstract

The over-consumption of meat continues to be a prevalent issue in many affluent nations, despite known environmental and public health issues. Meat Attachment (MA) (a positive relationship with meat consumption) is associated with high meat intake and a lower willingness to reduce. Evaluating survey data collected from three countries n=1,777 (Australia, China, UK), this study aimed to understand the influence of age, country, gender and personality traits on MA, which are yet to be explored in the literature. Multi-group Confirmatory Factor Analysis (CFA) was performed to verify the configural model 'fit' for the factorial constructs of the Meat Attachment Questionnaire (MAQ). The model fit results demonstrated good overall fit and high reliability, with construct and discriminant equivalence, meaning the MAQ dimensions were interpreted well within each country. Overall, Australian consumers were significantly higher in MA, followed by Chinese and UK consumers. Comparing the mean scores for the MAQ dimensions (hedonism, affinity, entitlement, dependence) showed affinity (a liking for meat) to be the highest scoring factor and dependence (reliance on meat in the diet) the least in all three countries. Regression Tree analysis found high MA scores to be associated with; males with low Neuroticism scores in the UK, females with high Neuroticism scores in China and 35–54-year-olds with low Neuroticism scores in Australia. Findings demonstrate the importance of considering cultural differences, age, gender and personality traits when reviewing MA. Additionally, consumer segments to target in social marketing campaigns are highlighted and potential strategies to reduce MA are discussed.

6.1 Introduction

Meat continues to be widely consumed despite growing scientific evidence of its high environmental impact (Poore & Nemecek, 2018; Xu et al., 2021). Although meat provides essential nutrients, over-consumption contributes to negative human health and environmental effects (Godfray et al., 2018). With an increase in global protein demand to meet growing populations, changing dietary patterns which reflect a reduction in animal-sourced foods and an increase in alternative proteins is therefore increasingly advised to help support a sustainable future (Springmann et al., 2018; Willett et al., 2019). For many meat-eaters, reducing their meat consumption creates a moral dilemma. This dilemma is appropriately named the 'meat-paradox', in which, the presence of an emotional human-animal bond does not reflect their broader meat-eating behaviour (Loughnan et al., 2010). Based on the theory of cognitive dissonance, it relates to the conflict individuals may feel if a behaviour does not match a belief or attitude (Rothgerber, 2020). Psychological traits, such as being attached to meat, provide insights as to why some meat-eaters apply cognitive dissonance and justify eating meat for different reasons, such as for pleasure, due to dependence or a sense of entitlement.

Meat attachment (MA) is described as a subconscious emotional behaviour which in essence relates to a positive relationship towards meat consumption (Graça et al., 2015a). Consumers with high MA are less willing to reduce meat (Szczebyło et al., 2022), less likely to follow a plant-based diet (Circus & Robison, 2019; Graça et al., 2015a) and accept plant-based meat alternatives (Bakr et al., 2022; Profeta et al., 2021b). In general, highly meat attached consumers are thought to demonstrate less sustainable food consumption behaviours. Therefore, decreasing MA is an important challenge that needs to be addressed to aid meat reduction (Van Dijk et al., 2023).
To provide an in depth understanding of the positive relationship with meat, the Meat Attachment Questionnaire (MAQ) was developed by Graça et al. (2015a). The MAQ consists of sixteen statements with four factorial constructs relating to; hedonism (i.e., the joy gained from eating meat), affinity (i.e., overall liking for eating meat), entitlement (i.e., the right to eat meat) and dependence (i.e., reliance on meat in the diet). Previous literature has mainly explored differences in MA based on socio-

demographic and socio-cultural factors. For example, men have consistently been identified as being higher in MA compared to women (Dowsett et al., 2018; Graça et al., 2015a; Lentz et al., 2018). Whilst on the country level, omnivores in the Netherlands were higher in MA compared to Finnish participants (Van Dijk et al., 2023), India was significantly lower in MA compared to China and the USA (Bryant et al., 2019) and Danish consumers scored affinity higher, and entitlement lower compared to Spanish and British consumers (Banovic et al., 2022). In addition, New Zealand consumers found some of the MA dimensions (affinity, dependence and entitlement) to be more important determinants of willingness to adopt a more plant-based diet compared to Chinese consumers (Wang & Scrimgeour, 2021). In terms of age, there are not many studies reviewing the relationship with MA. One study found consumers aged 25-40 years-old to be high in MA (Szczebyło et al., 2022), but associations have not yet been explored from a cross-cultural perspective which could provide interesting insights.

Another psychological construct worth exploring, is the role personality traits play in predicting consumption habits. Traits are often described in the context of the Five Factor Model which encompass the Big Five (Digman, 1990); Openness (i.e., curious, imaginative), Conscientiousness (i.e., thorough, productive), Agreeableness (i.e., considerate, forgiving), Extroversion (i.e., talkative, outgoing) and Neuroticism (i.e., emotionally unstable, anxious). Literature has described the link between personality traits and food choice (Machado-Oliveira et al., 2020). For example, more open, conscientious and extroverted young adults consumed more plant-based foods (Conner et al., 2017). Whilst a study with middle-to-older adults found healthy eating habits to be associated with more agreeable, conscientious, open and less neurotic individuals (Weston et al., 2020). In relation to dietary preferences, non-meat eaters are found to be more open (Holler et al., 2021; Pfeiler & Egloff, 2018a), but also more neurotic compared to meat-eaters (Forestell & Nezlek, 2018). Additional research has also found meat consumption to be negatively associated with Openness as well as Agreeableness and Conscientiousness (Keller & Siegrist, 2015; Pfeiler & Egloff, 2018b). Extroversion was likewise associated with higher overall meat consumption (Pfeiler & Egloff, 2018c; Tiainen et al., 2013).

To the best of our knowledge, the relationship between MA and the Big Five personality traits is yet to be explored. Therefore, the outcome is relevant for targeted social marketing campaigns using consumer segmentation tactics. To understand cultural differences related to these psychological traits, responses from Australia, China and the UK were compared. These counties represent different cuisines, specifically Western (Australia and the UK) versus Asian. Furthermore, the three countries have differing meat-eating habits, with Australia having one of the highest per capita meat intakes in the world and China representing a rapid increase in meat consumption (FAO, 2022).

The initial study objective was to validate the universal properties of the MAQ and to contribute to the literature on the nations previously studied (Bryant et al., 2019; Graça et al., 2015a; Lentz et al., 2018). Additional objectives include: exploring cross-cultural differences in the four MA dimensions and understanding the influence of age, gender, country and personality traits on overall MA. Results built on current findings reviewing the influence of age and gender on willingness to reduce meat and willingness to adopt protein alternatives amongst the same consumers (Ford et al., 2023b).

Based on the literature, the hypothesis was that MA differed based on country and gender, with Australian consumers and males more attached to meat. Considering differences in meat consumption have been observed for age and personality traits, the hypothesis is that these factors will also influence MA. Specifically, younger consumers and those who are more extroverted and less agreeable, conscientious, neurotic and open are more likely to be associated with greater MA.

6.2 Materials and method

6.2.1 Participants and questionnaire measurements

A total of 1,777 meat-eating participants from Australia (n= 503), China (n= 785) and the UK (n= 489) completed an online survey. The UK and China surveys were approved by the University of Nottingham's Faculty of Medicine and Health Sciences Ethics Committee (UK Ref. number: 89-0820; China Ref. number: 154-0121), and the

Australian survey was approved by the Human Research Ethics Committee at the University of Adelaide (Ref. number: H-2021-022).

The survey also collected additional data in relation to willingness and motivations to reduce meat and adopt protein alternatives (plant-based meat, edible insects and cultured meat) which have been published (Ford et al., 2023b). There were also questions pertaining to consumers' perceptions towards sustainable diets and the environmental impact of food. The questionnaire was piloted in the UK (n=13), Australia (n=5) and in China (n=12) to address any errors. The survey recruited participants throughout October 2020 to June 2022 in the UK and Australia and within the city of Shanghai in China. The survey link was circulated across various social media platforms and utilised snowball sampling through email chains. To address initial skews towards female participants, Facebook Ads were used to recruit males in the UK and Australia and a market research agency (Credamo, China) was utilized in China.

In total, 2,504 consumer responses were collected, however non-meat eaters n=460 (Australia n = 123, China n= 161, UK n= 176) and invalid responses n=987 (Australia n= 25, China n= 946, UK n= 16) were removed. Invalid responses were identified as consumers whose dietary preferences did not match self-reported meat intake and completion times <15 minutes. The relevant socio-demographic measurements of interest in this study (age, gender) for the validated responses are reported in Table 6.1. Both the MAQ and the personality trait statements followed a back-translation process from English into Chinese by two native Mandarin speakers. The questionnaire statements were also piloted in China (n=12). The final translated statements can be found in the Appendix (Tables S6.1 and S6.2).

Table 6.1
Socio-demographic characteristics of the sample (n=1,777) expressed as (%) within each country

	Australia n= 503	China n= 785	UK n=489
Gender			
Male	39.6	50.8	40.9
Female	58.1	48.2	58.1
Other/prefer not to say	2.4	1.0	1.0

Age (years)			
18 – 34	23.0	65.9	52.9
35 – 54	34.6	14.8	18.4
55 – 65+	41.8	19.4	28.3
Prefer not to say	0.6	0	0.4

6.2.2 Meat Attachment Questionnaire

The MAQ was applied with the sixteen statements presented on a fully labelled 7-point scale with the anchors ‘strongly disagree (1)’ to ‘strongly agree (7)’. It must be noted that during the piloting of the questionnaire, the original wording of the hedonism statement ‘A good steak is without compromise’ created confusion. Therefore, the wording was changed to ‘Nothing is comparable to a good steak’.

To date, the MAQ has been used in numerous studies exploring the following topics; meat consumption, willingness to reduce meat and willingness to adopt a plant-based diet (Lentz et al., 2018; Roozen and Raedts, 2022; Szczebyło et al., 2022; Wang & Scrimgeour, 2021), the influence of parental MA on children’s diets (Erhardt & Olsen, 2021), the influence of the ‘meat-animal’ connection on MA (Dowsett et al., 2018), the interrelationship between MA and the 4N’s (Roozen & Raedts, 2022), masculinity and meat (De Backer et al., 2020) and attitudes towards meat hybrids (Asioli et al., 2023; Banovic et al., 2022; Profeta et al., 2021a, 2021b; Tarrega et al., 2020; Van Dijk et al., 2023). The aforementioned studies were used amongst consumers in Australia, Belgium, Finland, Germany, Netherlands, Poland, Portugal and Spain, whilst cross cultural-studies compared consumers in Canada and Kuwait (Bakr et al., 2022), USA, India and China (Bryant et al., 2019), China and New Zealand (Wang and Scrimgeour, 2021), Denmark, Spain and the UK (Banovic et al., 2022; Asioli et al., 2023).

6.2.3 Big Five Personality Traits

Personality traits were measured using the shortened version of the Big Five Inventory (BFI-S; Gerlitz & Schupp., 2005). Adapted from the original 44-item scale (John et al., 1991), the shortened version includes 15 statements designed to measure the Big Five factorial constructs of personality (Openness, Conscientiousness, Agreeableness, Extroversion and Neuroticism). Statements were presented on a fully labelled 7-point scale to ensure consistency with the other scales. The anchors 'strongly disagree (1)' to 'strongly agree (7)' were applied and preceded by the text, 'I see myself as someone who…'.

To date, the BFI-S has been applied to explore how personality correlates to meat consumption (Pfeiler & Egolf, 2018b, 2018c) and vegetarian diets (Pfeiler & Egloff, 2018a). It has also demonstrated strong validity compared to other personality measurement tools (Hahn et al., 2012), as well as being a satisfactory substitute for the longer version (Donnellan & Lucas, 2008). Although the BFI-S has predominantly been applied in Germany, translated versions have also been used amongst consumers in the UK as part of the British Panel Household survey (Taylor et al., 2009) and amongst Chinese consumers (Xing et al., 2020). By comparison, a longer version of the BFI has been applied to Australian consumers (Pfeiler & Egloff, 2018c).

6.3 Data Analysis

XLSTAT version 2022.2.1 (Addinsoft, 2023) and AMOS version 28 (IBM SPSS, 2021) were used as the statistical tools, with a 5% significance level.

6.3.1 CFA on the country level: Establishing model fit for the MAQ

To establish a baseline model, the four-factor structure of the MAQ was initially assessed within each country separately using Confirmatory Factor Analysis (CFA). This preliminary step provided valuable insights into the structure within each group and allowed for a conceptually consistent model to be applied cross-culturally (Fischer and Karl, 2019).

Maximum likelihood was used as the extraction method due to its suitability with multivariate data sets, violations of normality and large sample sizes (Kline, 2016). The first variable on each construct (latent factor) was set to a metric value of 1.0 to act as a reference point for the other indicators. To establish model fit, the chi-square degrees of freedom ratio (χ^2/ df) with a value ≤3 is considered a reasonably good indicator of model fit (Kline, 2016).

However, this statistic is known to be sensitive to detecting differences in large sample sizes (Egolf et al., 2019; Putnick & Bornstein, 2016). Therefore, the following alternative fit indices were also included; Root-mean-square error of approximation (RMSEA) (Browne & Cudeck, 1992) with values ≤ 0.08 for acceptable fit and ≤0.05 for good fit, and the comparative fit index (CFI) (Bentler, 1990) with values ≥0.90 for acceptable fit and ≥0.95 for good fit (Hu & Bentler, 1999; McDonald & Ho, 2002).
Construct validity (i.e., are the statements measuring the intended construct) was established by reviewing the composite reliability (CR) of the subscales to test for internal consistency of the items on their respective latent factors, with values ≥0.7 considered acceptable (Hair et al., 2018). Furthermore, standardized factor loadings for each item were reviewed with values >0.5 considered acceptable and >0.7 ideal (Hair et al., 2018).

Convergent validity (i.e., are the statements sharing a high proportion of variance in common) was established by reviewing the average variance extracted (AVE) with acceptable values >0.5 (Fornell & Larcker, 1981; Hair et al., 2018). To assess discriminant validity (i.e., how different are the factors from each other) ideally the AVE estimates should be greater than the squared inter-factor correlation estimates (Fornell & Larcker, 1981; Hair et al., 2018).

6.3.2 Multi-group CFA: Exploring construct and measurement equivalence across countries

A multi-group CFA was applied to understand if the model was identical across groups to provide additional insights to the country level CFA analyses. Following a stepwise procedure (Steenkamp & Baumgartner, 1998), Metric invariance (also known as weak factorial) and scalar invariance (also known as strong factorial/ intercept invariance) were assessed to understand the equivalence of factor loadings and item intercepts across the three countries (Putnick & Bornstein, 2016). To allow for comparisons to be made, the regression weights and the intercepts are set to be equal across groups. Firstly, the configural model (no constraints) is compared with the metric model in which the regression weights of the factors are constrained to be equal. The metric model is then compared with the scalar model in which the intercepts are constrained to be equal.

The chi-square (χ^2) goodness of fit (i.e., difference test) was applied to understand invariance across countries by comparing the baseline model with a nested model (Kline, 2016). Invariance was established with a non-significant χ^2 , however as this can be sensitive to large sample sizes, changes to the CFI values ≤0.01 and RMSEA ≤0.015 were also reviewed (Chen, 2007; Cheung & Rensvold, 2002). In the presence of non-invariance across groups, partial invariance was established by releasing constraints in a sequential process (Putnick & Bornstein, 2016).

6.3.3 Correlations, ANOVA and Regression Tree Analysis

The latent means and bivariate correlations were reviewed overall and within each country to understand cross-cultural differences in MA and personality traits. A two-way Analysis of Variance (ANOVA) was conducted (country*MA dimension) to compare the differences between groups. Identified significant differences were reviewed using Tukey's Honest Significant Difference (HSD).

One-way ANOVA was applied to understand the variation in covariates (age, gender, personality traits) across countries for overall meat attachment. Regression Tree Analysis with the Chi-squared Automatic Interaction Detector (CHAID) algorithm was applied to explore the influences of age, gender and personality traits on overall MA. To prevent overfitting, the minimum number of observations to allow for a split was set at 5%. Additional tree parameters included a 5% merge threshold, 5% significance and a maximum tree depth of 3.

6.4 Results

6.4.1 CFA: Validation of the MAQ within each country

Preliminary analyses of the MAQ using CFA revealed reasonable model fit within each country (Appendix Figs. S6.1a – S6.1c). To improve model-fit, the modification indices were reviewed to help identify certain parameters where restrictions could be removed to help reduce the chi-square value. Subsequently, error term correlations (i.e., when the relationship is not fully represented) were included to assist in the reduction of the chi-square value. As shown in Fig. 6.1, this related to the statements A3 = 'meat reminds me of diseases' and A4 = 'by eating meat I'm reminded of the death and suffering of animals', which had the largest modification index (43.72) in the UK sample. It seems reasonable to assume these statements would be linked as they broadly relate to the topic of animal welfare. In addition, error term correlations were included between the statements D4 = 'If I couldn't eat meat I would feel weak' and D5 = 'If I was forced to stop eating meat I would feel sad' which had the largest modification index in the Australian (29.98) and Chinese (123.46) samples. Error term correlations have been included between these statements in a previous study with the justification that both are suggesting the concept of meat being absent from the diet (Lentz et al., 2018). Applying the baseline model in Fig. 6.1 in all three countries established good model fit for all sixteen statements (CFI ≥ 0.95 and RMSEA ≤ 0.08), with the Australian data having the best model fit (CFI= 0.97, RMSEA= 0.06) (Fig. S6.1a). The standardized factor loadings and the inter-correlations between the MA factors for each country can be found in the Appendix (Table S6.3 and Tables S6.4a – 6.4c).

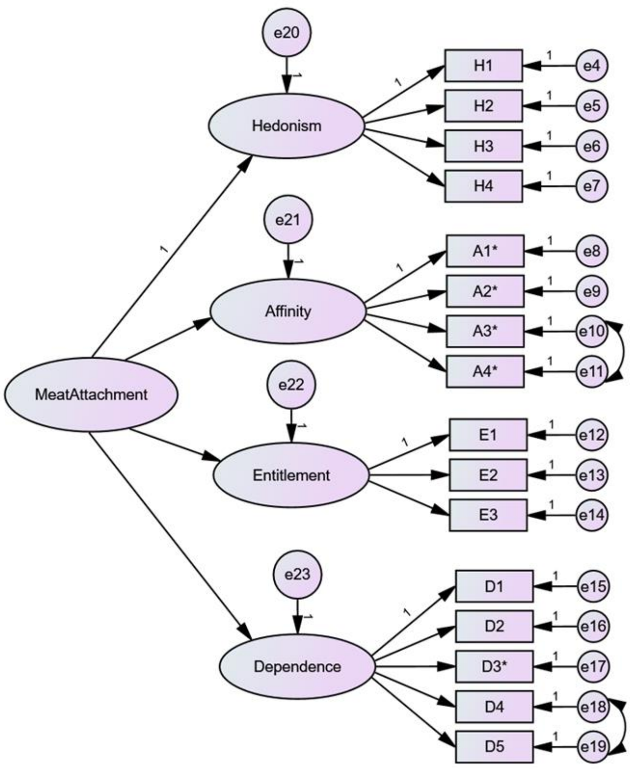

Fig. 6.1. Baseline model of the MAQ. The model includes the four latent factors (subscales) and one second order dimension (overall MA). Error-covariances are included between e10 and e11 as well as e18 and e19. Please note * indicates reverse scored items. Please refer to Table S6.1 for the statements related to each code.

6.4.2 Multi-group CFA and measurement invariance testing for the MAQ

To test whether the MAQ can be compared across countries and therefore to provide additional insights beyond the country level CFA's with regards to statement interpretation, a multi-group CFA was conducted. Results established good overall fit (χ^2/ df = 3.69, CFI= 0.96, RMSEA= 0.04) despite a significant chi-square ($p<0.001$) (Table 6.2, Model 1). The standardized factor loadings for the entire sample were significant and ranged from 0.623 to 0.887 and the CR and AVE values were also within the acceptable thresholds (Table 6.3). Intercorrelations between the MAQ factors for the entire sample are presented in Table 6.4. All correlations were significant, with dependence, hedonism and entitlement correlating highly (>0.76). Together, these results demonstrate configural invariance (i.e., same factor structure) across the three countries.

Comparing the configural model to the metric model which constrained all factor loadings to be equal across the three countries (Table 6.2, model 2), there was a significant increase in chi-square ($\Delta\chi 2$ (30) = 306.57, $p<0.001$). However, the alternative fit indices did not change much (ΔRMSEA= 0.004, ΔCFI= 0.015) and the overall model fit was still acceptable which to some extent suggests metric invariance of the factor loadings. Further examination of the factor scores and modification indices found the Chinese sample set to be driving the increase in chi-square. Attempts were made to relax the parameters, one item at a time, to explore the drivers of non-invariance but no clear items could be identified. However, the partial metric invariance achieved between the Australian and UK sample (Table 6.2, model 3) provides further evidence that in the Chinese sample, each item is contributing differently to the latent construct. This implies the dimensions are interpreted differently amongst Chinese consumers compared to Australian and UK consumers.

Introducing constraints on the item intercepts (Table 6.2, model 4) scalar invariance was not supported as reflected by the significant increase in chi-square square ($\Delta\chi 2$ (62) = 1,402.42, $p<0.001$) and the deterioration in practical fit indices. However, placing constraints on the item intercepts on the invariant factor loadings (Table 6.2, model 5) also did not establish scalar invariance between the UK and Australia.

Collectively, these results show that the factor structure is the same across countries, but the factor loadings and scales are different. It is worth noting that the MAQ is a relatively comprehensive measure of the narrow domain of meat attachment and the data here highlights the challenges to achieve consistency for cross-cultural data. Although scalar invariance was not achieved, the results can still be meaningful, but caution would need to be taken when comparing group scores as a systematic bias (e.g., when comparing meat attachment across countries) could exist.

Table 6.2
Multi-group CFA for the MAQ, invariance levels and model fit change

Model number and description	χ^2	*df*	χ^2 / *df*	Δ*df*	*p*	RMSEA	ΔRMSEA	CFI	ΔCFI
1. Configural	1083.82	294	3.686			0.039		0.958	
2. Metric	1390.39	324	4.291	30	<0.001	0.043	0.004	0.943	0.015
3. Partial metric	1097.818	304	3.61	10	0.173	0.038	0.001	0.957	0.001
4. Scalar	2486.235	356	6.984	62	<0.001	0.058	0.019	0.885	0.073
5. Partial scalar	1287.068	315	4.09	21	<0.001	0.053	0.014	0.948	0.01

Partial metric and scalar invariance relate to freeing the following parameters across the UK and Australia H4,A2,D2,D4,D5 and allowing China to be freely estimated for all parameters.

Table 6.3
Standardized factor loadings for the combined data set (n=1,777) for the MAQ

Latent factor and item	Standardized factor loading	CR	AVE
Hedonism			
H1= To eat meat is one of the good pleasures in life	0.837	0.90	0.69
H2= I love meals with meat	0.849		
H3= I'm a big fan of meat	0.887		
H4= Nothing is comparable to a good steak	0.747		
Affinity		0.83	0.55
A1= I feel bad when I think of eating meat*	0.765		
A2= To eat meat is disrespectful towards life and the environment*	0.836		
A3= Meat reminds me of diseases*	0.623		
A4= By eating meat I'm reminded of the death and suffering of animals*	0.724		
Entitlement		0.86	0.66
E1= According to our position in the food chain, we have the right to eat meat	0.803		

E2= To eat meat is an unquestionable right of every person	0.793		
E3= Eating meat is a natural and undisputable practice	0.846		
Dependence		0.88	0.59
D1= Meat is irreplaceable in my diet	0.857		
D2= I don't picture myself without eating meat regularly	0.857		
D3= I would feel fine with a meatless diet*	0.737		
D4= If I couldn't eat meat I would feel weak	0.682		
D5= If I was forced to stop eating meat I would feel sad	0.697		

Please note: CR = Composite Reliability. AVE = Average Variance Extracted. Reverse scored items indicated by *.

Table 6.4
Mean, Std. dev, and Pearson correlations of the MAQ and the BFI for the entire sample (n=1,777)

Variables	Mean ± SD	1	2	3	4	5	6	7	8	9	10
1. Entitlement	4.54 ± 1.49	**1**									
2. Dependence	4.25 ± 1.51	**0.79**	**1**								
3. Hedonism	4.78 ± 1.44	**0.76**	**0.83**	**1**							
4. Affinity	5.26 ± 1.32	**0.60**	**0.63**	**0.64**	**1**						
5. Overall MA	4.69 ± 1.23	**0.88**	**0.94**	**0.92**	**0.79**	**1**					
6. Agreeableness	5.33 ± 0.94	**0.11**	**0.10**	**0.09**	**0.14**	**0.12**	**1**				
7. Conscientiousness	5.31 ± 1.04	**0.24**	**0.22**	**0.18**	**0.22**	**0.24**	**0.38**	**1**			
8. Neuroticism	3.86 ± 1.31	**-0.28**	**-0.22**	**-0.27**	**-0.28**	**-0.29**	**-0.23**	**-0.41**	**1**		
9. Extraversion	4.69 ± 1.20	**0.14**	**0.12**	**0.13**	**0.09**	**0.13**	**0.31**	**0.36**	**-0.40**	**1**	
10. Openness	5.26 ± 0.97	-0.04	-0.02	-0.01	-0.07	-0.03	**0.21**	**0.25**	-0.08	**0.33**	**1**

Please Note: Values in bold denote statistical significance at the 95% level.

6.4.3 Cross-cultural differences in meat attachment

Overall, ANOVA found a significant country effect, where Australian participants were significantly ($p<0.001$) higher in MA (M=5.2, SD=1.4), compared to the Chinese (M=4.6, SD=1.0) and UK participants (M=4.3, SD=1.2). Significant interactions ($p<0.05$) between country and MA dimensions (hedonism, affinity, entitlement, dependence) were also found (Fig. 6.2). Australian participants scored significantly higher than Chinese and the UK for all four dimensions. However, Chinese consumers scored significantly higher for dependence and entitlement, but lower for affinity than UK participants. The variations in scores could be related to differences in language interpretations (English versus Chinese version) and cultural answering patterns (e.g., scale usage and extreme scoring). In this instance, it would be expected that similar scores are observed amongst Australian and UK consumers based on language and westernised cultures. However, as China often scores somewhere between Australia and the UK, it reduces the possibility of these factors and instead highlights scale validity as an alternative explanation.

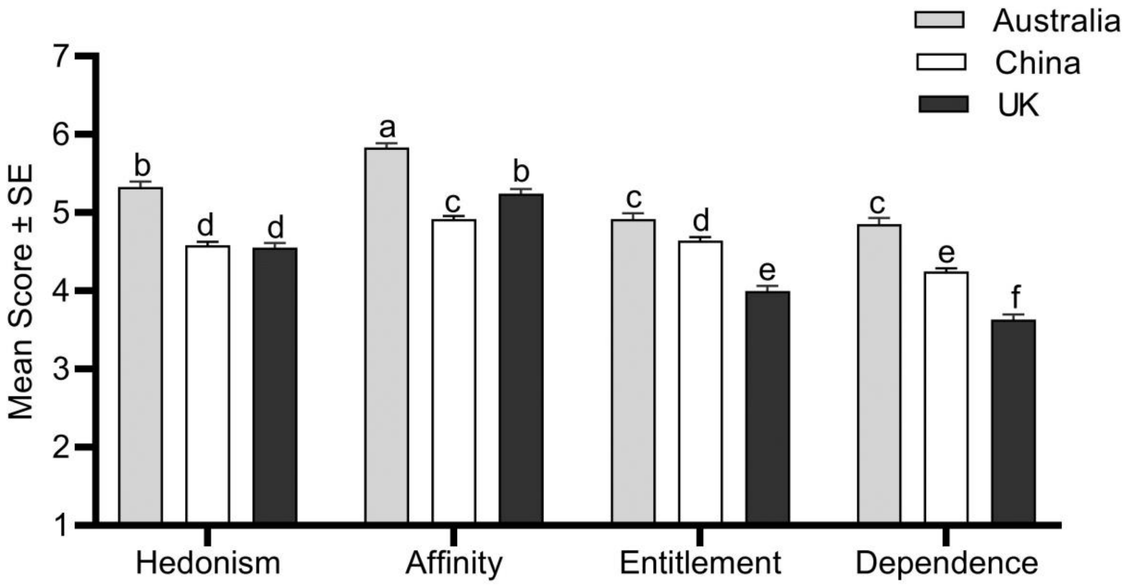

Fig. 6.2. Overall MA scores for each dimension between countries. **Please note:** Different letters denote significant difference ($p \leq 0.05$). The original scale: 1=Strongly disagree, 2= disagree, 3= somewhat disagree, 4= neither agree nor disagree, 5= somewhat agree, 6= agree, 7= strongly agree.

6.4.4 Age, gender and personality traits within each country

The BFI-S personality trait scale was found to be consistent and robust within each country as indicated by the Cronbach's alpha values ≥0.50 (Table 6.5). Reliability analysis of the 15 statements revealed an acceptable overall average Cronbach α of 0.7 in each country (Tavakol & Dennick, 2011). Scores were therefore equal to or greater than the Cronbach's alpha values previously reported in studies applying the BFI-S (Pfeiler & Egloff, 2018b; Xing et al., 2020). As expected, most of the correlations were relatively weak between traits, indicating clear distinctions between the personality dimensions (Table 6.5).

Table 6.5
Cronbach Alpha Values of the BFI Personality Traits

Personality Trait	Aus	China	UK
Conscientiousness	0.68	0.68	0.74
Extraversion	0.77	0.70	0.82
Agreeableness	0.61	0.62	0.62
Neuroticism	0.80	0.64	0.82
Openness	0.59	0.75	0.57

One-way ANOVA explored differences in overall MA across the covariates (Table 6.6). The mean values for age, gender and three of the personality traits (Conscientiousness, Neuroticism, Openness) were found to be significantly different ($p < 0.01$). However, no significant difference was observed for Extraversion ($p = 0.057$) and Agreeableness ($p = 0.120$). In general, results suggest an unbalance of covariates across the three countries in relation to overall MA. Therefore, to manage the unbalanced groups, regression tree analysis using the CHAID algorithm was applied. To improve interpretation, respondents were divided into groups (High/Low) based on the mean subscale scores for each personality trait within each country using K-means clustering. A similar method has been applied in a study by Chung et al., (2024).

Table 6.6
Results of the post-hoc groupings (M±SD) with overall meat attachment as the dependent variable.

Covariates	**Australia**	**China**	**UK**
Age (18-34: 0, 35-54: 1, 55-65+: 2)	1.21 ± 0.78^{a}	0.54 ± 0.80^{c}	0.75 ± 0.87^{b}
Gender (0: Female; 1: Male)	0.41 ± 0.49^{b}	0.51 ± 0.50^{a}	0.41 ± 0.49^{b}
Personality Traits			
Conscientiousness	5.57 ± 4.76^{a}	5.22 ± 1.03^{b}	5.19 ± 1.03^{b}
Extraversion	4.76 ± 1.27^{a}	4.72 ± 1.09^{a}	4.59 ± 1.28^{a}
Agreeableness	5.40 ± 1.01^{a}	5.30 ± 0.88^{a}	5.30 ± 0.97^{a}
Neuroticism	3.51 ± 1.39^{c}	3.82 ± 1.09^{b}	4.29 ± 1.42^{a}
Openness	5.39 ± 0.97^{a}	5.18 ± 0.97^{b}	5.27 ± 0.96^{ab}

Please Note: Different letters denote significant difference ($p \leq 0.05$). The original scale for the personality traits: 1= 'strongly disagree', 2= 'disagree', 3= 'somewhat disagree', 4= 'neither agree nor disagree', 5= 'somewhat agree', 6= 'agree', 7= 'strongly agree'.

6.4.5 *Influence of age, country, gender and personality traits on overall meat attachment*

Results found different influencing factors within each country (Fig. 6.3). In the UK, gender was the most influential factor, as identified by the first split, with males scoring significantly higher in overall MA (M=4.8) compared to females (M=4.0). The next split for males related to the personality trait Neuroticism, where lower scores (i.e., less anxious, fearful individuals) were associated with higher MA (M=5.2). In China, the personality trait, Neuroticism, was the most influential factor, with higher Neuroticism scores corresponding to higher overall MA (M=4.8). The next split for this group was gender, where females were found to be slightly more attached to meat (M=4.9) compared to males (M=4.7), whilst in Australia, age was the most influential factor, with 35–54-year-olds scoring higher in MA (M=5.9) compared to the other age groups (M=4.9). Similar to the UK, further splits for the highly MA group related to Neuroticism, with lower Neuroticism scores related to high MA score (M=6.3).

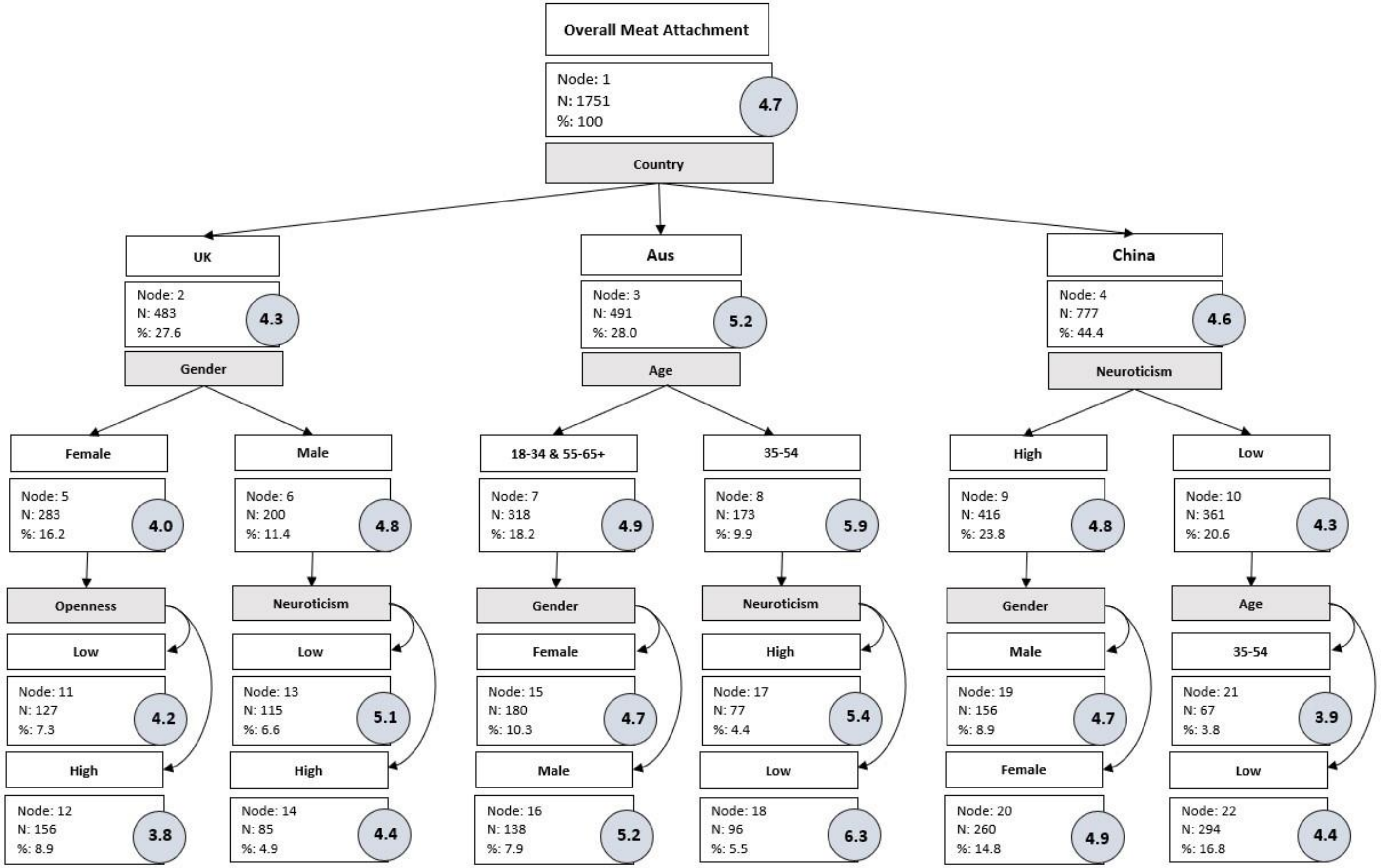

Fig. 6.3. Regression tree generated for overall meat attachment (dependent variable), with country, age, gender and personality traits (independent variables). The predicted values are based on the original meat attachment scale: 1= 'strongly disagree', 2= 'disagree', 3= 'somewhat disagree', 4= 'neither agree nor disagree', 5= 'somewhat agree', 6= 'agree', 7= 'strongly agree'. Consumers who scored 'prefer not to say' and 'other' for age and gender were excluded.

6.5 Discussion

High attachment to meat is a known barrier to reduced meat consumption. Currently, little is known about the psychological profiles of individuals who are more likely to be highly meat attached and whether this differs based on cultural backgrounds. The MAQ showed good reliability and model fit for the four factorial constructs on the country and multi-group level. Findings therefore validate the universal properties of the MAQ and support previous validation studies involving consumers from Western and Asian high-middle income countries (Banovic et al., 2022; Lentz et al., 2018; Wang & Scrimgeour, 2021).

6.5.1 Cultural differences in meat attachment

Cross-cultural comparisons for MA were confounded by the lack of measurement equivalence when reviewing metric and scalar invariance. In other words, the results found the meanings of the four MA dimensions to be interpreted differently between countries. It is possible that different cultural interpretations and linguistic equivalence, especially between Australian and British consumers compared to Asian consumers, led to the conceptual differences observed for some statements. Low factor loadings were particularly apparent for some of the reverse coded items, which are known to create variability in responses for cross-cultural data (Wong et al., 2003). Although reverse coded items have many advantages, a review by Weijters & Baumgartner (2012) advises that they ideally be included as 'polar opposite reversals' rather than simple negation statements. For example, the reverse coded statement 'I feel bad when I think of eating meat', could be supplemented with 'I feel good when I think of eating meat'. However, as acceptable AVE and CR values were observed for the MAQ factors in this study, some meaningful and insightful comparisons can be discussed. In general, the variations in interpretation observed between countries provide novel insights and opportunities for a deeper understanding as to which dimensions are driving the differences.

Australian consumers had the highest overall MA scores compared to consumers in China and the UK. To some extent, meat consumption in Australia is a form of cultural and national identity (Ankeny, 2008). For example, the advertisement campaigns developed by Meat and Livestock Australia claimed for many years that it was ‘un-Australian’ not to eat lamb on Australia Day (Ranta et al., 2022). Furthermore, there may be a stronger association between masculinity and meat in Australia, contributing to the meat-eating identity (Loughnan et al., 2014). The concept of ‘meat as masculine’ is thought to be culturally determined, with certain forms of masculinity leading to greater attachment (De Backer et al., 2020; Schösler et al., 2015). For example, a recent survey found Australian men may resist reducing meat because of its ability to engender masculinity (Stanley et al., 2023). It is therefore likely that masculine identities evoked by meat-eating contributes to the cultural differences in overall MA.

In addition, Australia has one of the largest per capita meat intakes in the world with current estimates at 115Kg/ year (FAO, 2022). High meat consumption and a strong national identity and lifestyle associated with meat is likely to strengthen positive attitudes towards meat. However, the significantly higher MA in China compared to the UK may relate to the rate at which meat consumption is increasing. China is one of the key countries driving global meat intake. Since 1961, per capita consumption has increased by 60Kg/year which is comparatively higher compared to Australia (+11Kg/year) and the UK (+10Kg/year) (FAO, 2022). Meat has therefore transitioned from being scarce in Chinese cuisines to a daily commodity and a symbolism of wealth (Garnett & Wilkes, 2014; Yu, 2015).

Reviewing the differences in mean scores and factor loadings for the MA dimensions provides further clarity as to which aspects of MA are driving the differences between countries. Overall MA was driven by the high scores for affinity which supports previous findings (Banovic et al., 2022). However, it should also be recognised that Chinese consumers scored significantly lower in affinity overall compared to Australian and UK consumers. Results support a similar finding whereby affinity was more influential amongst consumers from New Zealand compared to China (Wang and Scrimgeour, 2021). The reasoning behind these differences could relate to greater awareness and subsequent importance on the issues of animal welfare amongst consumers in the UK (European Commission, 2015; O’Keefe et al., 2016) and

Australia (Cornish et al., 2022; Buddle et al., 2018) compared to China (Shimokawa, 2015; You et al., 2014).

In general, dependence scored significantly lower in all three countries compared to the other MA dimensions which has also been observed in a prior study (Banovic et al., 2022). However, the higher scores for entitlement and dependence amongst Australian consumers compared to Chinese also aligns with findings comparing New Zealand and Chinese consumers (Wang & Scrimgeour, 2021). It was suggested that the differences may be related to higher overall meat consumption and variations in dietary traditions, whereby Chinese diets historically contained more plant-based foods (Wang et al., 2015). Yet, this does not explain why UK consumers, a western society with greater meat intake compared to the Chinese, scored significantly lower in both dimensions. These findings suggest the cause is much greater than meat intake and engrained dietary traditions but could also be influenced by wider mindsets and cultural norms. For example, in China the more frequent occurrence of meat in the diet, partially due to economic growth, may reaffirm a sense of entitlement towards a food commodity that may have previously been unobtainable. In contrast, in the UK, the increased availability and consumption of plant-based products may strengthen the belief that meat is not a necessity (Alae-Carew et al., 2022).

Additional advertisement campaigns in Australia may also explain the high scores for entitlement and dependence. Successful campaigns include ‘Feed the Man Meat’ and ‘Red Meat, We Were Meant to Eat It’. Arguably, this type of messaging confirms the concept of entitlement and dependence for meat following the narrative ‘we are instinct driven hunters’ and essentially meat has helped us to evolve (TCP & MLA, 2007). Additionally, social sustainability factors are also likely to influence the high scores in Australia. For example, meat production contributes to the employment and livelihoods of rural farming communities and supports many associated businesses such as processing, packaging and transportation. Therefore, the reliance on meat may have wider implications outside of personal needs.

6.5.2 The influence of age, country, gender and personality traits on meat attachment

The influence of country above other variables reaffirms the need to consider cultural differences when designing meat reduction strategies. The greater MA in Australia suggests there is likely to be more resistance towards recommendations to reduce meat consumption. However, if highly meat attached consumers are to be classified, age was found to be more influential than gender and personality traits. In particular, 35–54-year-olds were the most attached to meat which aligns with previous findings in which the same group of consumers were the least willing to reduce meat intake (Ford et al., 2023b). Excluding a study amongst Polish consumers who found MA to be high amongst consumers aged 25-40 year-olds (Szczebyło et al., 2022), there is little additional understanding surrounding the influence of age on MA. By comparison, for the UK cohort, gender was more influential compared to age and personality traits. Specifically, men were more attached to meat compared to women which supports previous findings (Dowsett et al., 2018; Graça et al., 2015a; Lentz et al., 2018).

In terms of personality traits, Neuroticism was the only trait to influence MA amongst Australian and UK consumers. Specifically, consumers scoring higher in Neuroticism in both countries were associated with lower MA scores. In general, the link between meat and climate change has gained mass media attention, resulting in environmental motives being a key driver for some consumers towards reduced meat diets (Sanchez-Sabate & Sabaté 2019). Therefore, it is likely that individuals who are more anxious, worried and concerned about the environment might be less attached to meat. Indeed, positive associations have been found between Neuroticism and environmental concern (Hirsh, 2010; Hopwood et al., 2021).

However, within the Chinese cohort, the personality trait Neuroticism was the most influential factor, more so than age and gender. Specifically, consumers scoring higher in Neuroticism related to greater MA, especially amongst females. Findings align with previous research, in which the same Chinese females were less willing to reduce meat and to adopt protein alternatives (Ford et al., 2023b). It also supports previous observations in which Chinese females have higher levels of Neuroticism (Carciofo et al., 2016; Zhang et al., 2022). Furthermore, high Neuroticism has been associated with rationalizing meat consumption as normal (Hopwood & Bleidorn, 2019).

Reasons for the opposite trends between Neuroticism and MA amongst UK and Australian consumers compared to Chinese consumers could relate to the lower Cronbach's alpha score amongst the Chinese cohort which implies this construct was not interpreted as well. However, it also suggests that a greater understanding of the link between Neuroticism and MA is needed from a cross-cultural perspective in future research. Considering the link between Neuroticism and eating healthy foods (Weston et al., 2020), the level of MA may also be associated with how consuming meat for health is perceived.

6.5.3 Limitations and considerations

The limitations associated with the data collection and sample demographics relate to the use of convenience sampling, the long period of data collection, self-reports and the skew towards female participants. Therefore, consumers consumption habits may have changed overtime, and or have been overestimated. A more nationally representative sample, collected over a shorter period of time and based on actual meat-eating behaviour would strengthen findings and reduce bias related to recall and social desirability. Furthermore, future studies should recruit participants from outside of Shanghai considering the differences in cuisines between provinces in China.

The lack of metric and scalar invariance observed for the MAQ means that systematic bias may be present when comparing mean scores between countries. However, prior studies which have conducted cross-cultural comparisons of the MAQ did not provide evidence of scale equivalence but shared high reliability statistics (Bryant et al., 2019; Van Dijk et al., 2023). Indeed, it is worth noting that the necessity of achieving measurement invariance is being contested in the literature (Welzel et al., 2021). Importantly, the different influential factors related to language equivalence, cross-cultural dissimilarity, additional bias and methodological issues is very difficult to conclude.

Considerations should also be given to the use of the BFI-S as a tool to measure the Big Five in cross-cultural studies following the variations in Cronbach's alpha values. Instead, a longer version like the BFI-2, which includes 60 items and has been validated amongst Chinese consumers is likely to yield more reliable results but also requires more time for participants to complete (Zhang et al., 2022).

6.5.4 Practical outcomes

Findings provide novel insights and contribute to the literature with regards to understanding the psychological constructs of MA from a cross-cultural perspective. In other words, it clarifies the level of importance placed on the MA dimensions between countries. In understanding the level of importance placed on each dimension, targeted behavioural change strategies can be implemented as mentioned below.

The importance placed on the affinity dimension by consumers in all three countries indicates the influential role of meat related cognitive dissonance. Interventions aiming to reduce consumers affinity for meat could focus on increasing consumer knowledge about the connections between meat consumption and the meat production process (i.e., meat-animal connection). Awareness could also encompass information on the more negative and emotionally triggering animal welfare issues. A previous experimental study which shared information around the meat-animal connection found little influence on MA overall but did find gender differences with MA decreasing in women (Dowsett et al., 2018). However, it should be noted that this study was conducted in Australia and just focused on lamb which is a meat associated heavily with national identity (Ranta et al., 2022). Future research should therefore explore how information pertaining to the meat-animal connection influences MA from a cross-cultural perspective, as it may have more influence on countries with lower MA like the UK. It would also be beneficial to understand if sharing information affects MA differently dependent on the type of meat.

Hedonism is another psychological construct driving MA. A practical strategy to reduce consumers hedonism for meat could be attaining a similar level of consumer enjoyment and pleasure from the consumption of meatless meals. Often, the taste of protein alternatives plays an important role in the consumption experience, and it can be both a motivator and a barrier to acceptance (Ford et al., 2023a; Onwezen et al., 2021). Other factors that influence pleasure and enjoyment of meatless meals that should be considered include the satisfaction of the meal feeling complete (Neff et al., 2018) as well as wider social norms and acceptance (Ford et al., 2023a). Arguably, for some consumers a similar level of enjoyment from meat-less meals may not be achieved. Therefore, hybrid meat products that combine meat and plant-based ingredients may be more suitable and require less of a sensory sacrifice, with MA shown to not reduce the appeal of products (Banovic et al., 2022). However, research has found high MA consumers are less likely to choose or prefer hybrid products (Asioli et al., 2023; Profeta et al., 2021b). In this case, messaging around the environmental and health benefits alongside growing familiarity may increase consumer acceptance for hybrid products over time.

In general, the entitlement and dependence dimensions were more applicable in driving MA in Australia and China. Considering the success of the campaigns previously discussed in contributing to Australian consumers meat-eating beliefs, other strategies thought to promote sustainable consumption could be applied. One example is the ‘less but better’ meat narrative which addresses both the supply and demand side (Pais et al., 2020). However, this concept also requires further clarity and cross-cultural considerations (Resare Sahlin et al., 2020). Alternatively, perhaps there is a need to challenge the framing around meatless meals being perceived as nutritionally inadequate.

6.7 Conclusion

MA is associated with higher meat intake and a lower willingness to reduce meat. Understanding how MA differs dependent on age, country, gender and personality traits can provide insights for consumer segmentation tactics to tackle high MA. Findings demonstrate the MAQ is a reliable measurement tool that can be applied to cross-cultural data to explore consumer behaviour towards MA. However, the lack of scalar and metric equivalence across countries (i.e., mean differences and item contributions in the latent constructs) suggests MA is interpreted differently and should therefore be a consideration for future research reviewing cross-cultural differences in MA. In general, Australia had the highest overall MA, followed by China and the UK. In particular, Australians aged 35-54 with low Neuroticism scores, UK males with low Neuroticism scores and Chinese females with high Neuroticism scores were the most attached to meat. Hedonism and affinity scored the highest in all three countries which suggests the pleasure and love of meat, alongside a dissociation of the meat-animal connection contributes the most to overall MA. Strategies to reduce MA should therefore focus on improving the hedonistic values of meat-free meals, promoting hybrid meat products and increasing awareness around the meat-animal relationship whilst considering cross-cultural gender, age and personality trait differences.

Chapter 7

Conclusion

This chapter concludes the thesis by summarising the key research findings in relation to the aims and objectives. It highlights the value and contribution of this research as well as limitations and opportunities for future research. A final statement considers the future of consumer behaviour in relation to food.

7.1 Summary of key findings and contributions

The overall aim of this thesis was to examine consumers perceptions, motivations and attitudes towards sustainable foods, specifically focusing on meat reduction and the adoption of protein alternatives. It also aimed to understand the influence of cross-cultural, socio-demographic and psychological differences towards sustainable food behaviours.

This thesis met the aims and provided contributing evidence by: Reviewing sustainable food consumption habits, perceptions and motives towards current and future protein alternatives through focus group discussions (Chapter 2). Measuring the effect of environmental information on consumer acceptance towards a novel alternative (precision fermented yoghurt) within a tasting context (Chapter 3).
Exploring the willingness, motives and barriers towards meat reduction and a range of protein alternatives amongst consumers from Australia, China and the UK (Chapter 4 & 5). Investigating associations between meat attachment, age, gender and personality traits across countries (Chapter 6). Collectively, the findings improve current understandings of the mechanisms behind sustainable food consumer behaviour, provide new knowledge and help inform country-specific protein transition strategies.

The introduction in **Chapter 1** highlighted the importance of understanding and encouraging sustainable food consumption habits. However, despite a growing body of research contributing to this understanding, there is a distinct lack of research reviewing and comparing multiple protein alternatives especially within a cross-cultural context. Furthermore, some alternatives are more researched than others. Considering the complex nature of sustainable food choices there is an additional need to explore socio-demographic and psychological differences in which the influence of some variables (e.g. age, personality traits) are less conclusive. Therefore, understanding consumer segments is valuable information for food product developers and for social marketing campaigns.

To address the objectives, **Chapter 2** utilised focus group discussions to gain a deeper insight into UK meat-eaters' current sustainable consumption habits and perceptions of sustainable foods. In particular, the target group was young consumers who arguably shape the future of food. Moreover, as highlighted in Chapter 1, young consumers are thought to be more accepting of alternatives (Bryant & Barnett, 2020; Mina et al., 2023; Szenderák et al., 2022). Considering the unfamiliar nature of some of the novel alternatives discussed, focus groups provided a conducive environment for participants to debate and interact freely, especially amongst consumers of similar ages. Specifically, the study addressed the following research questions. What (if any) changes are young meat-eaters making to consumption habits? How do young meat-eaters perceive sustainable foods? Particularly, how aware are they of the environmental impact of food? The second half of the discussion reviewed consumers personal experiences and perceptions towards a range of protein alternatives, some of which are comparably under-explored (plant-based seafood, cell-based seafood and precision fermented dairy).

Overall, a general trend towards meat reduction was observed, partly due to newfound self-sufficiency, limited food budgets and the influence of others. Although consumers were aware of the link between food and climate change, they struggled to quantify the impact, which led to difficulties in making sustainable food choices. Variations in familiarity and consumption of plant-based meat vs plant-based seafood products were apparent as was the environmental impact of dairy and seafood compared to meat. However, in general an optimistic view towards new food technology's ability to support a sustainable food future was apparent; especially in relation to precision fermented dairy, which is likely to be commercially available soon.

Recommended strategies to encourage more sustainable food consumption amongst young UK meat-eaters were suggested using the COM-B model. A key outcome related to the capability domain, in particular the need to increase knowledge and understanding around the environmental impact of food to allow consumers to make more informed choices. The effect of information as an intervention strategy was implemented in **Chapter 3**. Specifically, this study explored the effect of sharing information related to the process and environmental impact of precision fermented dairy (PFD) on overall liking and emotional response using two identical commercial yoghurts labelled as conventional dairy (CD) and PFD. In addition, how food neophobia and food technology neophobia influence liking and emotional response to PFD and CD were explored.

Interestingly, all consumers were willing to try the yoghurts labelled as PFD which re-affirms the optimistic outlook consumers projected towards this novel technology. Although, it must be noted that they are a skewed pool of people, who are younger and more knowledgeable and interested in food science. Furthermore, there was no significant difference in liking between yoghurts labelled as CD and PFD, indicating potential acceptance if products can mimic the sensory properties of CD. Sharing information slightly increased liking for PFD yoghurt and evoked more positive emotions ('understanding', 'adventurous' and 'enthusiastic'). By comparison, information decreased liking for CD yoghurt and made participants feel slightly 'guilty'. In particular, sharing information led high food neophobic and food technology neophobic individuals to be more 'understanding' towards PFD in comparison to the low neophobic groups. Therefore, environmental information could be utilised as an intervention strategy to increase consumer acceptance towards sustainable foods which is discussed in more detail in the implications section.

The aforementioned studies were amongst UK consumers. However, socio-cultural and socio-demographic factors also influence sustainable food choices. Therefore, **Chapter 4** extended findings by exploring the influence of age, gender and country on current meat consumption habits, changes to meat and meat substitute consumption and willingness to reduce meat and adopt three protein alternatives of differing familiarity (meat substitutes, edible insects, cultured meat). The three countries reviewed (Australia, China, UK), represented different meat-consumption habits and also allowed for comparisons with non-western consumers which are less researched in the literature. To assist with the interpretation of complex interactions, regression tree analysis using the CHAID algorithm was applied. It proved to be a useful tool, giving a visually intuitive output that is high in accuracy. Overall, Australians, especially those aged 35–54, were significantly less willing to reduce and adopt alternatives compared to Chinese and UK consumers. Conversely, Chinese males were more willing to reduce meat and adopt alternatives, whilst the opposite trend was found in the UK. Therefore, findings highlighted the need for country specific meat reduction strategies, tailored to specific subgroups, whilst emphasising the need to introduce appropriate protein alternative categories that are going to help facilitate a dietary transition.

To help inform meat reduction strategies there is a need to understand the underlying motivations determining food choice behaviour. **Chapter 5** provided rich insights into the motivations and barriers to reduce meat and adopt meat substitutes, edible insects and cultured meat. Findings therefore complimented Chapter 4 and link in with previous motives and barriers observed in Chapter 2. Key motivations were collected via closed-ended statements whilst open-ended questions provided qualitative insights regarding extremely unwilling consumers barriers to change. Currently, only willing consumers have been considered in research, yet it is important to understand the mindset of consumers who are the most resistant to change.

Key motives across countries for meat reduction and protein alternative adoption related to food safety and the environmental benefits. Chinese and UK consumers were more motivated by these factors compared to Australian consumers who had the greatest proportion of consumers unwilling to reduce based on the belief meat consumption is necessary for health reasons. Relative differences in motivational importance were also apparent by protein alternative type. In general, the greatest proportion of unwilling responses amongst Australians related to the use of meat substitutes, whilst for Chinese and UK consumers it related to edible insects. Extremely unwilling consumers perceived protein alternatives as unhealthy, unnecessary, unsustainable, unsafe, unnatural and unappealing. The prominence of themes differed between countries and across protein categories, but the perception that alternatives were unnecessary was a communal theme. Overall, the findings provide interesting insights and recommendations to support country-specific protein transitions.

To enrich findings, it is increasingly important to consider the influence of psychological characteristics on sustainable food choices. Chapter 1 suggested that factors such as personality traits can influence our food choices (Machado-Oliveira et al., 2020), whilst chapters 2 & 5 found meat attachment (MA) to be a barrier to meat reduction. At the time of research, it was understood that there were no studies reviewing the association between meat attachment and personality traits, nor in a cross-cultural context. **Chapter 6** aimed to address this research gap by understanding the influence of age, gender, personality traits and country on MA. Firstly, the results demonstrated that the Meat Attachment Questionnaire (MAQ) had good model fit across countries which validates its suitability as a multi-cultural measurement tool. Following good model fit, comparisons across countries found Australian consumers, especially those aged 35–54-years and who had low levels of Neuroticism, to be more attached to meat. Comparatively, males with low Neuroticism scores in the UK and females with high Neuroticism scores in China were associated with high MA scores. Subsequently, the results align with the observations made in chapter 4 in relation to the consumers most unwilling to reduce meat. Findings are therefore useful in identifying consumer segments most resistant to change.

7.2 Implications

For each of the analytical chapters, practical implications have been suggested based on the results. Overall, the information generated is of interest to stakeholders in the food industry, marketers, policy makers, health professionals and fellow researchers. In particular it can inform new product developments (e.g., suitable formats to introduce consumers to PFD), assist in predicting market trends, highlight specific consumer segments to target (e.g., top product-specific motives and messages to promote) and provide insights on how best to implement protein-alternative strategies (e.g., coherent eco-labels, updated dietary guidelines, educational programmes, tax and subsidies on unsustainable food). In addition to the recommendations below, it is worth noting that some key reviews also provide an overview of intervention strategies to reduce meat consumption and adopt protein alternatives which support the recommendations (Harguess et al., 2020; Kwasny et al., 2022; Onwezen, 2022; Van Huis & Rumpold, 2023).

Chapter 2 provided a summary of behavioural intervention strategies given as general suggestions and opportunities for encouraging sustainable food consumption using the COM-B model. Overall, this study highlighted the importance of targeting young consumers when developing sustainable products, as they are at an important transitional life stage where behavioural change is likely to occur. Furthermore, findings reinforce the suggestion that first sensory impressions are key for consumer acceptance and repeat consumption. Subsequently, there needs to be a balance between delivering a positive sensory experience and the level of processing required to achieve a palatable product which is often associated with negative perceptions (e.g., unnatural, unhealthy). Product developers also need to account for other factors driving acceptance for protein alternatives amongst young consumers in the UK. Specifically; affordability, availability, functionality, convenience, environmental, ethical and health benefits.

In addition, part of the discussions highlighted that consumers expect cultured meat to be available in a processed format (e.g., nuggets, burgers, calamari). Therefore, presenting cell-based products whole (e.g., chicken breasts, steaks, fish fillets) could allow the cell-based market to differentiate itself from the plant-based market. However, it is acknowledged that achieving this is more of a technological challenge.

Moreover, the perceived unnecessary nature of novel alternatives needs to be counter-balanced through positive messaging and framing. For example, in the context of accepting plant-based of cell-based seafood, the need to protect fish-stocks and reduce by-catch could be highlighted. Conversely, messaging promoting PFD should highlight the need to reduce GHG emissions and improve animal welfare. Furthermore, the added benefits of PFD compared to current dairy alternatives should be emphasized (e.g., sensory equivalence, functionality to CD).

Lastly, there is a need for educational programs to bridge the knowledge gap that exists when consumers evaluate the environmental impact of meat vs dairy vs seafood. Particularly in the UK, there is a need to inform consumers about the best way to consume fish sustainably (e.g., consuming a wider variety of species, consuming in moderation, substituting with plant-based/ cell-based seafood).

Chapter 3 suggested that UK consumers are accepting of PFD when presented in a yoghurt format. Therefore, stakeholders should consider yoghurt as a good format in which to introduce consumers to PFD as other formats (cheese, milk) may elicit more barriers. Furthermore, the inclusion of environmental information increased acceptance slightly and elicited positive emotions. Therefore, as found for Chapter 2, making consumers aware of the environmental benefits PFD can offer, especially in relation to conventional dairy, could be a useful strategy to increase acceptance. However, consumers perceive a range of information in relation to food (e.g., animal welfare, health benefits, production process, wider ethical implications). Therefore, dependent on the subject, one topic may be more important.

The current study utilised a video to share information. However, there are many resources available for consumers to access and / or be exposed to information (e.g., newspapers, magazines, books, public billboards, radios, podcasts, blogs, social media). Although the effects of the video were subtle, it showed promise. Therefore, it could be critical for companies and governments to identify what information to share and through which sources. For example, a study amongst UK consumers found that online news articles were one of the most far reaching and influential sources of information in relation to the negative impacts of eating animal sourced products (Bryant et al., 2023). Moreover, the influence of information is likely dependent on the source and type of information aligning with personal values, socio-demographic and socio-cultural factors.

Chapter 4, 5 and 6 provided useful insights for policy makers designing meat reduction strategies. Specifically, findings highlighted the need for country specific approaches, tailored to specific subgroups. An overview of strategies to implement on the country level are provided below.

7.2.1 Implications for Australian consumers

Of the consumers studied, Australians were the most resistant to meat reduction and scored the highest in meat attachment and were the least willing to adopt meat substitutes and cultured meat. This is particularly concerning when the average Australian diet contains more than twice the recommended amounts of animal-based meats compared to the global dietary recommendations for health and environmental sustainability (Hendrie et al., 2022). Therefore, there is a great need to reduce meat intake and increase acceptance of protein alternatives amongst Australians.

However, these results alongside the defensive and emotionally charged responses from extremely unwilling consumers (chapter 5), suggest that meat consumption is a personal and sensitive topic. Therefore, enforcing the concept of meat reduction on consumers who have strong culturally embedded habits could aggravate the problem. Instead, it may be more suitable to shift consumers towards more sustainable meat consumption, such as the 'less but better' meat narrative and/ or substituting red meat for more environmentally friendly meat (e.g., chicken instead of beef). The knowledgeable responses in relation to the benefits of regenerative agriculture (chapter 5) suggest consumers are more interested in this course of action. Educating consumers on this topic and the need to consume meat sustainably may also make consumers aware of the environmental impact of consuming more meat servings than is recommended by dietary guidelines.

It is worth noting that the number of consumers willing to reduce meat (38%) is slightly higher than previous observations amongst Australians (22%) (Malek et al., 2019b). Despite differences in scales used and question formats, it potentially suggests a slight trend towards meat reduction. This would also align with an increase in plant-based products on the Australian market. For those willing to change, the health benefits of meat reduction need to be promoted which may equally address the unhealthy stigma associated with reduced meat diets. In particular, there is a need to challenge the framing around meatless meals being perceived as nutritionally inadequate. Educating young children rather than adults could bring about more effective long-term behavioural change.

Typically, animal sourced foods rich in key nutrients (iron, zinc and Vitamin B12), are often described as ‘complete’ protein sources. Whereas many plant-foods do not contain all the essential amino acids and are termed ‘incomplete’ protein sources (Hoffman & Falvo, 2004). However, a review of the health benefits of meat consumption based on observations amongst vegetarians stated that these nutrients can be obtained from a combination of plant-based foods (Appleby et al., 2016; Godfray et al., 2018). In particular, protein quality and quantity are not compromised when switching to a plant-based diet (BDA, 2019). However, this is dependent on including the correct sources and combinations of foods, as some plant-based foods (e.g., refined grains, potatoes/fries) in high quantities can have unhealthy consequences (Hemler & Hu, 2019). Health professionals, in particular, dieticians play an important role in informing the general public of the best sources of plant-based foods to consume and re-assuring consumers of the benefits of plant-based diets (BDA, 2019).

Of the protein alternatives reviewed, edible insects received the highest willingness to try scores amongst Australians and therefore provide the most promising opportunity for consumer acceptance. Findings suggest Australian governments and food companies should prioritise developing and promoting edible insect products. In addition, alternatives that may be able to “fill the gap” for day-to-day meals in terms of meat reduction should also be explored. An exposure approach, in which hybrid products (e.g., 20% meat subs/ plant-based products to 80% meat) could be a good starting point and potentially without the need to compromise on taste.

Currently, there are few edible insect products on the Australian market, with those available in supermarkets in the form of savoury or sweet snacks (i.e., corn chips, biscuits, cakes) (circleharvest.com.au). In addition, “willingness to try” does not always mean a willingness to replace as part of a meal. To further increase acceptance, key motives in relation to food safety and the environmental benefits should be promoted. Critically, products need to be sensorily appealing which is likely to reduce unappealing perceptions. Sensory scientists, chefs and food developers should continue to understand the most accepted flavour profiles, preferred formats and meal contexts in which to consume edible insects in. Ideally, to provide impactful sustainability benefits, edible insects could be used to enrich products (breakfast cereals, bread, pasta) or as a substitute in meat dishes. Consumers then need to be educated on how best to incorporate edible insects into their diets.

In terms of plant-based meat substitutes and cultured meat, providing a reason as to why these products are necessary could increase acceptance which is currently low. Therefore, marketers should promote the top motives observed amongst Australians which relate to food safety, health and environmental benefits. Currently, products are promoted with a focus on the health benefits (e.g., high in protein & fibre) but perhaps there is a need to accompany this messaging with food safety claims (e.g., natural/ safe ingredients). Moreover, messages should align with those given around meat reduction to highlight the purpose of products. Importantly sensory appeal is key, especially as consumers are likely to make comparisons with conventional products. Currently, more processed meat substitute products can lack certain micro-nutrients (Tso & Forde, 2021). Therefore, nutritionists, food product developers and sensory scientist need to work closely to improve the nutrient profile and ensure meat substitute products are palatable. Specifically, the challenge will be to improve nutrient-poor plant sources with adequate micronutrients, without incorporating adverse ingredients such as sugar, salt and fat often needed to enhance palatability (Tso & Forde, 2021).

In relation to specific consumer segments to target, despite females being more willing to reduce meat compared to males, there were no significant gender differences for meat reduction and protein alternative adoption. However, age differences were more apparent. Specifically, those aged 35-54 were the most attached to meat and least willing to reduce meat and adopt alternatives. Promotional campaigns aiming to change consumer behaviour should be aware of this resistant consumer group and should strive to find a common ground for sustainable protein consumption. Although younger consumers (18-34) also had low willingness scores, they may be the most open to change compared to the other age groups. Behavioural change models provide some insightful strategies that could be applied. For example, exposure

7.2.2 Implications for Chinese consumers

Of the three countries, Chinese consumers were the most willing to reduce meat consumption (70.4%). Therefore, despite positive trends in China with regards to meat consumption, largely as a result of population growth (Font-i-Furnols, 2023), from an individual perspective, the majority of Chinese consumers are willing to consume a sustainable amount of meat. In particular, encouraging a reduction in lamb consumption may be more successful compared to other types of meat (beef, pork, chicken) (Chapter 4).

In terms of protein alternative acceptance, plant-based meat substitutes followed by cultured meat seem the most viable options compared to edible insects (Chapter 4). To increase reduction of meat and acceptance of alternatives, the key motives (environmental benefits, health benefits and food safety) should be promoted. Especially when marketing products and encouraging consumers to follow sustainable dietary guidelines (Chapter 5).

When segmenting consumers, gender should be a greater consideration than age. Specifically, males are more likely to be open to meat reduction, less attached to meat and more accepting of protein alternatives (Chapter 4 & 6). In relation to personality traits, the link between high meat attachment and neuroticism is worth considering as it could be related to health perceptions of meat consumption (Chapter 6). However, it is worth highlighting that these observations are amongst consumers in Shanghai, which is a thriving cosmopolitan city. Consequently, there would be regional differences across China, especially in relation to dietary habits. Therefore, more research is needed to understand these differences across provinces in China.

7.2.3 Implications for UK consumers

Overall, UK consumers represented a higher willingness to reduce meat consumption (66.7%), which signifies potential for following sustainable diets. In particular, promoting the reduction of beef, pork and lamb is more likely to be accepted than a reduction in chicken (Chapter 4). A reduction in red meat is also more likely to have a more positive and greater environmental impact. Top motives should be promoted in relation to the environmental benefits, food safety and animal welfare (Chapter 5).

In relation to protein alternatives, meat substitutes and cultured meat provide more viable options than edible insects (Chapter 4). Across alternatives the environmental benefits and sensory appeal are top motives and should be considered when developing and promoting products. However, for meat substitutes and cultured meat, price is also of importance and should be comparable and/ or cheaper than conventional meat options. Conversely, despite the low willingness to adopt edible insects, ensuring consumers of the safety of products could increase acceptance (Chapter 5).

Lastly, a greater focus should be given to gender differences when implementing meat reduction strategies. In particular, females are likely to be more willing to reduce meat and have lower meat attachment (Chapter 4 & 6). Conversely, when promoting protein alternatives, age is more influential than gender. Specifically, younger consumers in general should be the target consumers based on higher acceptance (Chapter 2, 4).

7.2.4 Collective country implications

Despite differences in willingness and motives across countries, there were some similarities in relation to meat attachment. Specifically, the affinity dimension was the most important across all three countries. Therefore, to tackle the barriers associated with high meat attachment, interventions should aim to reduce consumers affinity for meat which was the most important dimension of MA across countries. For example, strategies should increase consumers connection between meat consumption and the meat production process (i.e., meat animal connection). Awareness could also encompass information on the more negative and emotionally triggering animal welfare issues. This would be especially applicable amongst UK consumers as this is a key motive for reduction. Furthermore, consumers scoring higher in Neuroticism (i.e., more anxious, worried) in Australia and the UK were associated with lower MA scores. This could be associated with environmental concern which is worth considering when developing communication campaigns.

7.3 Limitations and future research opportunities

Despite the contribution of research to the field of sustainable consumer food behaviour, there are also limitations to acknowledge which provide opportunities for future research.

The results presented in **Chapter 2** are based on focus group discussions, therefore the sample size is small, and the results are not generalizable to the UK population. Furthermore, convenience sampling was used which resulted in a skew towards females and more educated participants and could have introduced self-selection bias. Specifically, it could be that only people interested in the topic advertised as 'exploring sustainable food consumption habits' took part. Therefore, these factors may have influenced the level of awareness and knowledge around the environmental impact of food and the acceptance of alternatives. Future research should employ quantitative research methods, with larger more representative sample sizes to explore additional demographic groups. For example, consumers with lower education and income levels may face more barriers towards sustainable consumption habits and be more resistant to accepting alternatives.

The findings observed in **Chapter 3** are based on hypothetical assumptions, as PFD products are not yet commercially available. Therefore, assessing actual PFD products in future studies will provide a more accurate measurement of overall liking and emotional response. In particular, it would be interesting to understand consumer acceptance, motives and barriers towards a range of PFD products (yoghurt, cheese, milk). This could be done through consumer surveys, focus groups, capturing emotional responses and sensory evaluations (e.g., choice-based experiments, hedonic scoring, ranking tasks, check-and-rate-all-that-apply). Furthermore, as observed in chapters 4 & 5, it would be beneficial to explore how different socio-demographic and socio-cultural factors influence consumer acceptance of PFD. It could be that some countries are more accepting than others or that motivations differ dependent on dairy format.

In addition, this study reviewed the effect of environmental information on consumer acceptance. However, alternative product factors may resonate more with consumers (e.g., animal welfare, health benefits). Current literature highlights the significance of animal welfare in driving consumer acceptance for PFD (Ford et al., 2023a, Powell et al., 2023). Therefore, future studies would benefit from extending these findings to understand which type of information causes the greatest increase in overall liking for PFD. In relation to the health benefits, it could relate to PFD being free of lactose, hormones and antibiotics (Powell et al., 2023). Lastly, the sample size was small (n=62), therefore, the findings should be viewed as preliminary. However, future research can apply the study design to a larger, more nationally representative sample to support the observations.

Chapters 4, 5 & 6 are based on the same survey data which had various limitations outlined below. In light of these observations, a paper by Jaeger & Cardello (2022) provides a comprehensive review of factors that influence online data quality which have been taken into consideration.

Convenience sampling: The use of convenience sampling resulted in a bias towards female participants in Australia and the UK as well as a higher proportion of educated consumers in all three countries and a higher proportion of younger consumers in China. Furthermore, the Chinese sample is just reflective of consumers from Shanghai. Subsequently, the results are not generalisable to all Australian, Chinese and British consumers and should be interpreted with caution. Future studies should strive to achieve more nationally representative samples with balanced socio-demographic groups.

Self-reported values and reporting bias: The self-reported consumption frequencies are potentially open to miscalculation. The same could be observed for the gender categories listed which did not allow for within-gender heterogeneity. Therefore, analysing the data simply based on binary differences may have oversimplified and overlooked the wider role of gender conformity which is also known to influence meat consumption (De Backer et al., 2020; Rosenfeld & Tomiyama, 2021). A more nationally representative sample, based on actual meat-eating behaviour (e.g., diet diaries), that captures ascribed masculinity/femininity would strengthen findings and reduce bias related to recall and social desirability. Furthermore, although consumers self-report that they are willing to reduce meat, mapping this against quantified meat-consumption could provide a deeper insight. For example, using diet diary data, consumers could be clustered into meat-eating groups (e.g., high, standard, low) with the level of willingness to reduce meat compared across groups. Specifically, whether high meat-eating consumers (e.g., consuming over >100g a day) are willing to change could be better understood (BDA et al., 2019).

Phrasing of questions: The wording of the willingness questions mentioned, 'for sustainability or environmental reasons' or 'in order to follow a sustainable diet.' Therefore, findings may not capture consumers who are willing to reduce meat for other reasons (i.e., personal health, price, animal welfare, food safety etc). In general, this may have influenced the results but provides an opportunity for future research to gain deeper insights into alternative motives. Likewise, the brief explanations given for the protein alternatives which mentioned sustainability benefits may have influenced consumers' opinions. Future research should consider the effects of framing on consumers' willingness and subsequent perceptions (Bryant & Barnett, 2019; Siegrist et al., 2018).

Translation: The translation of the term 'cultured meat' into Chinese '人造肉' may have resulted in a different linguistic equivalence especially considering the novelty of this concept which may impact responses. Just like in English, cultured meat has many variations (e.g., lab-grown, cell-based, in-vitro, clean meat) however, the translation of 'cultured meat' was deemed most appropriate and consistent compared to the alternative definitions. Furthermore, additional errors may have occurred when translating the validated scales (MAQ & BFI-S). Future studies should consider using consistent translations for the term 'cultured meat' and the MAQ statements. Furthermore, model-fit and reliability statistics for the MAQ should be reported to allow accurate comparisons to be made. In relation to the BFI-S, concerns regarding its reliability as a measurement tool for the personality traits have been highlighted, especially amongst Chinese consumers (Chapter 6). Subsequently, future research should consider using the BFI-2, which includes 60 items and has been validated amongst Chinese consumers. Subsequently, it is likely to yield more reliable results but also requires more time for participants to complete (Zhang et al., 2022).

Time frame: The surveys were disseminated across Australia, China, and the UK during the Covid-19 pandemic. Subsequently, the importance placed on the environmental and health benefits as a motive for reducing meat and adopting protein alternatives may be a consequence of this time period. For example, lockdown altered consumer behaviour such as; more time to consider food choices, cooking meals from scratch, ordering food online (Borsellino et al., 2020; Chen et al., 2021; Ellison et al., 2021; Filimonau et al., 2021; Murphy et al., 2020). These lifestyle changes have reportedly driven some consumers towards more sustainable and healthier food choices (Di Renzo et al., 2020; Murphy et al., 2020; Rodríguez-P´erez et al., 2020; Wang et al., 2020). Future research should repeat these studies outside of a pandemic context to fully understand if the levels of willingness and motivations change.

Across all the studies, changes in consumer liking are based on a brief period of time. Therefore, becoming more familiar with protein alternative products, or becoming more knowledgeable/ aware of the environmental impact of food. For example, through repeated exposure of the video in Chapter 3, could lead to incremental shifts in liking. Therefore, future research should utilise longitudinal studies that capture whether sustainable behavioural changes are made and maintained (i.e., reduced meat consumption, adoption of alternatives) over the period of a few years.

In addition, the studies only explored willingness to try/ adopt and liking which does not equate to buying. Therefore, future research should explore more realistic purchase situations. One method would be to use choice-based conjoint (CBC) analysis tasks (also known as discrete choice modelling). This method requires participants to choose concepts based on different attributes (e.g., product, price, nutritional claims, country of origin) with each attribute having different levels (e.g., high price, low price, high in protein, low in fat). Choice based tasks are thought to be better at mimicking food shopping behaviours compared to rating or ranking tasks, especially with the growth of online shopping (Almli & Næs, 2018). Another method would be to use immersive virtual or augmented reality to provide a better understanding of how consumers may behave in real-world environments (Torrico et al., 2023; Xu et al., 2021). By improving the ecological validity and providing representative contexts, food companies will be better positioned to predict food choice (Low et al., 2021). Combining these methods will create a whole consumption experience journey, to understand consumers choice behaviour from the beginning to the end (i.e., from shopping, during tasting to after consumption).

Lastly, the studies did not review consumers implicit responses which are thought to play a different role in decision making compared to explicit attitudes (Perugini, 2005). These subconscious behaviours can be captured through a variety of novel techniques using biometric measurements (e.g., facial expressions, eye tracking, pupil dilation, heart rate, skin conductance, body temperature, brain activity) (De Wijk & Noldus, 2023; Torrico et al., 2023; Low et al., 2022). Coupling implicit and explicit methods together (e.g., FaceReader and EsSense profiling) can be complementary (Rocha et al., 2019) and provides a more accurate prediction of food preferences (Schouteten, 2021).Therefore, future research should consider utilising and combining a wider range of measurement tools when exploring consumer behaviour and strategies for nudging to enrich findings.

7.4 Beyond this thesis: Consumer behaviour towards future sustainable foods

Consumer behaviour will continue to play an integral role in shaping the future of sustainable food. In response to the ongoing climate crisis, more international organisations are recognising the importance of considering the demand side of food. For example, for the first time the recent COP 28 summit acknowledged sustainable and healthy diets as a valuable tool in which to transform the current food system. Subsequently, the need to further understand consumer food choices is more urgent than ever.

Consumers are increasingly aware of the link between food, health and the environment. Consequently, it is likely the trend for sustainable food will continue to grow partly in response to consumer demand. As the market becomes increasingly saturated with new sustainable foods all vying for consumer attention it will be interesting to understand how consumers make trade off decision between products. Critically, it will be important to explore how these products fit into the diet holistically to help evolve the move away from meat-based diets. In other words, will they substitute conventional meat, fish and dairy or will they be incorporated as an addition within consumer diets. This is an important aspect to consider in future consumer studies if protein alternatives are to have a supportive role in alleviating environmental pressures and providing health benefits. Specifically, questions should capture the frequency and format in which protein alternatives are consumed and whether this has changed previous food consumption habits.

In the next decade, the supermarket shelves in Australia, China and the UK are likely to look quite different and will largely depend on sensory appeal. As mentioned in the introduction, there are numerous other novel protein alternatives currently being developed that have not been addressed in this thesis. Some of which include; underutilised legume crops (e.g., grass pea, lupine, winged bean, Bambara groundnut) and edible plants (e.g., duckweed, drumstick tree (moringa), microalgae) (Quintieri et al., 2023). There is also the potential of hybrid meat substitutes (e.g. part meat, part vegetable) and other precision fermented products (e.g., milk, cheese, ice cream, eggs). Moreover, the use of novel food technologies such as vertical farming and 3D printing utilising byproducts to help with the concept of ‘circular eating’ are likely to grow in popularity. Therefore, it is undoubtedly important to mention these products and technologies as they could play a pivotal role in encouraging and achieving sustainable food consumption. Moreover, these products and technologies highlight fruitful avenues of research as ultimately success depends on consumer acceptance. The stark reality is, if this trajectory of unsustainable food consumption continues, eventually many might no longer have the luxury of choosing the products they prefer. However, the findings from this thesis offer an optimistic outlook and suggest many consumers are willing to change their behaviour towards sustainable food consumption habits and are accepting of protein alternatives.

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Appendix

Chapter 2

Table S2.1: Focus Group Discussion Guide

Event	*Description*	*Estimated duration*
Opening remarks	A brief introduction is given by the moderator covering housekeeping rules whilst ensuring a clear understanding of the video call functions. The purpose and formality of the focus group are discussed with participants encouraged to share their opinions openly and respectfully.	5 mins
Warm up	The recorded session commences with a quick warm up exercise incorporating the poll and chat box functions to familiarise participants with these video call functions and to maximise engagement. **POLL:** "How are you feeling today?" **CHAT BOX:** "Where do you currently live?" **PROMPT:** "What is your favourite meal and why?" *Moderator to encourage participants to raise/lower their hands when they wish to share something with the group.*	5 mins
Topic 1: Sustainable consumption habits	The following discussions centre around food consumption habits through a series of open-ended questions such as: **PROMPT:** "Have you made any changes to your food consumption habits over the last three-five years?" **PROBE:** "What influenced you to change your consumption habits?" **PROMPT:** "What does sustainable food consumption mean to you?" **PROMPT:** "What do you do/ have you done to make your food consumption habits more sustainable?" **PROBE:** "What has helped you?" **PROBE:** "What did you find difficult?" *If they have not made changes to their consumption habits to be more sustainable.* **PROBE:** "Do you think your food consumption habits are sustainable anyway?" *All questions were pasted in the chat box for reference. When participants mention reductions in meat/fish/dairy an open-ended discussion as to what has replaced meat/fish/dairy was initiated.*	15 mins

Topic 2 – Awareness of the environmental impact of food.	A series of statements were then pasted into the chat box to initiate discussions in relation to the environmental impact of food, such as: **PROMPT:** “Some people think 'what we eat is contributing to climate change' . Do you agree with this statement?” **PROBE:** “Can you explain your response?”. **PROMPT:** “Some people believe 'eating less meat and dairy would be good for the environment'. Do you agree with this statement?” **PROBE:** “Can you explain your response and why you think meat/ dairy has a high/low/no impact?”. **POLL:** “How willing would you be to reduce your meat consumption for the environment’s sake?” **POLL:** “How willing would you be to reduce your dairy consumption for the environment’s sake?” *For those that are willing:* **PROBE:** “What difficulties do you think you would face?” **PROBE**: Did anyone score a difference in willingness between meat and dairy? Like to explain your response. **PROMPT:** “Some people believe ‘our current consumption of fish is unsustainable’. Do you agree with this statement?” **PROBE:** “Can you explain your response?”.	20 mins
Topic 3 – Consumer experiences and perceptions of plant-based products.	*The discussions moved on to talk about plant-based products. To help introduce the topic, pictures of products currently available in the supermarket were shared with participants to clarify what was meant by plant-based products and to encourage associative thinking and behaviours.* **PROMPT:** "Have you tried any of these products and or similar products before?” **PROBE:** “What was your experience like?” **PROBE**: “What made you want to try them?” **PROBE:** ”Do you frequently consume them?” *For those who haven’t tried any:* **PROBE:** “Why haven’t you tried any?” **PROBE:** “What would instil greater trust?” **CHAT BOX:** “Can you name at least one advantage of consuming plant-based products compared to conventional meat and fish products?” **CHAT BOX**: “Can you name at least one disadvantage of consuming plant-based products compared to conventional meat and fish products?”	30 mins
Topic 4 – Consumer perceptions of cell-based meat/ seafood	*The next topic introduced the concept of cell-based meat and cell-based seafood with a presentation slide providing a definition of how products are made with an accompanied graphic to aid visualisation. This was followed by examples of a couple of companies currently working on such products in the UK to demonstrate the potential for these products to become available in the future.* **POLL:** “Have you heard of cell-based meat?” **POLL:** “Have you heard of cell-based seafood?” *For those that have previously heard of cell-based meat/seafood.* **PROBE:** “What do you know about it?”	

	CHAT BOX: What 3 words come to mind when you think about consuming cell-based meat/ seafood products made using this method? **POLL:** "Does the thought of consuming cell-based meat and cell-based seafood for the environments sake appeal to you?" Response options: o Only cell-based meat appeals to me o Only cell-based seafood appeals to me o Both equally appeal to me o Neither appeal to me **PROBE:** "Can you explain your response?" **PROBE:** "What is motivating you to try cell-based meat and or seafood? **PROBE:** "Is there a particular product(s) and or way that you would prefer to try cell-based meat and cell-based seafood?" **PROBE:** "Why that particular format?" *For negative comments/ 'neither appeal' responses e.g. *predicted: unnatural, bad taste, unsafe, unhealthy .* **PROBE:** "Why do neither appeal to you?" **PROBE:** "What would instil greater trust?" **CHAT BOX:** "Can you name at least one advantage of consuming cell-based meat compared to conventional meat?" **CHAT BOX:** "Can you name at least one disadvantage of consuming cell-based meat compared to conventional meat?" *Moderator to review responses and expand on the mention of environment*. **PROMPT:** "Are the advantages/ disadvantages previously mentioned the same when comparing cell-based seafood to conventional seafood?" **PROBE:** "Do you think these products will promote sustainable consumption habits?"	

Topic 5 – Consumer perceptions of animal-free dairy.	*The final topic introduced the concept of animal-free dairy with a presentation slide providing a definition of how products are made with an accompanied graphic to aid visualisation. This was followed by examples of a couple of companies currently working on such products including the availability of ice cream products made using this method in the USA. The aim being to demonstrate the potential for these products to become available in the UK.* **CHAT BOX**: "What 3 words come to mind when you think about consuming dairy products using this method?" **PROBE:** Most popular words and reasons. **POLL:** "Please select the animal-free dairy product(s) you would be willing to try from the list below". Response options: o Milk o Cheese o Butter o Ice cream o Other o None of the above *Moderator to discuss results.* **PROBE:** "What is motivating you to try these products?" **PROBE:** "Who scored a difference between products and why?" **PROBE**: "What is preventing you from trying (insert product)?" **PROMPT:** "Would you be willing to regularly consume dairy products made using this method for the environment's sake". **PROBE**: "Do you see this technology as likely to help with sustainable consumption?" **CHAT BOX:** "Can you name one advantage of consuming animal-free dairy compared to conventional dairy?" **CHAT BOX:** "Can you name one disadvantage of consuming animal-free dairy compared to conventional dairy?"	15 mins
Closing Remarks	*The moderator ends the session by asking participants to share with the group what they found the most interesting allowing time for additional opinions and comments.* *Participants are thanked for their time and contribution and given Instructions to complete a short follow up questionnaire relating to their personality traits and food technology neophobia.*	5 mins

Chapter 3

Figure S3.1: Image depicting presented yoghurt samples.

Table S3.1: Cox & Evans. (2008). The Food Technology Neophobia Scale

Factors	Statements
New Food Technologies are unnecessary	There are plenty of tasty foods around so we don't need to use new food technologies to produce more.
	The benefits of new food technologies are often grossly overstated.
	New food technologies decreases the natural quality of food.
	There is no sense trying out high-tech food products because the ones I eat are already good enough.
	New foods are not healthier than traditional foods.
	New food technologies are something I am uncertain about.
Perception of risks	Society should not depend heavily on technologies to solve its food problems.
	New food technologies may have long term negative environmental effects.
	It can be risky to switch to new food technologies too quickly.
	New food technologies are unlikely to have long term negative health effects. (R).
Healthy choice	New products produced using new food technologies can help people have a balanced diet. (R).
	New food technologies gives people more control over their food choices. (R).
Information/media	The media usually provides a balanced and unbiased view of new food technologies. (R).

Table S3.2: Pilner & Hobden. (1992). The Food Neophobia Scale

Statements
I am constantly sampling new and different foods (R)
I don't trust new foods
If I don't know what is in a food, I won't try it
I like foods from different countries (R)
Ethnic food looks too weird to eat
At dinner parties I will try a new food (R)
I am afraid to eat things I have never had before
I am very particular about the foods I will eat
I will eat almost anything (R)
I like to try new ethnic restaurants (R)

Table S3.3: Definitions provided during the sensory evaluation.

Product	Definition
Conventional Dairy	Dairy made by the conventional method refers to dairy made with milk that was produced directly by a cow.
Precision Fermented Dairy	Precision Fermented Dairy is produced by taking a small amount of DNA from a cow non-invasively. The DNA is then introduced into a microorganism (e.g., a yeast cell) and transferred into fermentation tanks along with nutrients and sugar to produce the components of milk which are combined to produce the final product.

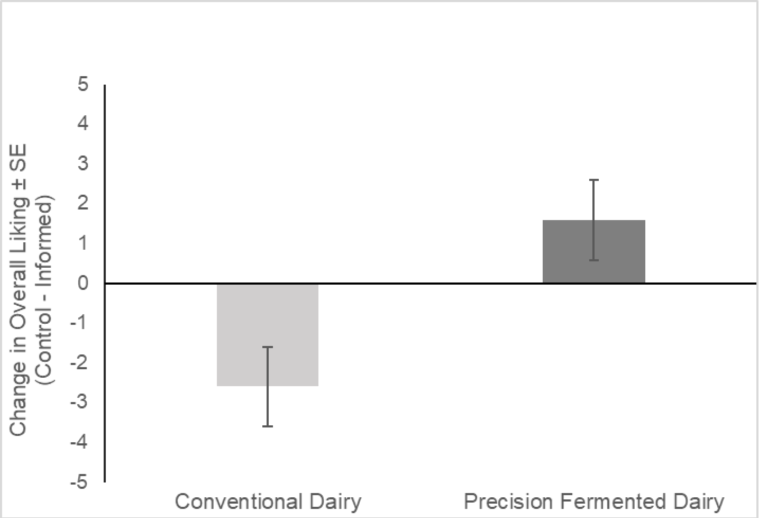


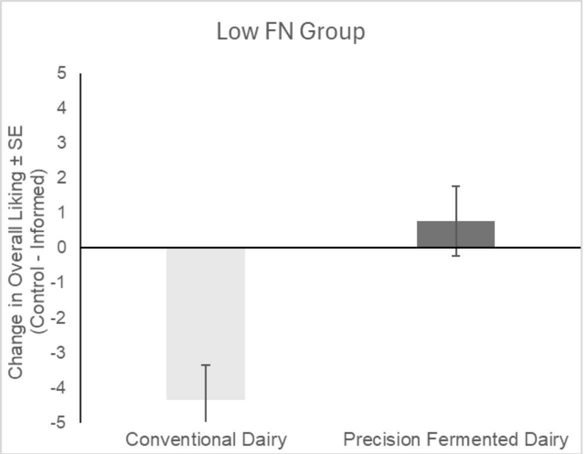
Fig. S3.2: Effect of information (environmental, PFD process) on the mean change in overall liking ± SE for the conventional and precision fermented dairy yoghurt. (CD; M= 74.35, SD= 9.08 for control, M= 71.75, SD= 9.4 for informed; t (61) = 2.60, p= 0.031, d= 0.28). (PFD; M= 70.83, SD= 9.57 for control, M= 72.41, SD= 9.99 for informed; t (61) = -1.585, p = 0.085, d= -0.22).

Table S3.4: Results (n=62) for the CATA emotional terms presented as citation frequencies (%) for the four yoghurt samples. The p-values are taken from the Cochran's Q test with post-hoc analysis based on the Sheskin procedure. Different letters within rows denote significant differences (5% level).

Emotional CATA terms	Control Conventional Dairy	Control Precision Fermented	Informed Conventional Dairy	Informed Precision Fermented	P-values
Active	21.0 (a)	16.1 (a)	11.3 (a)	17.7 (a)	0.340
Adventurous	**0 (a)**	**19.4 (b)**	**3.2 (a)**	**27.4 (b)**	**<0.0001**
Aggressive	0 (a)	0 (a)	0 (a)	0 (a)	1.000
Bored	1.6 (a)	1.6 (a)	4.8 (a)	3.2 (a)	0.666
Calm	41.9 (a)	35.5 (a)	40.3 (a)	33.9 (a)	0.603
Disgusted	0 (a)	0 (a)	0 (a)	0.032 (a)	0.112
Enthusiastic	**14.5 (a)**	**17.7 (ab)**	**24.2 (ab)**	**32.3 (b)**	**0.025**
Free	**6.5 (ab)**	**4.8 (a)**	**4.8 (a)**	**19.4 (b)**	**0.008**
Good	59.7 (a)	71.0 (a)	72.6 (a)	71.0 (a)	0.200
Good_Natured	21.0 (a)	29.0 (a)	35.5 (a)	37.1 (a)	0.121
Guilty	1.6 (a)	1.6 (a)	9.7 (a)	3.2 (a)	0.063
Happy	51.6 (a)	43.5 (a)	58.1 (a)	54.8 (a)	0.238
Interested	**24.2 (a)**	**51.6 (b)**	**22.6 (a)**	**59.7 (b)**	**<0.0001**
Joyful	33.9 (a)	25.8 (a)	33.9 (a)	29.0 (a)	0.494
Loving	21.0 (a)	16.1 (a)	12.9 (a)	21.0 (a)	0.440
Mild	17.7 (a)	25.8 (a)	19.4 (a)	16.1 (a)	0.345
Nostalgic	**38.7 (c)**	**17.7 (ab)**	**33.9 (bc)**	**14.5 (a)**	**<0.0001**
Pleasant	79.0 (a)	74.2 (a)	71.0 (a)	62.9 (a)	0.090
Satisfied	58.1 (a)	41.9 (a)	59.7 (a)	58.1 (a)	0.076
Secure	14.5 (a)	6.5 (a)	17.7 (a)	14.5 (a)	0.176
Tame	8.1 (a)	8.1 (a)	12.9 (a)	6.5 (a)	0.572
Understanding	**0 (a)**	**6.5 (a)**	**14.5 (a)**	**32.3 (b)**	**<0.0001**
Warm	6.5 (a)	9.7 (a)	14.5 (a)	12.9 (a)	0.407
Wild	1.6 (a)	3.2 (a)	6.5 (a)	6.5 (a)	0.392
Worried	1.6 (a)	9.7 (a)	3.2 (a)	4.8 (a)	0.133

Fig. S3.3a – 3.3d: Effect of information (environmental, PFD process) on the mean change in overall liking ± SE for the conventional and precision fermented dairy yoghurt for the four consumer groups (Low FTN= 26, High FTN= 35, Low FN= 32, High FN= 29).

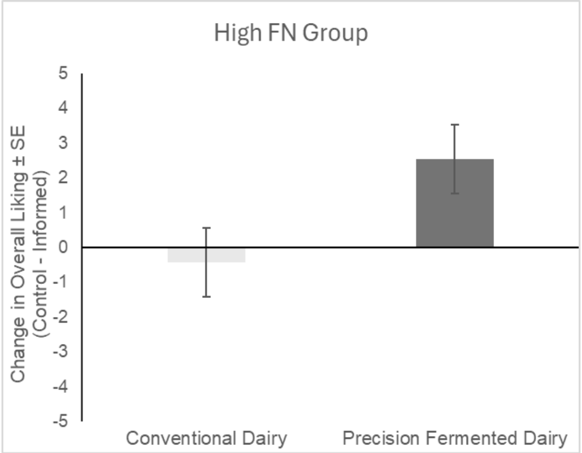
Fig. S3.3a



CD; M= 75.78, SD= 6.13 for control, M= 71.44, SD= 10.07 for informed; t (31) = -4.34, p= 0.011, d = 0.48).

PFD; M= 71.54, SD= 8.79 for control, M=72.31, SD= 9.71 for informed; t (31) = 0.77, p= 0.541, d = -0.12).

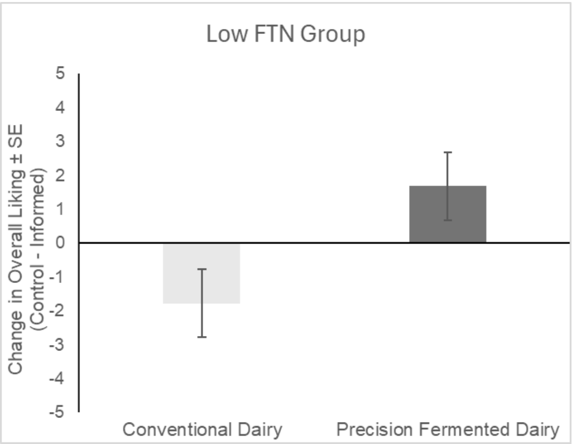
Fig. S3.3b



CD; M= 72.32, SD= 11.18 for control, M= 71.89, SD= 8.87 for informed; t (28) = -0.43, p= 0.806, d = 0.05).

PFD; M= 70.08, SD= 10.63 for control, M= 72.62, SD= 10.61 for informed; t (28) = 2.54, p= 0.076, d = -0.34).

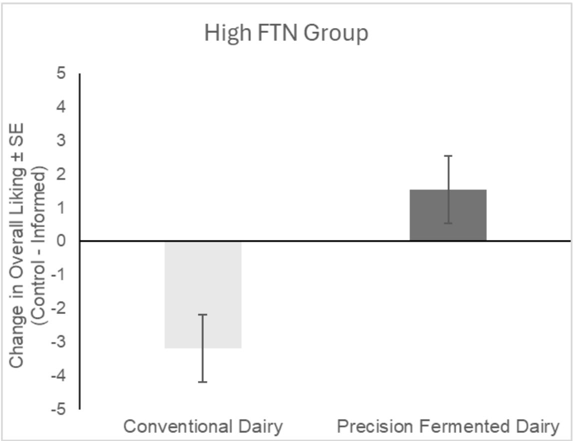
Fig. 3.3c



CD; M= 73.55, SD= 7.61 for control, M= 71.78, SD= 7.87 for informed; t (29) = -1.77 , p= 0.273 , d = 0.20).

PFD; M= 72.0, SD= 8.97 for control, M= 73.69, SD= 8.34 for informed; t (29) = 1.69, p= 0.172, d = -0.26).

Fig. 3.3d



CD; M= 74.170, SD= 10.24 for control, M= 71.54, SD= 10.88 for informed; t (30) = -3.17 , p= 0.087 , d =0.32).

PFD; M= 69.74, SD= 10.30 for control, M= 71.26, SD= 11.50 for informed; t (30) = 1.53, p= 0.286, d = -0.20).

Table S3.5. Results for the four consumer groups (Low FTN= 26, High FTN= 35, Low FN= 32, High FN= 29) for the CATA emotional terms presented as citation frequencies (%) for the four yoghurt samples. The p-values are taken from the Cochran's Q test with post-hoc analysis based on the Sheskin procedure. Different letters within rows denote significant differences (5% level).

Attributes	Consumer Group	Control Conventional Dairy	Control Precision Fermented	Informed Conventional Dairy	Informed Precision Fermented	p-values
Active	Low FTN	16.7 (a)	13.3 (a)	6.7 (a)	16.7 (a)	0.494
	High FTN	25.8 (a)	19.4 (a)	16.1 (a)	19.4 (a)	0.673
	Low FN	18.8 (a)	12.5 (a)	12.5 (a)	12.5 (a)	0.771
	High FN	24.1 (a)	20.7 (a)	10.3 (a)	24.1 (a)	0.297
Adventurous	**Low FTN**	**0 (a)**	**13.3 (ab)**	**3.3 (a)**	**26.7 (b)**	**0.004**
	High FTN	**0 (a)**	**25.8 (bc)**	**3.2 (ab)**	**29.0 (c)**	**0.001**
	Low FN	**0 (a)**	**8.8 (ab)**	**3.1 (a)**	**37.5 (b)**	**<0.0001**
	High FN	**0 (a)**	**20.7 (b)**	**3.4 (ab)**	**17.2 (ab)**	**0.011**
Aggressive	Low FTN	0 (a)	0 (a)	0 (a)	0 (a)	1.000
	High FTN	0 (a)	0 (a)	0 (a)	0 (a)	1.000
	Low FN	0 (a)	0 (a)	0 (a)	0 (a)	1.000
	High FN	0 (a)	0 (a)	0 (a)	0 (a)	1.000
Bored	Low FTN	3.3 (a)	3.3 (a)	3.3 (a)	0 (a)	0.801
	High FTN	0 (a)	0 (a)	6.5 (a)	6.5 (a)	0.261
	Low FN	0 (a)	0 (a)	6.2 (a)	0 (a)	0.112
	High FN	3.4 (a)	3.4 (a)	3.4 (a)	6.9 (a)	0.896
Calm	Low FTN	46.7 (a)	43.3 (a)	46.7 (a)	36.7 (a)	0.762
	High FTN	35.5 (a)	25.8 (a)	32.3 (a)	29.0 (a)	0.741
	Low FN	46.9 (a)	37.5 (a)	46.9 (a)	34.4 (a)	0.516
	High FN	34.5 (a)	31.0 (a)	31.0 (a)	31.0 (a)	0.976
Disgusted	Low FTN	0 (a)	0 (a)	0 (a)	3.3 (a)	0.392
	High FTN	0 (a)	0 (a)	0 (a)	3.2 (a)	0.392
	Low FN	0 (a)	0 (a)	0 (a)	0 (a)	1.000
	High FN	0 (a)	0 (a)	0 (a)	6.9 (a)	0.112
Enthusiastic	Low FTN	6.7 (a)	10.0 (a)	16.7 (a)	26.7 (a)	0.060

Attributes	Consumer Group	Control Conventional Dairy	Control Precision Fermented	Informed Conventional Dairy	Informed Precision Fermented	p-values
	High FTN	22.6 (a)	25.8 (a)	32.3 (a)	38.7 (a)	0.376
	Low FN	15.6 (a)	21.9 (a)	37.5 (a)	40.6 (a)	0.028
	High FN	13.8 (a)	13.8 (a)	10.3 (a)	24.1 (a)	0.337
Free	Low FTN	3.3 (a)	3.3 (a)	3.3 (a)	16.7 (a)	0.112
	High FTN	9.7 (a)	6.5 (a)	3.2 (a)	19.4 (a)	0.133
	Low FN	6.2 (a)	9.4 (a)	0 (a)	15.6 (a)	0.134
	High FN	**6.9 (ab)**	**0 (a)**	**6.9 (ab)**	**20.7 (b)**	**0.033**
Good	Low FTN	63.3 (a)	70.0 (a)	83.3 (a)	70.0 (a)	0.207
	High FTN	54.8 (a)	71.0 (a)	61.3 (a)	71.0 (a)	0.277
	Low FN	68.8 (a)	71.9 (a)	65.6 (a)	65.6 (a)	0.910
	High FN	**48.3 (a)**	**69.0 (ab)**	**79.3 (b)**	**75.9 (b)**	**0.005**
Good_Natured	Low FTN	16.7 (a)	26.7 (a)	40.0 (a)	40.0 (a)	0.110
	High FTN	25.8 (a)	29.0 (a)	32.3 (a)	35.5 (a)	0.784
	Low FN	21.9 (a)	21.9 (a)	21.9 (a)	34.4 (a)	0.536
	High FN	**20.7 (a)**	**34.5 (ab)**	**51.7 (b)**	**41.4 (ab)**	**0.034**
Guilty	Low FTN	3.3 (a)	0 (a)	3.3 (a)	0 (a)	0.572
	High FTN	0 (a)	3.2 (a)	16.1 (a)	6.5 (a)	0.054
	Low FN	3.1 (a)	0 (a)	12.5 (a)	3.1 (a)	0.112
	High FN	0 (a)	3.4 (a)	6.9 (a)	3.4 (a)	0.494
Happy	Low FTN	53.3 (a)	43.3 (a)	63.3 (a)	56.7 (a)	0.297
	High FTN	51.6 (a)	45.2 (a)	51.6 (a)	54.8 (a)	0.824
	Low FN	59.4 (a)	46.9 (a)	50.0 (a)	53.1 (a)	0.667
	High FN	44.8 (a)	41.4 (a)	65.5 (a)	58.6 (a)	0.075
Interested	**Low FTN**	**10.0 (a)**	**53.3 (b)**	**13.3 (a)**	**70. 0 (b)**	**<0.0001**
	High FTN	**35.5 (a)**	**48.4 (a)**	**29.0 (a)**	**51.6 (a)**	**0.101**
	Low FN	**18.8 (a)**	**59.4 (b)**	**28.1 (a)**	**65.6 (b)**	**<0.0001**
	High FN	**7.6 (ab)**	**41.4 (ab)**	**13.8 (a)**	**55.2 (b)**	**0.001**
Joyful	Low FTN	30.0 (a)	20.0 (a)	33.3 (a)	26.7 (a)	0.486
	High FTN	35.5 (a)	32.3 (a)	35.5 (a)	32.3 (a)	0.965

Attributes	Consumer Group	Control Conventional Dairy	Control Precision Fermented	Informed Conventional Dairy	Informed Precision Fermented	p-values
	Low FN	31.2 (a)	18.8 (a)	37.5 (a)	31.2 (a)	0.175
	High FN	34.5 (a)	34.5 (a)	31.0 (a)	27.6 (a)	0.848
Loving	Low FTN	13.3 (a)	13.3 (a)	16.7 (a)	20.0 (a)	0.786
	High FTN	29.0 (a)	19.4 (a)	9.7 (a)	19.4 (a)	0.195
	Low FN	21.9 (a)	15.6 (a)	9.4 (a)	18.8 (a)	0.486
	High FN	20.7 (a)	17.2 (a)	17.2 (a)	20.7 (a)	0.950
Mild	Low FTN	13.3 (a)	26.7 (a)	23.3 (a)	13.3 (a)	0.106
	High FTN	19.4 (a)	22.6 (a)	16.1 (a)	19.4 (a)	0.914
	Low FN	12.5 (a)	28.1 (a)	15.6 (a)	15.6 (a)	0.209
	High FN	20.7 (a)	20.7 (a)	24.1 (a)	17.2 (a)	0.861
Nostalgic	**Low FTN**	**50.0 (b)**	**26.7 (ab)**	**40.0 (ab)**	**16.7 (a)**	**0.002**
	High FTN	29.0 (a)	9.7 (a)	29.0 (a)	12.9 (a)	0.024
	Low FN	**46.9 (b)**	**25.0 (ab)**	**43.8 (b)**	**15.6 (a)**	**0.002**
	High FN	**31.0 (a)**	**10.3 (a)**	**24.1 (a)**	**13.8 (a)**	**0.041**
Pleasant	Low FTN	86.7 (a)	80.0 (a)	73.3 (a)	70.0 (a)	0.147
	High FTN	71.0 (a)	67.7 (a)	67.7 (a)	58.1 (a)	0.628
	Low FN	4.4 (b)	71.9 (ab)	68.8 (ab)	59.4 (a)	0.027
	High FN	72.4 (a)	75.9 (a)	72.4 (a)	69.0 (a)	0.927
Satisfied	Low FTN	50.0 (a)	46.7 (a)	50.0 (a)	60.0 (a)	0.672
	High FTN	64.5 (ab)	38.7 (a)	677 (b)	54.8 (ab)	0.034
	Low FN	62.5 (a)	6.9 (a)	65.6 (a)	59.4 (a)	0.345
	High FN	51.7 (a)	37.9 (a)	51.7 (a)	55.2 (a)	0.422
Secure	Low FTN	6.7 (a)	3.3 (a)	13.3 (a)	10.0 (a)	0.511
	High FTN	19.4 (a)	9.7 (a)	22.6 (a)	19.4 (a)	0.392
	Low FN	5.6 (a)	9.4 (a)	18.8 (a)	15.6 (a)	0.691
	High FN	10.3 (a)	3.4 (a)	17.2 (a)	13.8 (a)	0.207
Tame	Low FTN	6.7 (a)	6.7 (a)	16.7 (a)	0 (a)	0.106
	High FTN	9.7 (a)	9.7 (a)	6.5 (a)	12.9 (a)	0.820
	Low FN	9.4 (a)	12.5 (a)	12.5 (a)	9.4 (a)	0.945
	High FN	6.9 (a)	3.4 (a)	10.3 (a)	3.4 (a)	0.629

Attributes	Consumer Group	Control Conventional Dairy	Control Precision Fermented	Informed Conventional Dairy	Informed Precision Fermented	p-values
Understanding	**Low FTN**	**0 (a)**	**3.3 (ab)**	**6.7 (ab)**	**20.0 (b)**	**0.013**
	High FTN	**0 (a)**	**9.7 (a)**	**19.4 (ab)**	**41.9 (b)**	**<0.0001**
	Low FN	**0 (a)**	**9.4 (ab)**	**12.5 (ab)**	**28.1 (b)**	**0.006**
	High FN	**0 (a)**	**3.4 (a)**	**13.8 (ab)**	**34.5 (b)**	**<0.0001**
Warm	Low FTN	6.7 (a)	3.3 (a)	10.0 (a)	6.7 (a)	0.779
	High FTN	6.5 (a)	16.1 (a)	16.1 (a)	16.1 (a)	0.510
	Low FN	6.2 (a)	.5 (a)	21.9 (a)	15.6 (a)	0.250
	High FN	6.9 (a)	6.9 (a)	3.4 (a)	6.9 (a)	0.925
Wild	Low FTN	3.3 (a)	3.3 (a)	6.7 (a)	6.7 (a)	0.801
	High FTN	0 (a)	3.2 (a)	6.5 (a)	6.5 (a)	0.532
	Low FN	3.1 (a)	6.2 (a)	12.5 (a)	6.2 (a)	0.438
	High FN	0 (a)	0 (a)	0 (a)	6.9 (a)	0.112
Worried	Low FTN	0 (a)	3.3 (a)	0 (a)	0 (a)	0.392
	High FTN	3.2 (a)	16.1 (a)	6.5 (a)	9.7 (a)	0.274
	Low FN	0 (a)	9.4 (a)	0 (a)	6.2 (a)	0.061
	High FN	3.4 (a)	10.3 (a)	6.9 (a)	3.4 (a)	0.629

S3.6: Video shared during the study.

During the second session, participants were shown a 5-minute video available via this link: https://mediaspace.nottingham.ac.uk/media/Environmental+Impact+of+Food/1_ekt5gwdh

The first part of the video focused on the Green House Gas emissions of a range of foods and the wider effect on climate change. The use of Life Cycle Assessment analysis, which takes into account the production, transportation, packaging and use and waste management, was described as the method to assess the environmental impact of food. The GHG emissions of a range of products were compared, such as beef, lamb, chicken and meat-free burgers. Other food categories compared included dairy (cheddar cheese, cow's milk, butter, yoghurt) and fruit and veg (tomatoes, beans, apples and potatoes).

The second part of the video focused on new food technologies as a potential solution to create more sustainable products. The processes involved in making lab grown meat and precision fermented dairy were described. Following this, estimated GHG emissions for a range of novel foods (lab grown meat, precision fermented dairy, edible insects) were referenced. For example, compared to conventional dairy, precision fermented dairy is estimated to release 35-65% less GHG emissions (Mendly-Zambo, Powell, and Newman 2021).

Chapter 4

Appendix S4.1: Short passages included in the Questionnaire.

a) **Reducing Meat:** Global meat consumption is predicted to double by 2050 (FAO,2019). As a result, there is increasing concern for meat to be produced sustainably by reducing the environmental impact and considering health, safety and quality concerns as well as animal and worker welfare rights.

b) **Meat Substitutes:** The benefits of meat substitutes include a reduction in the amount of land and water used and the prevention of animal suffering. The production of just one 'Impossible burger' (a plant-based meat substitute product) is estimated to use 96% less land, 87% less water and 89% fewer green-house gas emissions compared to a burger made from cows (Impossible Foods, 2019).

c) **Edible Insects:** With the population continuing to grow at a rapid rate, edible insects are increasingly being discussed as plausible alternative protein sources. This is predominantly due to their nutritional benefits being high in protein and their pro environmental impact which makes better use of land, water and produces less green-house gas emissions than most domestic breeding animal species.

d) **Cultured Meat:** Cultured meat, also known as in vitro or synthetic meat, is produced in a laboratory by extracting the stem cells from the muscle tissue of animals. The cells are fed and nurtured in order to multiply and create muscle tissue which is biologically the same as meat and therefore has the same taste and texture. The benefits of cultured meat include reduced animal suffering, reduced production of greenhouse gasses and the creation of a new source of proteins with the potential of feeding the growing world population (Post, 2012).

Chapter 5

Table S5.1: Socio-demographic characteristics of the sample (n=1,777) expressed as (%) within each country sub-sample.

	Australia n= 503	China n= 785	UK n=489
Gender			
Male	39.6	50.8	40.9
Female	58.1	48.2	58.1
Other/prefer not to say	2.4	1.0	1.0
Age (years)			
18 - 34	23.0	65.9	52.9
35 - 54	34.6	14.8	18.4
55 - 65+	41.8	19.4	28.3
Prefer not to say	0.6	0	0.4
Education			
No qualification	0.8	0.1	1.0
Some secondary school	8.7	1.9	16.2
Technical/ trade/ diploma/ vocational training	28.8	19.9	18.6
Completed University graduate (Bachelor's degree)	35.8	63.8	34.4
Completed Postgraduate/ Doctorate degree	25	13.4	28.0
Prefer not to say	0.8	0.9	1.8
Dietary preference			
Omnivore	87.5	74.4	78.9
Flexitarian	12.5	25.6	21.1

S5.2: Meat substitutes

Unappealing, Unsafe: Subsequently, the unnatural theme was closely linked with the Unappealing and Unsafe themes. In particular, consumers commented on the negative sensory aspects of meat substitutes, especially amongst Chinese consumers (24.2%) compared to UK (11.3%) and Australian (1.2%) consumers. In addition, Chinese consumers also commented more frequently (15.2%) on safety ('*not safe/ cannot ensure safety/ safety to be checked')* compared to consumers in Australia and the UK respectively (4.1%, 1.6%).

"I consider fake meat to be full of additives and unnatural ingredients."
(Australia, Female, 45-54)

"Meat alternatives don't taste good."
(China, Male, 18-24)

"*Meat substitutes are just another form of processed foods*."
(UK, Male, 65+)

Unsustainable: Only Australian (17.1%) and UK (14.5%) consumers commented on the unsustainability of meat substitute alternatives. Similar to the reasons given for being extremely unwilling to reduce meat, the damaging effects of plant-based foods/ mono-cropping were highlighted. Australian participants particularly felt that meat substitutes were potentially worse for the environment mentioning large carbon footprints through manufacturing and transportation as well as greater land clearing causing a threat to biodiversity and erosion of topsoil.

"*All meat substitutes I have examined are highly processed, use imported raw ingredients, are highly packaged and have high food miles*."
(Australia, Female, 55-65)

"*Most monocultures grown on cleared land with zero biodiversity grown using animal or chemical fertilisers are worst for the planet than locally sourced meat and home-grown vegetables.*"
(Australia, Male, 25-34)

"*Plant-derived products or meat substitutes have their own production and unsustainability horror stories*."
(UK, Female, 45-54)

In total, 15.3% of consumers stated that they disagreed with the statement that accompanied the question (S4.1 – statement B). The majority of consumers were Australian (17.1%) and from the UK (16.1%) whilst no Chinese consumers explicitly disagreed. Some consumers in all three countries felt that others are behind the change (total 4.7%). Notably, this related to the belief that such products were giving control to big food companies and people of power to make profit.

"*You are intentionally trying to mislead and control people*".
(Australia, Male, 35-44)

"It's another way of marketing to make money to deceive the public".
(China, Male, 65+)

"Meat substitutes are made of vile chemicals in a factory, making billionaires more millions".
(UK, Male, 55-65)

S5.3: Edible Insects

Unsafe: Edible insects were perceived to be unhygienic, disease carriers and pests. This observation was made more frequently amongst consumers in the UK (5.2%) and

Australia (4.7%) compared to China (2.5%). Subsequently, this theme was closely related to unknown health effects.

"I do not know how their chemical make-up will affect my system."
(Australia, Male, 65+)

"*Insects can contain a lot of bacteria and other things that are not very safe*."
(China, Female, 25-34).

"*I associate insects as vectors for disease.*"
(UK, Female, 35-44).

Unhealthy: Few consumers mentioned this theme (≥3.9%), where it was felt insects were nutritionally inadequate especially compared to conventional meat, in which consumers felt edible insects lacked sufficient fat levels and were an incomplete source of protein.

"*They do not come as a complete protein. You would need to substitute with vitamins and minerals, whereas eating meat has everything you need*."
(Australia, Female, 45-54)

"The nutrients they provide are not sufficient for adopting a healthy lifestyle, compared to meat."
(UK, Female, 18-24)

Unsustainable: In general, concern over the sustainable nature of edible insects was most frequently mentioned by consumers in the UK (7.2%) and Australia (3.2%) compared to China (1.9%). In particular, consumers in the UK were more concerned about the welfare aspect highlighting how insects were also sentient beings. Some therefore felt there was no difference to the aspect of killing animals. In contrast, Australian consumers were more concerned about potentially changing the balance of the environment and felt insects were important as pollinators.

"We need insects as pollinators and as part of the natural cycle. Mixed organic farming is far more efficient, environmentally friendly and capable of improving soil quality and the environment without another high input industrial food source like insects."
(Australia, Male, 65+)

"Insects are equally important to the ecology; insects have difficulty feeding and reproducing."
(China, Female, 18-24)

"Surely if I stop eating meat to be kinder to animals that should also apply to insect, they're sentient life too."
(UK, Male, 55-65)

S5.4: Cultured Meat

Unsustainable: More Australian consumers mentioned the potentially, environmentally damaging nature of cultured meat (20.8%) compared to Chinese (9.0%) and UK (1.9%) consumers. Specifically, Australians struggled to see how cultured meat could be more sustainable compared to regeneratively farmed meat. The resources required to set up the industry and the process itself was questioned with predicted high carbon emissions, resource intensive procedures and a large dependence on monocrops.

For UK consumers (13%), sustainability related more to the ethical nature of the process, with consumers mentioning how animals are still used and had concerns regarding the potentially devastating effects it could have on the farming industry. For Chinese consumers (12.1%), the sustainability of cultured meat related more to the affordability and availability of products. Cultured meat was predicted to be expensive and impossible or difficult to eat which the authors interpreted to be related to the availability of products.

"*Feel that artificial meat is not cheap, after all, there are royalties.*"
(China, Female, 18-24)

"*It will destroy the agricultural jobs as everything will be done in labs".*
(UK, Female, 18-24)

"It's still producing carbon with manufacturing process. It's not providing carbon back into the soil that we need for production of plants/mineral rich agriculture."
(Australia, Male, 25-34)

Unsafe: Concerns about how safe cultured meat will be were most frequently mentioned by consumers in China (12.1%) followed by Australia (8.3%) and the UK (7.4%). In general, consumers were unsure about the unknown health risks. Therefore, clinical trials and more information around the manufacturing processes and ingredients used could help to reassure consumers.

“It's man-made and we don't have long term large population studies to look at the potential negative and yet unknown side effects.”
*(*Australia, Male, 45-54*)*

“*Fear of harmful effects on the body*.”
(China, Female, 18-24)

“I can see there being a major issue with it along the line in time.”
(UK, Male, 45-54)

Unhealthy: Only Australian (11.5%) and Chinese (6.1%) consumers commented on the potential unhealthy effects of cultured meat. This was strongly associated with the laboratory production process. Australians in particular highlighted how it cannot possibly contain the same nutritional value as meat.

“Because it feels like it's all synthetic, and if the material is not good and the production process is not good, it will definitely be very unhealthy.”
*(*China, Female, 45-54*).*

“How can ANYTHING Produced in a laboratory be healthy?”
*(*Australian, Female, 55-65*).*

In total, 9.3% of consumers stated that they disagreed with the information presented above (Appendix S4.1 - statement D). The majority of consumers disagreeing were Australian (9.9%) and UK (13%) consumers, whilst no Chinese consumers explicitly disagreed. Likewise, only Australian (7.8%) and UK (13%) consumers felt that the consumption of cultured meat gives power, control and profit to other industries and wealthy individuals. Some responses were emotionally charged and fearful of the outcome.

“Cultured meat will allow a handful of corporations to control supply of most essential food”
(Australia, Female, 35-44)

“Nature knows what she is doing, and clearly your billionaire pals are wanting to rake in the cash and power pushing this fake agenda of world domination outside of Nature. Shame on you”.
(UK, Male, 45-54)

Chapter 6

Table S6.1
Translation of the MAQ statements

Code	UK & Australia	China
H1	To eat meat is one of the good pleasures in life	吃肉是生活中美好的乐趣之一
H2	I love meals with meat	我爱在我的饮食加入肉类食品
H3	I'm a big fan of meat	我是肉类消费的超级粉丝
H4	Nothing is comparable to a good steak	没有任何可以可以比得过一个好的牛排
A1	I feel bad when I think of eating meat (R)	当我想吃肉的时候我会心情很不好
A2	To eat meat is disrespectful towards life and the environment (R)	吃肉是对生活和环境的不尊重
A3	Meat reminds me of diseases (R)	吃肉让我认为我会生病
A4	By eating meat I'm reminded of the death and suffering of animals (R)	吃肉让我想起了动物的死亡和痛苦
E1	According to our position in the food chain, we have the right to eat meat	根据我们在食物链中的位置，我们有权吃肉
E2	To eat meat is an unquestionable right of every person	吃肉是每个人不容置疑的权利
E3	Eating meat is a natural and undisputable practice	吃肉是一种自然和无可争议的做法
D1	Meat is irreplaceable in my diet	肉在我的饮食中是不可替代的
D2	I don't picture myself without eating meat regularly	我无法想象自己不能经常吃肉
D3	I would feel fine with a meatless diet (R)	没有肉的饮食我会感觉很好
D4	If I couldn't eat meat I would feel weak	如果不能吃肉，我会感觉到虚弱
D5	If I was forced to stop eating meat I would feel sad	如果我被迫停止吃肉，我会感到悲伤

Table S6.2
Translation of the BFI-S statements

Code	UK & Australia	China
E1	Is communicative, talkative	我善于交际，健谈
E2	Is outgoing, sociable	我外向善于交际
E3	Is reserved (R)	我有安静的性格
N1	Gets nervous easily	我非常容易紧张
N2	Worries a lot	我十分担心我的工作或学习
N3	Is relaxed, handles stress well (R)	我可以轻松的处理压力
C1	Does a thorough job	我会完全完成我自己的工作
C2	Does things effectively and efficiently	我可以高效的处理事情
C3	Tends to be lazy (R)	我倾向于懒惰的生活方式
A1	Is sometimes somewhat rude to others (R)	我有时对他人有些粗鲁
A2	Has a forgiving nature	具有宽容的本性
A3	Is considerate and kind to others	体贴的善待他人
O1	Has an active imagination	我有积极的想象力
O2	Is original, comes up with new ideas	我可以原创的提出新的想法
O3	Values artistic experiences	重视艺术体验

Figures S6.1a-S6.1c. CFA of the MAQ theoretical structure for each country separately. Four factors (Hedonism, Affinity, Entitlement, Dependence) and one second order dimension for overall meat attachment with standardized factor scores. Reverse coded items indicated by (*). Please refer to Table S1 for the codes.

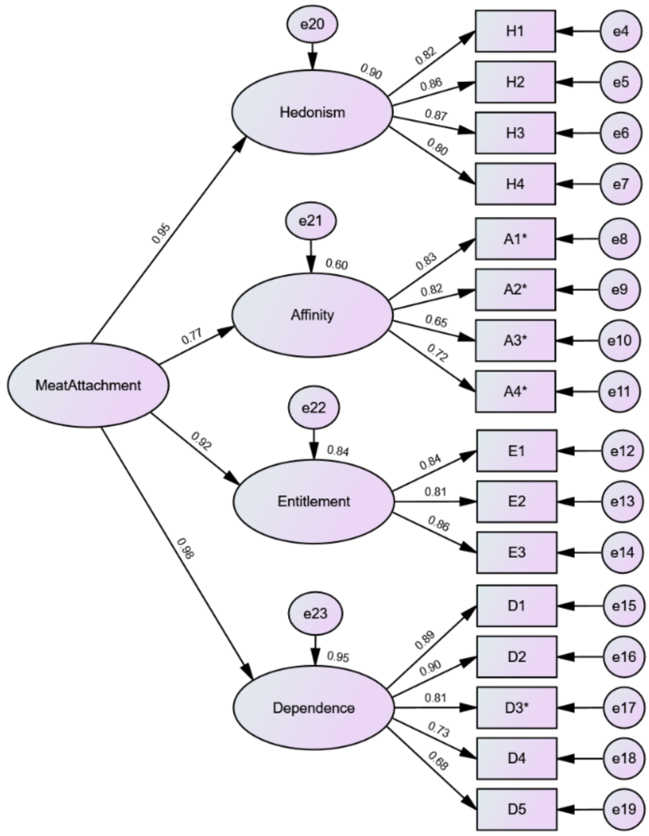


Fig S6.1a. CFA of the MAQ theoretical structure for the Aus sample (n= 503). Reasonable model fit was established (x^2/df = 3.204, CFI= 0.96, RMSEA = 0.07). Including error-covariances between e10 – e11 and e18 – e19 improved the model fit (x^2/*df* = 2.75, CFI= 0.97, RMSEA = 0.06).

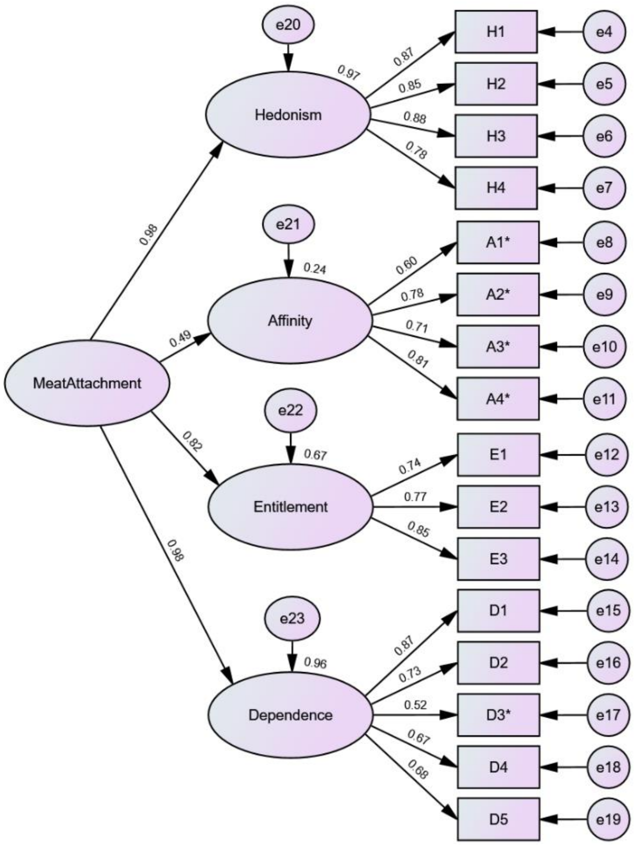


Fig S6.1b. CFA of the MAQ theoretical structure for the China sample (n= 785). Reasonable model fit was established (x^2/df = 6.309, CFI= 0.93, RMSEA = 0.08). Including error-covariances between e10 – e11 and e18 – e19 improved the model fit (x^2/*df* = 4.95, CFI= 0.95, RMSEA = 0.07).

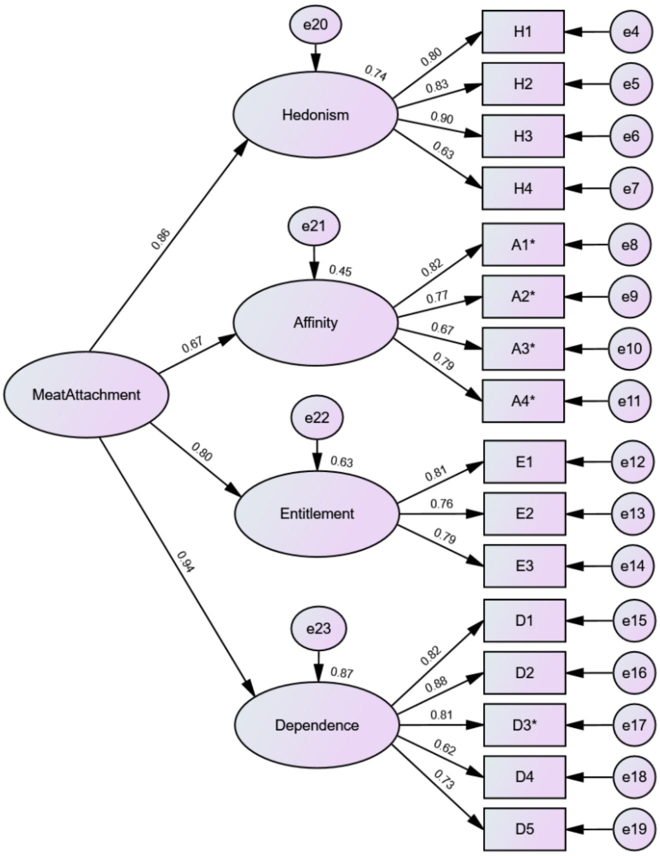


Fig S6.1c. CFA of the MAQ theoretical structure for the UK sample (n= 489). Reasonable model fit was established (x^2/df = 3.86, CFI= 0.94, RMSEA = 0.08). Including error-covariances between e10 – e11 and e18 – e19 improved the model fit (x^2/df = 3.36, CFI= 0.95, RMSEA = 0.07).

All three countries had standardized factor loadings above the acceptable limit (>0.5) for the 16 items. Loadings ranged from 0.59 to 0.90 in the UK, 0.62 to 0.90 in Australia and 0.51 to 0.88 in China. The CR values in all three countries were >0.7 indicating good construct reliability. The AVE values were acceptable (>0.5) in Australia and the UK for all statements and in China, with the exception of the dependence construct where the threshold was marginally achieved (0.48 close to 0.5). However, the high CR score for this construct (0.82) signifies satisfactory scales (Table S6.3). The inter-correlations between the four factors for each country are presented below (Tables S6.4a – S6.4c). Results found the majority of correlations to be significant and below 0.80. Therefore, severe multicollinearity between the factors was not a concern in the current dataset (Tabachnick & Fidell, 2001). There were also strong correlations when comparing the factors with overall MA indicating good reliability. Although come correlations were >0.7, the high CR values (>0.8) and the large sample size suggest there would be little multicollinearity influence (Grewal et al., 2004; Pieniak et al., 2009). In general, the AVE values for each factor were above the squared inter-factor correlation estimates further establishing discriminant validity.

Table S6.3

CFA of the MAQ within each country separately.

Latent factor and item	Aus (n = 503)			China (n = 785)			UK (n = 489)		
	Standardized factor loading	CR	AVE	Standardized factor loading	CR	AVE	Standardized factor loading	CR	AVE
Hedonism		0.91	0.71		0.91	0.71		0.87	0.63
H1= To eat meat is one of the good pleasures in life	0.82			0.87			0.80		
H2= I love meals with meat	0.86			0.86			0.83		
H3= I'm a big fan of meat	0.88			0.88			0.90		
H4= Nothing is comparable to a good steak	0.80			0.78			0.63		
Affinity		0.84	0.57		0.81	0.52		0.83	0.56
A1= I feel bad when I think of eating meat (R)	0.83			0.62			0.85		
A2= To eat meat is disrespectful towards life and the environment (R)	0.83			0.82			0.79		
A3= Meat reminds me of diseases (R)	0.62			0.66			0.59		
A4= By eating meat I'm reminded of the death and suffering of animals (R)	0.70			0.77			0.74		
Entitlement		0.88	0.70		0.83	0.62		0.83	0.62
E1= According to our position in the food chain, we have the right to eat meat	0.84			0.74			0.81		
E2= To eat meat is an unquestionable right of every person	0.81			0.77			0.76		
E3= Eating meat is a natural and undisputable practice	0.86			0.86			0.79		
Dependence		0.90	0.65		0.82	0.48		0.88	0.60
D1= Meat is irreplaceable in my diet	0.89			0.87			0.82		
D2= I don't picture myself without eating meat regularly	0.90			0.73			0.88		
D3= I would feel fine with a meatless diet (R)	0.81			0.51			0.81		
D4= If I couldn't eat meat I would feel weak	0.72			0.64			0.62		
D5= If I was forced to stop eating meat I would feel sad	0.67			0.65			0.73		

Please note: CR = Composite Reliability. AVE = Average Variance Extracted. (R) indicates reverse scored items.

Table S6.4a

Australia (n=503): Mean, standard deviation and Pearson correlation for the MAQ & BFI-S.

Variables	Mean ± SD	1	2	3	4	5	6	7	8	9	10
1. Entitlement	4.92 ± 1.73	**1**									
2. Dependence	4.85 ± 1.73	**0.79**	**1**								
3. Hedonism	5.33 ± 1.56	**0.76**	**0.83**	**1**							
4. Affinity	5.83 ± 1.32	**0.60**	**0.63**	**0.64**	**1**						
5. Overall MA	5.23 ± 1.41	**0.88**	**0.94**	**0.92**	**0.79**	**1**					
6. Agreeableness	5.40 ± 0.97	**0.11**	**0.10**	**0.09**	**0.14**	**0.12**	**1**				
7. Conscientiousness	5.57 ± 1.00	**0.24**	**0.22**	**0.18**	**0.22**	**0.24**	**0.38**	**1**			
8. Neuroticism	3.51 ± 1.39	**-0.28**	**-0.22**	**-0.27**	**-0.28**	**-0.29**	**-0.23**	**-0.41**	**1**		
9. Extraversion	4.76 ± 1.27	**0.14**	**0.12**	**0.13**	**0.09**	**0.13**	**0.31**	**0.36**	**-0.40**	**1**	
10. Openness	5.40 ± 1.01	-0.04	-0.02	-0.01	-0.07	-0.03	**0.21**	**0.25**	-0.08	**0.33**	**1**

Please Note: The numbers relate to the variables listed in column 1. Values in bold denote statistical significance at the 95% level.

Table S6.4b

China (n=785): Mean, standard deviation and Pearson correlation for the MAQ & BFI-S.

Variables	Mean ± SD	1	2	3	4	5	6	7	8	9	10
1. Entitlement	4.65 ± 1.19	**1**									
2. Dependence	4.25 ± 1.17	**0.62**	**1**								
3. Hedonism	4.58 ± 1.29	**0.70**	**0.82**	**1**							
4. Affinity	4.91 ± 1.16	**0.36**	**0.40**	**0.41**	**1**						
5. Overall MA	4.57 ± 0.99	**0.79**	**0.90**	**0.91**	**0.66**	**1**					
6. Agreeableness	5.30 ± 0.88	-0.01	**-0.17**	**-0.12**	-0.03	**-0.12**	**1**				
7. Conscientiousness	5.22 ± 1.03	**-0.09**	**-0.29**	**-0.22**	**-0.14**	**-0.24**	**0.58**	**1**			
8. Neuroticism	3.82 ± 1.09	**0.14**	**0.30**	**0.23**	**0.15**	**0.26**	**-0.42**	**-0.57**	**1**		
9. Extraversion	4.72 ± 1.09	0.01	**-0.11**	-0.05	-0.03	-0.06	**0.39**	**0.58**	**-0.52**	**1**	
10. Openness	5.18 ± 0.97	0.03	**-0.11**	-0.03	**-0.14**	**-0.08**	**0.42**	**0.46**	**-0.19**	**0.39**	**1**

Please Note: The numbers relate to the variables listed in column 1. Values in bold denote statistical significance at the 95% level.

Table S6.4c

UK (n=489): Mean, standard deviation and Pearson correlation for the MAQ & BFI-S.

Variables	Mean ± SD	1	2	3	4	5	6	7	8	9	10
1. Entitlement	3.99 ± 1.50	**1**									
2. Dependence	3.63 ± 1.49	**0.65**	**1**								
3. Hedonism	4.55 ± 1.41	**0.57**	**0.73**	**1**							
4. Affinity	5.24 ± 1.36	**0.47**	**0.50**	**0.53**	**1**						
5. Overall MA	4.33 ± 1.20	**0.79**	**0.90**	**0.86**	**0.75**	**1**					
6. Agreeableness	5.30 ± 0.97	**-0.09**	**-0.20**	**-0.11**	-0.06	**-0.15**	**1**				
7. Conscientiousness	5.19 ± 1.03	0.08	0.08	0.03	**0.12**	**0.09**	**0.19**	**1**			
8. Neuroticism	4.29 ± 1.42	**-0.17**	**-0.21**	**-0.22**	**-0.23**	**-0.25**	0.01	**-0.25**	**1**		
9. Extraversion	4.59 ± 1.28	0.07	0.06	**0.11**	0.04	0.08	**0.12**	**0.17**	**-0.30**	**1**	
10. Openness	5.27 ± 0.96	**-0.11**	**-0.12**	**-0.11**	**-0.20**	**-0.16**	**0.12**	0.03	0.06	**0.14**	**1**

Please Note: The numbers relate to the variables listed in column 1. Values in bold denote statistical significance at the 95% level.

Conferences

8th Nursten Symposium, June 2021

Oral: Meat me half-way.

14th Pangborn Sensory Science Symposium, August 2021

Poster: Meat me half-way: Consumer Intention to reduce meat consumption.

EMDoc conference, September 2021.

Oral: Meat me half-way: Changing consumer behaviour towards more sustainable diets.

4th LEAP conference, December 2021

Poster: Exploring consumers' willingness and motivations to reduce meat intake and accept protein alternatives: A cross-cultural study.

IFST Sensory Science Group & 10th E3S Annual Symposium, May 2022.

Oral: A cross-cultural perspective of meat-eating consumers' willingness and motivations to reduce meat intake and accept protein alternatives.

9th Nursten Symposium, June 2022.

Oral: "I guess it's quite trendy": A qualitative study exploring young meat-eaters sustainable food consumption habits and acceptance of novel alternatives.

Biosciences PGR Symposium, July 2022.

Poster: "I guess it's quite trendy": A qualitative study exploring young meat-eaters sustainable food consumption habits and acceptance of novel alternatives.

Total Food conference, July 2022.

Oral: Exploring meat eating consumers' willingness and motivations to reduce meat intake and accept protein alternatives between Australia, China, and the UK.

EUROSENSE 10th European Conference on Sensory & Consumer Research, September 2022

Oral: A cross-cultural perspective of meat-eating consumers' willingness and motivations to reduce meat intake and accept protein alternatives.

15th Pangborn Sensory Science Symposium, August 2023,

Poster: Meat Attachment: Exploring differences associated with culture, age, gender and personality traits.

Awards

- **December 2020:** *Awarded the Giract 1st year PhD in Flavour Research Bursary*
- **May 2021:** *Finalist, University of Nottingham, Faculty of Science, 3 Minute Thesis*
- **June 2021:** *Winner of the most popular presentation, Nursten conference*
- **May 2022***: Winner of the best student presentation, IFST Sensory Science Group & 10th E3S Annual Symposium*
- **September 2022**: *Winner of the E3S EuroSense Student Award*
- **August 2023*****:*** *Awarded the Pangborn Student and ECR conference Bursary*
- **November 2023:** *Winner of the Food and Nutrition Award, best presentation, University of Adelaide Postgraduate Symposium*

Other work

2021 – Jan 2024
IFST Sensory Science Group (UK), Communication Team

2021 – September 2023
European Sensory Science Society (E3S), Next Generation Group, General Enquires Manager