Consumer perceptions and intentions towards sustainable meat consumption and lab-grown meat in Australia

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A thesis submitted to The University of Adelaide

in fulfillment of the requirements for the degree of

Doctor of Philosophy

The Centre for Global Food and Resources

Faculty of the Professions

The University of Adelaide

October 2021

Contents

Glossary

CSIRO: Commonwealth Scientific & Industrial Research Organization is a government science organisation and is an authority commonly cited to be trusted by Australians.

Conventionally/traditionally raised livestock: includes farming systems and fishing methods that include: beef, lamb, chicken, pork, kangaroo, dairy, eggs and fish and seafood.

Fetal bovine serum (FBS): is the most widely used serum-supplement for the in vitro cell culture.

Food system (FS): the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded. (FAO, 2018).

Lab grown meat (LGM): also known as *in vitro* meat, cultured meat and clean meat, LGM is derived from a biotechnological tissue-culture approach, which involves extracting animal stem cells and culturing them into a muscle tissue on an industrial scale (Post, 2014).

Multispecies pasture rotation (MSPR): a system which symbiotically stacks multiple animal production enterprises (i.e., chickens, cattle, sheep, and pigs) on one landscape (Rowntree *et al.*, 2020).

Plant-based meat alternatives: are made from beans, peas, lentils, grains. E.g., tofu, tempeh, seitan, Quorn, veggie/bean burgers, 'Beyond Burger'.

Regenerative agriculture: a newly approach to agriculture that emphasizes reducing reliance on exogeneous inputs, as well as restoring and enhancing ecosystem services such as soil carbon (C) sequestration (Rowntree *et al.*, 2020).

Syntropic agriculture: bears elements present in most of the types of agroecology, such as no use of chemicals, no-impact or low-impact technologies, and a design strongly based on ecological succession. It was developed over 45 years by Swiss farmer Ernst Götsch, who lives in Brazil since 1982 (Andrade *et al.*, 2020).

Sustainable development: development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Bruntland Commission, 1987).

Sustainable food system (SFS): delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised (FAO, 2018).

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Abstract

Animal-sourced products are among the most nutritious food products available to humans. However, the sustainability of food derived from modern livestock production methods are under increased scrutiny. Growing consumer concerns over the impacts of global meat production and consumption have led to growing demand for alternative sources of protein, and the use of production-related credence attributes and related 'sustainability' labels on meat products.

To address these issues, this thesis aims to increase understanding of Australian consumers' views and intentions regarding sustainable meat and meat substitutes. Consumers' perceptions of six key attributes (health, safety, affordability, eating enjoyment, animal welfare and environmental friendliness) were measured for conventionally produced meat, plant-based protein products, and novel lab-grown meat alternatives. Market opportunities for lab-grown meat were also explored. Australia provided a unique context to conduct this research because both per capita meat consumption and per capita greenhouse gas emissions have been high relative to other countries around the globe.

The main empirical work for this thesis is presented in Chapters 2-4. The empirical study presented in Chapter 2 focuses on understanding what sustainability means to consumers in the context of meat and how consumers relate production-related credence attributes of chicken meat to sustainability. The exploratory research used a multi-method approach (an online survey (n=87), in-person interviews (n=30) and eye-tracking methods (n=28)). Environmental dimensions of sustainability were most important to consumers' definition of a 'sustainable food system', and chicken meat sustainability was most commonly associated with the perceived environmental impact of chicken meat production. Consumers made incorrect inferences about some sustainability labels and frequently associated a higher price with higher sustainability, indicating a belief that 'doing the right thing' might cost more.

Chapter 3 employed an online survey to investigate 1078 Australian consumers' perceptions of meat products (chicken and beef) and meat substitutes (plant-based meat alternatives and lab-grown meat). Consumers' behavioural intentions with respect to lab-grown chicken and beef were also explored using multinomial logistic regression analyses to understand what factors are likely to influence willingness to consume lab-grown meat products. On average, relative to other products, lab-grown meat was perceived negatively on all attributes considered, with the exception of animal welfare. Factors that helped predict willingness to consume lab-grown meat were positive perceptions of eating enjoyment and the healthiness of lab-grown meat; familiarity with lab-grown meat; higher consumption frequency of conventionally raised chicken meat; tertiary education; and younger age.

Chapter 4 utilised the data set from Chapter 3 to provide further insight on the market potential for lab-grown meat in Australia. A latent class cluster analysis revealed six unique clusters, of which three (49% of consumers) showed some willingness to consume lab-grown meat when available on the market. One segment, 'Prospective LGM eaters' (12%), appeared 'very willing' to consume lab-grown meat. These consumers were more likely to be younger (<35 years); university-educated; live in metropolitan areas; have greater prior awareness of lab-grown meat; stronger beliefs regarding the potential self- and society-related benefits of growing demand for lab-grown meat; and they had higher trust in diverse information sources.

Keywords: Meat, Consumer behaviour, Sustainability, Food systems, Eco-labelling, Perceptions, Animal Welfare, Environment, Health, Eye-tracking, Lab-grown meat, Plant-based protein, Alternative protein sources, Food choice values, Dietary preferences, Segmentation.

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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I acknowledge the support I have received for my research through the provision of Adelaide Graduate Research Scholarship from The University of Adelaide.

Lívia Garcez de Oliveira Padilha

Date: 20 October 2021

Acknowledgements

"Write down your dreams. Write them down often. Speak of them to your relatives and friends. Seek out people who share those dreams. Ignore those who do not. Don't spend time with naysayers. As your vision becomes your passion, dreams will give place to reality." – Joel Salatin

During my PhD journey several people were extremely important and helped me so that one of my dreams could become a reality.

In Australia, my wonderful supervisors Professor Wendy Umberger and Dr Lenka Malek were vital and guided me through the entire time. Wendy, your support and encouragement were amazing. Lenka, your friendly smile and your willingness to teach me every day will always be in my mind. Dr Alexandra Peralta and Dr Daniel Gregg, even though for a short time, you were also very important in this journey as co-supervisors. Dr Patrick O'Connor, you taught me so much, especially about the power of storytelling, whether when writing an article, at a lunch table or around a campfire. My PhD friends, what an honour was to study with you, you are so wonderful and such amazing friends. Alfinura, Trang, Sara, Till, I miss our lunches, coffees and "good mornings", my dear ladies. Nikki, I am forever grateful for your friendship, you are my favourite Aussie. Larissa, my Brazilian friend at GFAR, thank you so much for your kindness, you, André, Julia and João are always welcome to visit us.

To all GFAR's staff and students, you were like a family to me during these years, thank you for providing such a nice environment for me to learn and develop.

In Brazil, a special thanks to my family, which was always sending me love and support. My mom, my dad, my brother and stepmother, thank you for always cheering for me. Despite the distance, you were always in my mind and being able to finish the thesis here with you and celebrate together is incredible. Love you all very much.

Lucas, I cannot express the importance you had in this journey, you embarked with me in this adventure, stayed by my side and encouraged me in all times. I love you so much.

Thanks to God for guiding me in the best directions in this journey.

Thank you all, from the bottom of my heart.

Chapter 1: Introduction

1.1. Background

Sustainability is a complex and multifaceted concept that is increasingly being discussed in relation to food systems. Most commonly, sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland Commission, 1987, p. 43). Since the publication of this definition in the Bruntland Report in 1987, the literature on sustainable development has grown. It has continued to contribute to the debate around what pillars or dimensions are central to the broad concept of 'sustainability'.

Multi-pillar models of sustainable development suggest that different sustainability goals in distinct areas should be pursued simultaneously rather than competitively (Alexandrescu *et al.*, 2018). This is the case with the "Three Pillar Model", which assumes a balancing of economic performance, social justice and wellbeing, and environmental protection (Elkington, 1999). Even though scholars have not limited their attention to this model, it was the most common conceptualization (Åhman, 2013) until relatively recently.

The last two decades saw increasing discussion about a fourth pillar of sustainable development – culture – introduced to discussions around sustainability (Magee *et al.*, 2013). One interpretation of cultural sustainability is recognising the "conservation, maintenance and preservation of cultural capital in different forms as arts, heritage, knowledge, and cultural diversity for the next generations" (Soini & Dessein, 2016). It has been argued that our culture shapes what is understood by development and determines how people act (Nurse, 2006); and that cultural sustainability should be considered "as parallel to ecological, social, and economic sustainability" (Soini & Dessein, 2016). In 2015, the United Nations (UN) launched a set of 17

Sustainable Development Goals (SDGs); and for the first time, cultural sustainability was officially incorporated in the UN's international development agenda (United Nations, 2015)

While four pillars of sustainable development are now recognised, consumer food behaviour research to date has mainly focused on the first three pillars of sustainability (Grunert *et al.*, 2014; Hartmann & Siegrist, 2017; van Dam & van Trijp, 2011; Van Loo *et al.*, 2017). Few studies have considered the cultural pillar (Paddock, 2017; Schösler *et al.*, 2015). To increase the likelihood of this thesis producing findings that can help policymakers and industry to better influence sustainable food consumption behaviour, all four dimensions of sustainability - the *social*, the *environmental*, the *economic* and the *cultural* – were considered in the research design.

Food systems[1], from production to consumption, have an important role to play in achieving the United Nations' SDGs (Adesogan *et al.*, 2019). In fact, progress towards several of the SDGs, depends on the development of more sustainable food systems (Jackson *et al.*, 2020). Sustainable food systems are defined as those that deliver food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised (FAO, 2018).

Existing literature suggests that understanding the motivations for buying sustainable food is the key to addressing the issue of today's 'unsustainable' consumption (Thøgersen, 2014). If individuals gradually change towards more sustainable food consumption patterns, the food system would transform in response to changing demand, and, subsequently, result in a more sustainable food system over time (Pearson *et al.*, 2014). In this area, there is a strategy

[1] The food system encompasses "the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded." (FAO, 2018, p. 1).

from some consumers regarding particular foods, known by the acronym "SOLE[2]" (Sustainable Organic Local Ethical). This behaviour consists of buying such foods in order to drive more sustainable production. However, as highlighted by Hepting *et al.* (2014), while the idea of SOLE food opens a door onto the discussion of ethics in the food system, it also points to the considerable difficulty in arriving at a one-size-fits-all solution to ethical consumption. This particular difficulty was investigated in this thesis, in one analytical chapter in particular, which explored production-related credence attributes and the perceptions consumers have between them and sustainability.

Looking through a food systems lens, there are a broad range of activities with environmental, social, economic and even cultural impacts, such as production, processing, retailing, and consumption, that affect the sustainable development of food systems. The main topic of this thesis is related to sustainable food consumption, more specifically, the consumption of meat and other "new" protein sources.

Animal-sourced products are among the most nutritious food products available to humans (Murphy & Allen, 2003). However, the sustainability of food products derived from the modern livestock industry are increasingly under scrutiny (Tilman & Clark, 2014). Meat, for example, is one of the most criticised animal-sourced foods, creating a "meat crisis" (D'Silva, 2013). The critics of meat as a food source, usually emphasise production-related issues such as the environmental impact (e.g., water usage and greenhouse gas emissions (Parodi *et al.*, 2018)) and the welfare of farm animals (Malek *et al.*, 2017; Spencer *et al.*, 2018).

Exacerbating this "crisis", are projections of future global meat demand. If current meat consumption patterns continue, the amount of meat consumed in 2030 is expected to be 72% higher than global meat consumption in 2000; and this increase is expected to be dominated

[2] Coined by Bonnie Azab Powell in 2006, as a possible name for the blog she was starting (Hepting *et al.*, 2014).

mostly by increases in chicken and pork consumption (Adesogan *et al.*, 2019; Fiala, 2008). Meat plays a vital role in sustainable food systems, since food security is not only about "producing sufficient food – it encompasses the need to ensure access to sufficient and nutritious food at all times" (FAO, 2012, p. 3). For instance, it is known that today two billion people (mainly in developing countries) suffer from micronutrient deficiencies and this is partly due to insufficient consumption of animal-sourced foods (e.g., milk and dairy products, meat, fish, and eggs) (Adesogan *et al.*, 2019). Thus, while more sustainable food consumption may mean reducing meat consumption in high meat-eating developed countries, it may mean increasing meat consumption in some developing countries.

The focus of this thesis is on consumers in Australia, a country known for its relatively high per capita meat consumption (average of 90 kg per person in 2019; three times the global average (OECD 2020)) and high per capita GHG emissions (average of 16 t per person in 2017; (Ritchie & Roser, 2017)). Research that improves understanding of the perceptions, preferences, motivations and behaviour of Australian consumers with respect to meat and meat-alternatives could help the food industry to match (and also influence) the demand for more sustainable foods.

Along with the increasing global demand for meat, there has also been an increasing availability of plant-based meat substitutes in the market. Most plant-based meat substitutes are based on soy (e.g., Tofu, Tempeh, "TVP: textured vegetable protein"), wheat proteins ("Seitan"), mycoprotein ("Quorn"), pea protein ("Chicken Free Chicken") or a mix of several protein sources (e.g., Impossible Foods™ and Beyond Meat™ hamburgers) (He *et al.*, 2020; Post, 2012). The new generation of substitutes for meat that have entered the market in the last ten years trying to mimic the physical (e.g. appearance), sensory (e.g., taste, texture, mouthfeel and aroma), and chemical (e.g., nutritional content) properties of meat (He *et al.*, 2020). This is typically achieved by using techniques such as extrusion and sheer cell to obtain the meat-

like structure and texture and by using beet juice/powder, soy leghemoglobin, colouring agents and aromatic ingredients to obtain the meat-like appearance and flavour (He *et al.*, 2020). In Australia alone, the range of plant-based meat alternatives on the market has grown by 429% over the last four years (2015-2019) (Curtain & Grafenauer, 2019).

A complex range of factors are known to influence food purchase and consumption decisions (Font-i-Furnols & Guerrero, 2014; Grunert, 2011). In the last two decades, a growing body of literature has examined issues surrounding changing meat and protein consumption patterns (Archer, 2011; Dagevos & Voordouw, 2013; Hartmann & Siegrist, 2017; Macdiarmid *et al.*, 2016; Malek & Umberger, 2021a; Pimentel & Pimentel, 2003). According to a recent review, the main factors that have driven the development of plant-based meat alternatives are concerns regarding human health, the environment and animal welfare (He *et al.*, 2020). Changes in the purchase and consumption behaviour of both meat and plant-based meat alternatives will play an important role in shaping sustainable outcomes (environmental, economic, social and cultural). It is, therefore, useful to investigate these new sources of protein, especially ones that promise to disrupt the entire food chain if it is well accepted. Lab-grown meat products (also known as *in vitro* meat, cultured meat and clean meat) are an example of such a novel new source of protein for human consumption.

Lab-grown meat products are derived from a process which involves extracting animal stem cells and culturing them into muscle tissue on an industrial scale (Post, 2014). The main goal of emerging lab-grown meat products is to satisfy the growing global demand for meat in a more 'sustainable' manner. Similar to developers of plant-based meant alternatives, developers of lab-grown meat products are attempting to develop meat alternatives that mimic the sensory properties (e.g., appearance, texture, flavour and odour) of conventional meat, but offer advantages over conventional meat, including more environmentally-friendly and animal-welfare friendly production methods (Bhat *et al.*, 2019; de Boer & Aiking, 2019). The expected

potential benefits of lab-grown meat will only be realized if it can be produced efficiently, if it is accepted by the market, and if consumers are willing to replace conventionally produced meat with novel lab-grown meat products (Hocquette, 2016).

Alongside with the potential benefits, there are still ethical and other issues associated with lab-grown meat, especially regarding the negative effects of the product regarding food sovereignty and that it would be a technological fix to a bigger problem that could be deal with more systematically (Dilworth & McGregor, 2015; Rodgers & Wolf, 2020).

The idea of 'manufacturing meat' without the need to farm and slaughter a living animal was first mentioned by Winston Churchill, who wrote "…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…". (Churchill, 1932; Post, 2014). It took slightly longer than Churchill imagined for the first laboratory-grown hamburger to be served on a TV set in London in 2013 (Mayer, 2013); and a few years longer than that to be served in a restaurant to consumers in Singapore in 2020 (Business Wire, 2020). So far, Singapore is the only country to allow sale of lab-grown meat products, with the Singapore Food Agency providing regulatory approval for a lab-grown chicken meat product, GOOD Meat Cultured Chicken (produced by Eat Just, Inc., a United States based company) in 2020 (The Guardian, 2020);and the first commercial lab-grown meat factory opened in Israel in 2021, with the capacity of producing 500 kgs of meat per day (Future Meat, 2021).

Consumers' willingness to substitute meat and other sources of protein or food in their diet with novel food products such as lab-grown meat product will depend on their familiarity with the product and perceptions about the intrinsic and extrinsic attributes of the product (Tuorila & Hartmann, 2020). If an emerging food technology such as lab-grown meat continues to evolve and scale-up, there may be diverse socio-economic, political, environmental and

cultural implications for consumers, the industry and even food regulators/policymakers if consumers substitute conventional meat with alternative protein sources such as lab-grown meat. Such impacts may contribute to or reconfigure existing political economies in the global food system (Stephens *et al.*, 2018). Therefore, along with conventionally-raised meat (chicken and beef) and plant-based meat alternatives' perceptions, Australians' acceptance of lab-grown meat products will be examined in this thesis.

1.2. Knowledge gaps and research objectives

There are great concerns about how food production and consumption can be transformed to reach a more sustainable system (Geels *et al.*, 2015; Jackson, 2005). The growing literature on sustainable food production and consumption, reflects the importance of the topic. However, current understanding of how consumers relate production-related credence attributes to sustainability in the context of food, remains limited (Barone *et al.*, 2020; Grunert *et al.*, 2014; Van Loo *et al.*, 2014). Key knowledge gaps in the existing literature are addressed in the analytical **Chapter 2**. Firstly, while previous studies have examined consumer perceptions of sustainability in a food context (Grunert *et al.*, 2014; Van Loo *et al.*, 2014), as far as I know, there is limited understanding of perceptions of sustainability specifically regarding meat.. Secondly, as far as I know, there are only a few studies that have sought to investigate how consumers identify sustainable meat products when grocery shopping (i.e., do production-related credence attributes play a role in forming perceptions of sustainability?).

Australia provides an ideal context in which to explore consumers' associations between sustainability and meat attributes due to the relatively high per capita consumption of both meat (in general) and chicken meat. Previous research revealed that 21-23% of Australian consumers were making conscious decisions to purchase meat products labelled as "free-range", "certified humane", or "antibiotic-free" (Malek *et al.*, 2019). However, if and how consumers relate these labels to sustainability remains unknown. This is a problem because how consumers perceive

sustainable food systems and how they relate meat price and production-system related labels to sustainability remains unknown. Without knowledge of such information, little can be done to overcome the potential barriers to sustainable consumption.

Different protein alternatives (including plant-based proteins, lab-grown meat, insect proteins, mycoproteins) have been compared with respect to attributes related to human health and environmental impact (Parodi *et al.*, 2018). However, few studies have explored consumers' perceptions of conventionally raised meat compared to alternative protein sources (Gómez-Luciano *et al.*, 2019; Siegrist & Hartmann, 2019; Verbeke *et al.*, 2015). Overall, no previous studies have simultaneously compared consumers' perceptions of conventionally raised meat, plant-based meat alternatives and lab-grown meat on the range of attributes considered in analytical **Chapter 3**. Yet, a comparison of these attributes across protein options may more closely match the comparisons made between products in real-life shopping situations. A greater understanding of which lab-grown meat attributes influence consumers' willingness to consume lab-grown meat, and to what extent, is therefore necessary, and may be key to developing effective communication strategies aimed at increasing future acceptance of alternative protein products.

Regarding consumer behaviour for LGM, the interest has grown and several publications were published on consumer acceptance of the product in the last years: 14 studies from 2014–2018 and 26 studies from 2018-2020 (Bryant & Barnett, 2018, 2020). On perceptions affecting willingness to eat LGM, findings from previous studies suggest that consumers' perceptions of product attributes generally play a more important role than most other factors such as food neophobia (Gómez-Luciano *et al.*, 2019; Verbeke *et al.*, 2015). For example, Gómez-Luciano *et al.* (2019) found that, collectively, consumers' perceptions of the healthiness, safety and nutritional characteristics and/or the perceived higher sustainability, better taste and lower price of LGM compared to conventionally raised meat, had the strongest influence on UK, Spanish

and Brazilian consumers' willingness to purchase LGM. Many studies have been done in different countries, but there is still a lack of understanding in Oceanian consumer behaviour towards LGM (Bogueva & Marinova, 2020; Siegrist & Hartmann, 2020). Furthermore, in this analytical chapter, multinomial logistic regressions to predict willingness to eat lab-grown meat products (chicken and beef) were conducted to provide different insights. We focused on product-related factors (perceptions of product attributes) and person-related factors (including consumption behaviour, familiarity and socio-demographics) that previous studies have found to be associated with acceptance of LGM and/or consumption of meat substitutes (Bryant et al., 2019; de Boer & Aiking, 2011; de Boer et al., 2014; Elzerman, Hoek, van Boekel, & Luning, 2015; Gómez-Luciano et al., 2019; Hoek, Luning, Stafleu, & de Graaf, 2004; Hoek, van Boekel, Voordouw, & Luning, 2011; Siegrist & Hartmann, 2019; Verbeke, 2015; Verbeke, Sans, & Van Loo, 2015).

Consumer acceptance of lab-grown meat has been identified as a key factor that will influence future demand for the product. The existing lab-grown meat literature already covers several topics ranging from technological advances (Datar & Betti, 2010; Post, 2014; Sharma *et al.*, 2015; Stephens *et al.*, 2018), analysis of public reaction to news (Goodwin & Shoulders, 2013; Laestadius & Caldwell, 2015) to consumer behaviour and marketing research (Bogueva & Marinova, 2020; Bryant & Barnett, 2020; Dupont & Fiebelkorn, 2020; Hwang *et al.*, 2020; Siegrist & Hartmann, 2020).

Previous studies have examined consumer acceptance of lab-grown meat. However, none have examined consumer heterogeneity. Considerable preference heterogeneity for meat alternatives (including lab-grown meat) has been shown to exist, and researchers have called for this heterogeneity to be explored in future studies (Van Loo *et al.*, 2020). Analytical **Chapter 4** presents the first consumer research on the topic of lab-grown meat to consider heterogeneity in willingness to consume the product. It is also the first to explore market

opportunities for lab-grown meat in Australia, using a nationally representative consumer sample. With the knowledge of the target markets' main food choice values, the nascent lab-grown meat industry can better tailor and target strategies for adoption. Conventional livestock industries could also benefit from a better understanding of the underlying factors for possible migration or substitution to the new product.

This thesis makes a substantial contribution from an applied point of view since consumers' everyday life choices can have an impact on sustainable food systems overall. Addressing the above outlined knowledge gaps is essential for understanding the perceptions and behavioural intentions of Australian consumers regarding meat and alternative protein sources; and providing evidence for the meat/protein industry and for future policies. In order to increase understanding of Australian consumers' views and intentions regarding sustainable meat and meat substitutes this thesis addresses the following research questions for Australian consumers:

i. What are consumers' perceptions of sustainable food systems and sustainable chicken meat production systems?

ii. What (if any) factors do consumers use to assess the sustainability of chicken meat products? How are three sustainability labels (text claims and logos) and prices used by consumers when assessing the sustainability of chicken meat products?

iii. What are consumers' perceptions of six key attributes (e.g. health, safety, affordability, eating enjoyability, animal welfare and environmental friendliness) across five different food products, including two 'conventionally raised' meat products (chicken and beef), 'lab-grown chicken', 'lab-grown beef' and 'plant-based protein alternatives'?

iv. Which factors (e.g. familiarity with lab-grown meat, perceptions, meat consumption frequency, and/or socio-demographic characteristics) help predict willingness to consume lab-grown chicken and lab-grown beef?

v. Is there heterogeneity in consumers' willingness to consume lab-grown meat products?

    a. If yes, how do consumer clusters (segments) differ in socio-demographic, behavioural (e.g., food consumption), and psychosocial factors (e.g., familiarity with and beliefs regarding lab-grown meat, and trusted information sources)?

1.3. Research methodology

To address the research questions empirically, the analytical chapters of this thesis used two different sets of data. First, the data presented in Chapter 2 was obtained using an exploratory multi-method approach; and second, the data presented in Chapter 3 and Chapter 4, also exploratory studies, was obtained via a quantitative online survey. All data collection was conducted by the author of this thesis and her supervisors.

Chapter 2

The multi-method approach used to collect data for the exploratory study (Chapter 2) was conducted in three stages. Participants first completed an online survey (Stage 1) before participating in a one-hour study appointment during which they completed a series of 10 eye-tracking choice tasks (Stage 2); this was followed by in-depth semi-structured interviews (Stage 3). Figure 1.1 shows the details of this multi-method study.

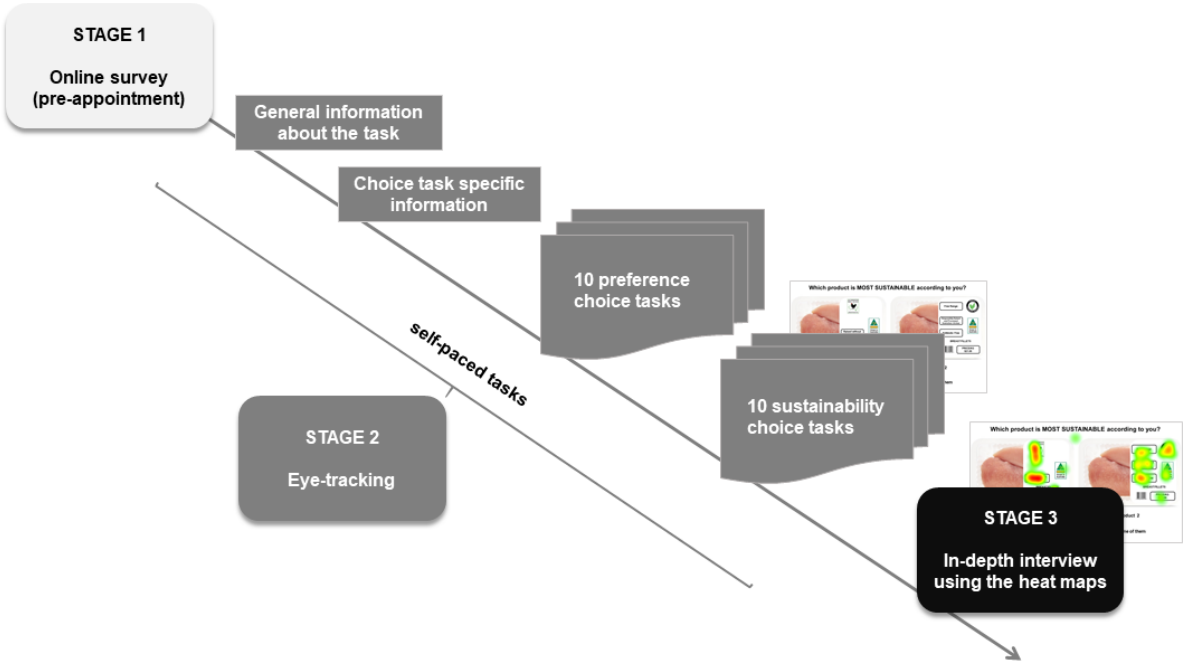

Figure 1.1. Chapter 2 study design with emphasis on the three appointment's stages.

The survey used in Stage 1 of data collection included questions on socio-demographics (including sex, age, area of residence, educational attainment and employment status); household characteristics (including income before taxes and number of children); consumption frequency of animal-based and plant-based protein foods and dietary preferences (omnivore, semi-vegetarian/flexitarian, full-time vegetarian or vegan); awareness and use of labelling information on chicken meat products (including the labels/claims shown in the following eye-tracking choice tasks; and perceptions of sustainability). A market research company (Dynata^{TM}) provided the consumer panel and administered the survey.

The eye-tracking method (Stage 2) is growing in popularity amongst researchers from different disciplines, and is generally used in combination with other methods, such as questionnaires, interviews and experimental choice methods (Holmqvist *et al.*, 2011). The innovative method of eye-tracking permits observation and measurement of the movement of eyes when individuals receive a visual stimulus or view a product (Vu *et al.*, 2016). This

method was selected as ideal to our investigation because our objective was to understand how sustainability labels and prices were used by consumers when assessing the sustainability of chicken meat products. Therefore, considering the small visual field the individual can scan (2 percent), tracking "eye movements can (in principle) help in our understanding of how information is obtained" (Balcombe *et al.*, 2017, p. 255). Besides that, according to a current review in the marketing field (Wedel & Pieters, 2008), the eye tracking method is considered a neuroscience tool, since it helps to measure physiological changes in response to a marketing stimuli, what helped our understanding about consumer behaviour.

Among the advantages of the modern eye-tracking devices is the fact that they are not invasive and they can provide immediate results in the form of heat maps, which were used in the following stage of the research. Heat maps provide a visual representation of the eye-tracking data. Specifically, they show the distribution of the participants' attention on the screen when completing the choice tasks. These heat maps were important to guide the next stage of the study which involved in-depth interviews.

The literature on label-usage has shown that the eye-tracking method provides researchers with good objective measures of attention (e.g., "where" participants look), but it does not provide an explanation for attention (e.g., "why" they look at certain labels) (Tanner *et al.*, 2019). To address this limitation, participants were interviewed immediately after the eye-tracking task, with the heat maps used as probing aids during the interview (Stage 3). Individual interviews typically generate a large volume of in-depth data from participants and were chosen as a research method due to the exploratory approach of the study. Different to other chapters, both qualitative and quantitative approaches were used in this chapter since the use of qualitative methods has the advantage of enriching the results by providing an in-depth understanding of issues (Malhotra, 2011).

The multi-method exploratory study was conducted between September 2019 and January 2020. Data cleaning and data coding required careful consideration. For a more detailed explanation of the methods, please see the methods section in Chapter 2. The interview guide and the ten choice sets used to collect data are provided as appendices in Chapter 2.

Chapter 3 and Chapter 4

The quantitative online survey used in the study described in Chapter 3 and Chapter 4, was completed by 1,078 Australian consumers between October and November 2018. Quotas were set to obtain a nationally representative sample with respect to age, gender and location (both metropolitan versus other areas, and distribution by state/territory). A market research company (Dynata™) provided the consumer panel and administered the survey.

The comprehensive questionnaire assessed: household food purchase behaviour; personal food consumption behaviour; food choice values; food production and consumption concerns; awareness, perceptions and intentions regarding lab-grown meat; and trusted sources of food safety information. The methods of data analysis used to address the research questions in Chapter 3, were: one-way analysis of variance (ANOVA) used for comparing perception scores across meat/alternative protein products; and logistic regression (multinomial logistic regressions (MNL)) used to predict the probability of being willing to consume lab-grown meats. The methods used to address the research questions in Chapter 4 were consumer segmentation (latent class cluster analysis), followed by post-hoc comparisons of the latent clusters.

For more detailed explanation of the methods, please see the methods sections in Chapter 3 and Chapter 4. The questionnaire used to collect the data is provided in the Appendix of this thesis.

It is important to note that for all samples (Chapters 2, 3 and 4) there were no restrictions regarding the respondents' dietary preferences. That is to say that omnivores, flexitarians, vegetarians and vegans could respond to the study. The inclusion of vegetarians and even vegans is justified because they are also potential consumers of lab-grown meat, given that some of their drivers to exclude meat from their diets are addressed with some characteristics of this meat substitute (e.g., Animal welfare concerns) (de Boer *et al.*, 2017; Rosenfeld & Burrow, 2017). Also, even if they do not consume meat, they could be the responsible for purchasing meat products for their household. (e.g., an individual who does not eat meat but buys chicken meat for his/her family, could participate in Chapter 2 study). To summarize the methodological approaches used in the exploratory studies, Table 1.1. shows the types of data collected, dates of data collection and sample sizes.

Table 1.1. Summary of data collected in Chapters 2, 3 and 4.

Exploratory studies	Data collection types	Data collection dates	Sample sizes
Chapter 2 – stage 1	Quantitative online survey	Sept 2019 – Jan 2020	n = 87
Chapter 2 – stage 2	Quantitative eye-tracking tasks	Sept 2019 – Jan 2020	n = 28
Chapter 2 – stage 3	Qualitative in-depth interviews	Sept 2019 – Jan 2020	n = 30
Chapter 3	Quantitative online survey	Oct - Nov 2018	n = 1,078
Chapter 4	Quantitative online survey	Oct - Nov 2018	n = 1,078

1.4. The structure of the thesis

An overview of the remaining four chapters of this thesis is provided in the following paragraphs.

Chapter 2 analysed data from an exploratory multi-method consumer study which involved an online survey, eye-tracking and individual interviews. The study explores consumers' perceptions of sustainable food systems and sustainable chicken meat production systems; examines what (if any) factors consumers use to assess the sustainability of chicken

meat products; and investigates how three sustainability labels (text claims and logos) and prices are used by consumers when assessing the sustainability of chicken meat products. Overall, the study suggests that the environmental pillar of sustainability is the most important to Australian consumers' definition of a 'sustainable food system', followed by the economic, social and cultural pillars. In general, Australian consumers incorrectly interpret many of the production-related sustainability labels in the market. However, results suggest that consumers' use of production-related credence labels to inform their perceptions/judgements of the sustainability of a meat product is less likely to be limited by their lack of awareness and understanding of the label, and more likely to be limited by the relatively lower importance they place on sustainability in their meat purchase decisions.

Chapter 3 analysed data from an online survey completed by 1,078 Australian consumers in October and November 2018. The study investigated consumers' perceptions of different types of meat products (chicken and beef) and meat substitutes (plant-based meat alternatives and lab-grown meat). Additionally, the study explored consumers' acceptance of lab-grown chicken and lab-grown beef and what factors influence acceptance. Relative to conventionally raised chicken and beef and plant-based protein products, lab-grown meat is perceived to be significantly less healthy, affordable, safe and enjoyable to eat. Multinomial logistic regressions (MNL) were estimated. Results of the MNL models showed a wide range of factors associated with willingness to eat lab-grown meats. In the models, factors that predicted willingness to consume lab-grown meat products were positive perceptions relative to their healthiness, eating enjoyability, safety and animal friendliness. Familiarity and higher consumption frequency of chicken meat also were significant predictors of willingness to eat lab grown meat, however, for lab-grown beef another products' consumption were significant as well. For both chicken and beef lab-grown products, consumers with tertiary educations and younger were more willing to eat lab-grown meat products. Overall, the current market

potential for lab-grown meat appears to be low, however, it may gain market acceptability if marketing campaigns can promote benefits related to eating enjoyability, healthiness, safety and animal friendliness.

Chapter 4 explores the market potential for lab-grown meat in Australia using the same dataset used in Chapter 3. Latent class cluster analysis revealed six clusters or segments, which were distinct in their degree of willingness to consume lab-grown meat and in their food choice values. Three of the six clusters (49% of consumers) indicated some willingness to consume lab-grown meat. Just one of the clusters, named 'Prospective LGM eaters' (12% of consumers), was 'very willing' to consume lab-grown meat. These 'Prospective LGM eaters' were more likely to be younger (<35 years); university-educated; live in metropolitan areas; have greater prior awareness of LGM; stronger beliefs regarding the potential self- and society-related benefits of growing demand for LGM; and they had higher trust in diverse information sources.

The final chapter of the thesis, **Chapter 5**, provides a summary and general discussion of the findings and the possible implications arising from them. It also provides market and policy recommendations, pathways towards more sustainable food systems, research limitations and potential topics for future research in this area.

The conceptual framework of this thesis is provided in Figure 1.2.

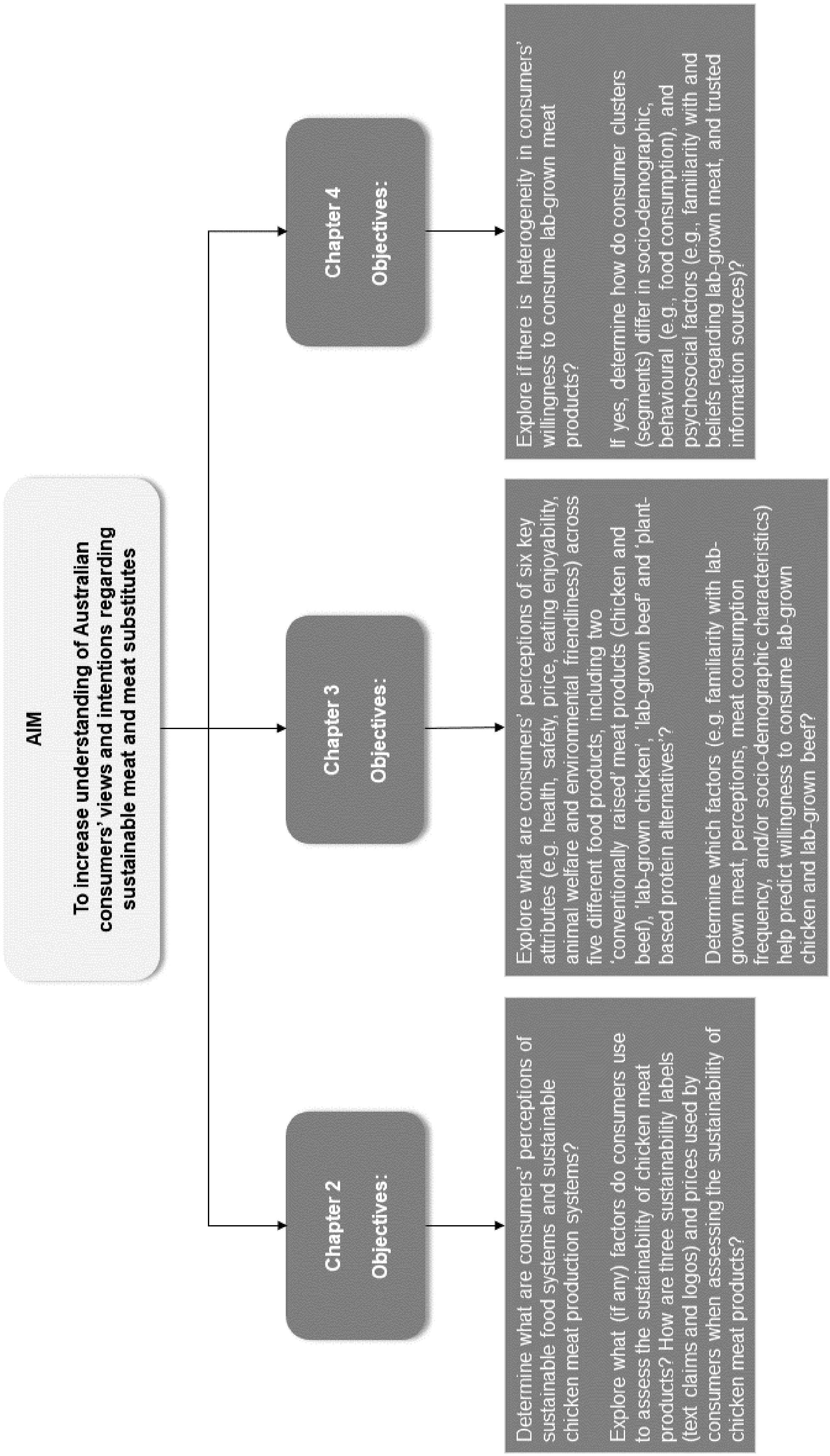

Figure 1.2. Conceptual framework.

Chapter 2: Statement of Authorship

Title of Paper	Sustainable meat: looking through the eyes of Australian consumers
Publication Status	Published.
Publication Details	Garcez de Oliveira Padilha, L., Malek, L., & Umberger, W. J. (2021). Sustainable Meat: Looking through the Eyes of Australian Consumers. *Sustainability, 13*(10), 5398. https://doi.org/10.3390/su13105398

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Name of Principal Author (Candidate)	Lívia Garcez de Oliveira Padilha
Contribution to the Paper	Contributed to primary survey, data collection, data analysis and interpretation, wrote manuscript.
Overall percentage (%)	60
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 20/05/2021

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Dr Lenka Malek
Contribution to the Paper	Contributed to primary survey instrument and study design, supervised data collection and interpretation, guided the development of the manuscript and data analysis, and critically edited the manuscript.
Signature	Date 20/05/2021
Name of Co-Author	Professor Wendy Umberger
Contribution to the Paper	Obtained funding for the research, contributed to primary survey instrument and study design, supervised data collection and interpretation, guided the development of

	the manuscript and data analysis, and critically edited the manuscript.
Signature	Date 20/05/2021

Chapter 2: Sustainable meat: looking through the eyes of Australian consumers

Abstract

Sustainability is a complex and multifaceted concept that comprises environmental, economic, social and cultural dimensions. Growing consumer concerns over the impacts of global meat production and consumption have led to increasing interest in sustainability initiatives and the use of sustainability labels. Yet, an understanding of what sustainability means to consumers in the context of meat and how consumers relate production-related credence attributes of chicken meat to sustainability, remains limited. Between September 2019 and January 2020, an exploratory research study was conducted using a multi-method approach. Participants completed an online survey before participating in a series of eye-tracking choice tasks followed by in-depth interviews. The study revealed that the environmental dimension of sustainability is most important to consumers' definition of a 'sustainable food system'. Likewise, the sustainability of chicken meat products was most commonly associated with the perceived environmental impact of chicken meat production, followed by animal welfare aspects. Consumers made incorrect inferences about some sustainability labels and these inferences sometimes contributed to positive associations with sustainability. Consumers frequently associated a higher price with higher sustainability, indicating a belief that 'doing the right thing' might cost more. This study provides new insights regarding consumers' perceptions of production-related credence attributes and sustainability labels.

Keywords: Meat; Consumer behavior; Sustainability; Food systems; Eco-labelling; Perceptions; Animal Welfare; Environment; Eye-tracking.

2.1. Introduction

Food systems, from production to consumption, have an important role to play in achieving the United Nations' Sustainable Development Goals (SDGs) (Adesogan *et al.*, 2019). In fact, progress towards several of the SDGs, depends on the development of more sustainable food systems (Jackson *et al.*, 2020). Therefore, it is not surprising that food system issues have been explored in-depth in the sustainability literature, especially regarding the impact of food production and consumption on the environment (Adesogan *et al.*, 2019; Resare Sahlin *et al.*, 2020). Research shows that food production and consumption contribute significantly to life-cycle environmental impacts (together with mobility, housing and energy), and account for 48% and 70% of household impacts on land and water resources, respectively (Ivanova *et al.*, 2016; Tukker, 2015). Other sustainability issues relating to social and economic aspects of food production and consumption include food security (Adesogan *et al.*, 2019; Godfray *et al.*, 2010) food waste (Aschemann-Witzel *et al.*, 2018), and animal welfare (Gross *et al.*, 2021).

Animal-sourced products are among the most nutritious foods available to humans (Murphy & Allen, 2003). However, the sustainability of products derived from the modern livestock industry are increasingly under scrutiny (Tilman & Clark, 2014). Meat, for example, is one of the most criticized animal-based products, creating a "meat crisis" (D'Silva, 2013). The critics usually emphasise production-related issues such as the environmental impact (e.g., water usage and greenhouse gas emissions (Parodi *et al.*, 2018)) and the welfare of farm animals (Malek *et al.*, 2017; Spencer *et al.*, 2018). If global meat demand growth patterns continue, the amount of meat consumed in 2030 will be 72% higher than the total in 2000. This demand increase will be due mostly to increasing chicken and pork consumption (Adesogan *et al.*, 2019; Fiala, 2008).

In Australia, chicken has been the most consumed meat for over a decade, and this trend is expected to continue (Umberger & Malek, 2020). On average, chicken meat consumption

was an estimated 43.5 kg per capita in 2019, accounting for 48% of total meat consumed (followed by pork, 20.3 kg; beef and veal, 19.7 kg; and sheep, 6.2 kg) (OECD, 2020). On the production side, chicken meat continues to face challenges, including community concerns related to animal welfare and misperceptions about the use of antibiotics. However, relative to other meat products, chicken meat also has some potential unexploited advantages related to sustainability issues, such as lower greenhouse gas (GHG) emissions relative to beef (Australian conventional production of chicken, 1.9-2.4 kg CO_2 equivalent versus production of beef, 10.3-13.0 kg) (Wiedemann *et al.*, 2012; Wiedemann *et al.*, 2014).

To address growing consumer concerns about the impact of meat production, sustainability labels are increasingly used on meat products to provide consumers with point-of-purchase information regarding production-related credence attributes (e.g. ethical and environmental aspects of production) (de Boer, 2003; Janßen & Langen, 2017). Sustainability labels (also termed 'eco-labels') provide consumers with an opportunity to make more sustainable purchase decisions (Grunert *et al.*, 2014). Labels are instruments that can lessen the asymmetric information problem between producers and consumers, as well as reduce the search costs for consumers who are interested in information on production or process attributes (Loureiro & McCluskey, 2000). Information asymmetry occurs when the consumer is unable to identify the credence attribute that he or she is looking for (e.g., environmental friendliness) by the look, taste, or smell of the product (van Amstel *et al.*, 2008). Thus, if a food product has been produced in a more sustainable way, communicating this information via labels is one way of creating awareness among consumers (Erskine & Collins, 1997).

2.1.1. Literature review

The growing literature on sustainable food production and consumption, reflects the importance of the topic. However, current understanding of how consumers relate production-related credence attributes to sustainability in the context of food, remains limited (Barone *et*

al., 2020; Grunert *et al.*, 2014; Van Loo *et al.*, 2014). Generally, findings indicate that consumers' definitions of sustainable food systems are dominated by environmental aspects, but there is still confusion and a lack of knowledge among consumers regarding the role of food in environmental issues (Annunziata & Scarpato, 2014; Grunert *et al.*, 2014; Macdiarmid *et al.*, 2016; Van Loo *et al.*, 2014). For example, research focusing on Australian consumers found that when directly asked about "environmentally-friendly food", the most listed terms by consumers were organic, free-range and recycled packaging (Hoek *et al.*, 2017). Further, just 42% of consumers believed livestock farming plays a role in the human contribution to climate change (Malek *et al.*, 2019).

A cross-country analysis revealed that consumers' motivations and understanding of sustainability labels influences their use of sustainability labels and this differs across countries (2014). Additionally, consumers' concerns about sustainability depend on the food product under investigation (Grunert *et al.*, 2014). To date, only a few consumer studies have focused specifically on the topic of sustainability as it relates to meat or chicken (Cornish *et al.*, 2020; Samant & Seo, 2016; Siegrist & Hartmann, 2019; Van Loo *et al.*, 2014). Of the studies that focused on chicken meat, one found that "free-range" labels were favoured over other sustainability labels (e.g., carbon footprint and organic); but there was no deeper exploration of associations with sustainability (Van Loo *et al.*, 2014). Other studies examined the impact of providing additional information about sustainability labels on purchase intention or behavior; and both found positive effects on visual attention to labels (Samant & Seo, 2016), or purchase intention of labelled products (Cornish *et al.*, 2020).

The design of the present study was guided by Grunert (2011, p. 209) framework, which identifies six possible barriers to consumers' use of sustainability labels in food purchasing decisions. Three of these barriers are considered in this exploratory study. The first barrier

essentially says, ‘exposure does not lead to perception’; the second says, ‘perception leads only to peripheral processing’, and the third says, ‘consumers make ‘wrong’ inferences’.

2.1.2. Study objectives

Key study objectives are 1) to explore consumers’ perceptions of sustainable food systems and sustainable chicken meat production systems; 2) to examine what (if any) factors consumers use to assess the sustainability of chicken meat products; and 3) to investigate how three sustainability labels (text claims and logos) and prices are used by consumers when assessing the sustainability of chicken meat products.

Key knowledge gaps in the existing literature are addressed in this exploratory research. Firstly, while previous studies have examined consumer perceptions of sustainability in a food context (Grunert *et al.*, 2014; Van Loo *et al.*, 2014), as far as I know, there is limited understanding of studies that have focused specifically on meat. Secondly, to my knowledge, there is limited understanding of… how consumers identify sustainable meat products when grocery shopping (i.e., do production-related credence attributes play a role in forming perceptions of sustainability?).

Australia provides an ideal context in which to explore consumers’ associations between sustainability and meat attributes due to the relatively high per capita consumption of both meat (in general) and chicken meat. Previous research revealed that 21-23% of Australian consumers were making conscious decisions to purchase meat products labelled as “free-range”, “certified humane”, or “antibiotic-free” (Malek *et al.*, 2019). However, if and how consumers relate these labels to sustainability remains unknown.

2.2. Materials and Methods

2.2.1. Study design and data collection

This exploratory study used a three-stage multi-method approach to collect data. Participants completed an online survey (Stage 1) before participating in a one-hour study appointment during which they completed a series of 10 eye-tracking choice tasks (Stage 2); this was followed by in-depth semi-structured interviews (Stage 3). Ethics approval for the study was obtained from The University of Adelaide's Human Research Ethics Committee (H-2016-255).

2.2.1.1. Stage 1: Online survey

The online survey included questions on socio-demographics (including sex, age, area of residence, educational attainment and employment status); household characteristics (including income before tax and number of children); consumption frequency of animal-based and plant-based protein foods; dietary preferences (omnivore, semi-vegetarian/ flexitarian, full-time vegetarian or vegan (Malek & Umberger, 2021a)); awareness and use of information on chicken meat products (including the labels/claims explored in Stage 2, the eye-tracking choice tasks); and perceptions of sustainability. One of the questions assessing sustainability perceptions asked participants to rank four characteristics in terms of their importance to their definition of a "sustainable food system": socially responsible; environmentally responsible; economically viable; and cultural integrity/preservation. Sustainability questions were adapted from the literature (Grunert *et al.*, 2014; Van Loo *et al.*, 2017). The time between participants' completion of the survey and their study appointment varied (ranging from 5-30 days).

2.2.1.2. Stage 2: Eye-tracking

Eye-tracking is an indirect method of data collection that allows researchers to explore nonverbal processes. In the eye-tracking choice task, consumers were asked to consider 10 sets of two chicken meat products (see example in Figure 2.1) shown on a computer monitor positioned directly in front of them with eye-tracking software enabled. Each chicken meat product varied in price (five price levels based on prices observed in the market: $9.00, $11.40,

$15.00, $18.60, $21.00) and several production-related credence attributes (e.g., Free-Range/Accredited Free-Range, RSPCA Approved Farming Scheme, and Antibiotic Free). The image of the chicken meat, the meat cut, and the country-of-origin label were kept constant in all chicken meat products used in the choice sets. All credence information was provided in text form (claims) and some were in visual form (image/logo). All labels (i.e., on-package claims and/or logos) and price tags were designed to have the same visual area (5.1cm) in the choice tasks. Labels and price tags all appeared in the same location each time they were shown. All ten choice set images that were used in the study are provided in Appendix B.

After visually examining the products on the monitor, participants were asked to indicate which of the two products they believed to be the 'most sustainable' product. Completion of the choice tasks was self-paced (i.e., no time limit was set) and participants were not provided with a definition of sustainability. Thus, participants made their choices based on their perceived meaning of sustainability.

The Tobii Pro TX300 desk-mounted eye tracker was used to record the eye movements of participants as they completed the choice tasks. Heat maps generated by the eye-tracking software (Tobii Pro Lab version 1.123) provided a visual representation of the eye-tracking data. Specifically, heat maps showed the distribution of the participants' attention on the screen to different product attributes when completing the choice tasks (see Figure 2.2).

Between each choice task, participants were presented with a fixation point (star image) positioned in the top centre of a white/blank screen, which they were instructed to click before proceeding to the next choice task (Banović *et al.*, 2016). This aimed to minimise first-fixation bias (Hummel *et al.*, 2017).

The three labels which were considered in the present study and which varied across chicken meat products, were all used in the market at the time the research was undertaken.

The underpinning standards or requirements for use of each claim or logo are provided in Table 2.1. At the time of the study, about 90% of the total production of chicken meat sold in Australia was conventionally produced. Free- range chicken meat accounted for 10% to 15% of chicken produced (Australian Chicken Meat Federation, 2020).

In Australia, chicken meat products can carry labels with text stating they are "Free-Range" as long as the chickens had some access to the outdoors during the day. There is not a standard definition of free-range chicken meat production systems in Australia and, therefore, the size of and access to the outdoor area can vary considerably from one free-range production system to the next. Free-Range Egg and Poultry Australia Ltd (FREPA) is a not-for-profit auditing and certification body that oversees free-range accreditation of one of the two largest Australian chicken meat brands (Lilydale, 2020). The FREPA standard specifies various requirements for outdoor access.

The RSPCA Approved Farming Scheme label is another not-for-profit and audited certification scheme for animal products (Cornish *et al.*, 2020) which has specific production standards. Antibiotic resistance has been an ongoing concern in relation to the sustainability of poultry production, therefore we included the Antibiotic Free claim (Cervantes, 2015).

2.2.1.3. Stage 3: In-person semi-structured interviews

After participants completed the eye-tracking choice task, semi-structured in-person interviews were conducted by one of two researchers. All interviews were audio-recorded for analysis. Each participant was asked several general questions: "*What comes to mind when you see the word 'sustainable' on food or in discussions around food?*", "*What comes to mind when you see/think about the word sustainable and chicken meat?*" and "*How important to you is sustainability when buying chicken meat products? (0=not at all important to 10=extremely important)*".

Then, the participant's heat maps from the eye-tracking task were used as probing aids to discuss each participant's awareness of claims and logos (labels) and the associations they made with the labels. For example, participants were shown the heat maps for the eye-tracking choice sets and were asked specific questions about each of the labels and price. Specifically, of relevance to this study, they were asked: "*Were you previously aware of [label]?*", "*Do you think [label/price] has something to do with sustainability?*" and "*What do you think [label/price] has to do with sustainability?*".

2.2.2. Participants

Participants were recruited between September and December 2019 using study advertisements shared on social media and displayed in food retail outlets around metropolitan Adelaide and The University of Adelaide city campus. After completing a brief online screening survey, participants were notified of their eligibility via e-mail. A unique link to the online survey was sent to eligible participants. A market research company (Dynata^{TM}) administered the online survey. Eligible participants were aged 18-years or older; did the majority of or were jointly responsible for the household food shopping; purchased chicken meat at least once per month; were able to give informed consent; and had no eye conditions that could create difficulties with collection of eye-tracking data[3]. Additionally, as the eye-tracking equipment was not mobile, participation was restricted to participants who were physically able to attend the appointment at the University.

After completing the online survey (Stage 1), participants were redirected to an appointment-booking website where they could choose a day and time for the eye-tracking appointment (Stage 2), which was immediately followed by the in-person interview (Stage 3). All data was collected between September 2019 and January 2020 on weekdays and weekends.

[3] Exclusion criteria: wear glasses with bifocal, trifocal, layered or regression lenses; or have cataracts, eye implants, glaucoma, lazy eye, strabismus and/or nystagmus.

Before data collection began, the methods were pretested with several participants to check understanding of interview questions and to test eye-tracking procedures.

Table 2.1. Sustainability labels considered in the present study and currently in the Australian market.

	RSPCA Approved Farming Scheme [1]	**Free-Range [2]**	**Free-Range [2]**	**Antibiotic-Free [3]**
				
Confinement in cages [4]	NO	NO	NO	NO
Antibiotics are allowed under veterinary advice	YES	Depends on accreditation program	If antibiotics are required, meat may no longer be sold as free-range	YES
Growth promoting hormones are allowed [5]	NO	NO	NO	NO
Birds have access to an outdoor area	NO Birds can be raised indoors; only applies when 'free-range' is written on logo,	YES Birds must have easy access to an area on which to range	YES	N/A
Animals are fed only certified organic feedstuffs	NO	NO	NO	NO
Animals are never fed grain or grain by-products	NO	NO	NO	N/A
On-farm assessment	YES	YES	YES	N/A

[1] RSPCA Approved Farming Scheme (2021), the RSPCA Australia is the Royal Society for the Prevention of Cruelty to Animals and is a well-known charity, [2] Free Range Accredited (2021), [3] Australian Chicken Meat Federation (2018), [4] In Australia confinement in cages is prohibited in the production of broiler chicken (Australian Chicken Meat Federation, 2014), [5] In Australia chickens are not given any growth promoting hormones, it has been illegal since 1967 (Australian Chicken Meat Federation, 2018).

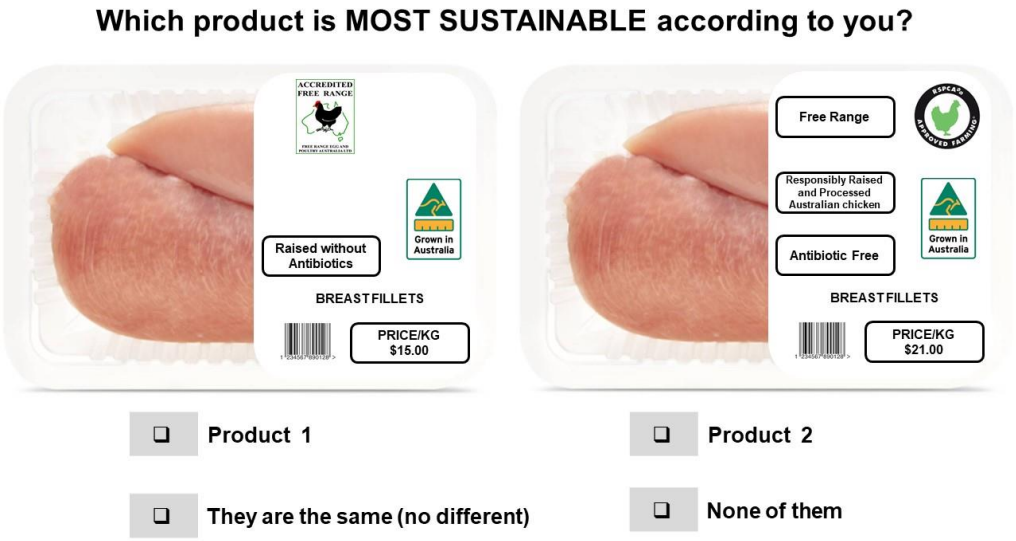

Figure 2.1. Example of a sustainability choice task.

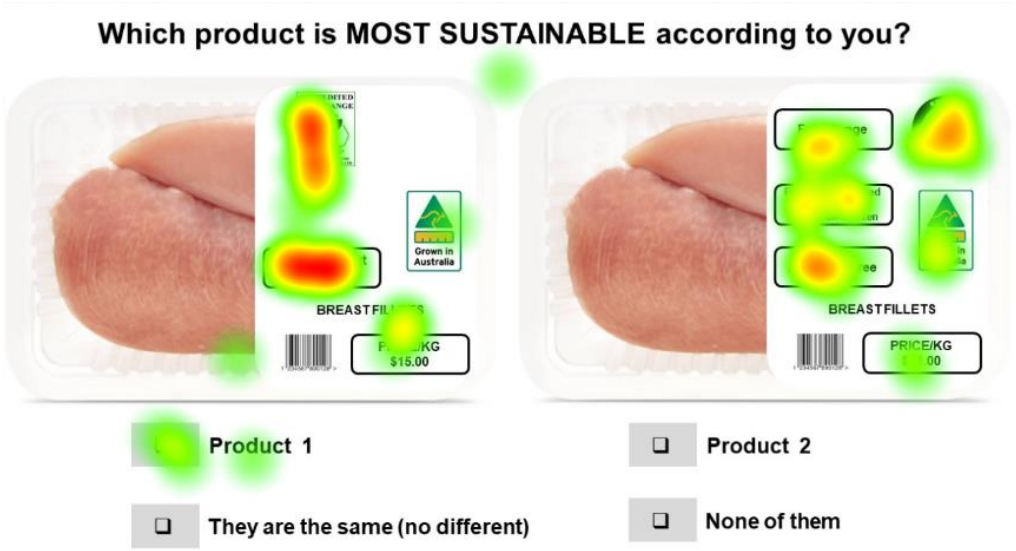

Figure 2.2. Example of a heat map produced by the eye-tracker (red areas show where attention was most concentrated, yellow areas indicate relatively less attention, green areas show the least attention and no color indicates no attention).

2.2.3. Analysis

2.2.3.1. Online survey

Descriptive analyses (e.g., means and standard deviations) of the online survey data were performed using IBM SPSS Statistics (version 25).

2.2.3.2. Eye-tracking

Tobii Pro Lab was used to specify areas of interest (AOI) for each of the 10 choice tasks. AOIs of particular relevance to this study included the labels which varied (Free-Range/Accredited Free-Range, RSPCA Approved Farming, Antibiotic Free) and price (which also varied). Additionally, metrics were obtained for other AOIs: country-of-origin label, the meat appearance, the meat cut name ('breast fillets') and the total area occupied by each product on the screen.

Four eye movement metrics were analysed in this study: fixation duration, fixation count, visit duration, and visit count. Fixation duration, the length of time a participant fixates within an AOI, is the most commonly analysed eye movement in eye-tracking research (Olsen, 2012; Wedel & Pieters, 2008). We used 60 milliseconds (ms) as the threshold value for defining a fixation. Fixation count is the total number of fixations that a participant makes in an AOI. Visit duration is the total length of time (ms) a participant spends in the AOI. Visit count is the total number of visits a participant makes to an AOI. A visit is characterized as the time span between the start of the first eye movement inside the AOI to the end of the last eye movement in the same AOI.

For each AOI, values for the 10 eye-tracking choice tasks were calculated for all four eye-tracking metrics (AOI fixation duration, AOI fixation count, AOI visit duration and AOI visit count). The metrics were exported from the Tobii Pro Lab Software into an Excel spread sheet, where means and standard deviations (SD) were calculated. Other tests were performed

using IBM SPSS Statistics (version 25). One-way analysis of variance (ANOVA) was used for comparison of continuous variables. Statistical significance was set at $\alpha = 0.05$ (two-tailed) level.

2.2.3.3. Interviews

After transcribing the audio-recordings, the interview data were analysed in NVivo 12.6 (2020) using a five-step framework approach (Ritchie *et al.*, 2003). The five steps carried out included: (1) familiarization (immersion in the data through reading all of the transcripts and listening to audio-recordings, when necessary); (2) identifying a thematic framework (identifying key ideas/themes in the data based on the research questions and on a priori themes highlighted in previous research (Grunert *et al.*, 2014), and using these themes to develop a data filtering and coding framework); (3) coding (identifying segments of text that correspond to the themes identified in step 2); (4) charting (arranging the coded text into matrices by theme using Nvivo's framework matrix function, and later exporting those matrices to an Excel spread sheet, to enable comparisons within and between participants); and (5) mapping and interpretation (analysing the key characteristics in the charts according to the research objectives). This framework approach has been used in previous research investigating participants' perceptions, understanding and experiences related to sustainability and other food-related issues (Brennan & Cotgrave, 2014; Malek *et al.*, 2020; Mills *et al.*, 2017).

2.3. Results

2.3.1. Participant characteristics

A total of 87 participants completed Stage 1 of the study and 30 of these participants completed Stages 2 and 3. Although 30 participants completed Stage 2, the data available for analysis from this stage is limited to 28 participants due to technical issues with the eye-tracking software.

The first column of Table 2.2 summarizes the socio-demographic characteristics of the 87 participants who completed Stage 1. Column 2 of Table 2 provides sociodemographic information specific to the 30 participants who completed Stages 2 and 3; and for comparison, the third column provides data for the relevant Australian population.

Table 2.2. Participant characteristics.

	Stage 1	**Stages 2-3**	**Australian adult population [c]**
	(n=87)	(n=30)	
Gender (females/males)	56% / 44%	60% / 40%	51% / 49%
Age, years			
18-24 years	18%	10%	9%
25-34 years	26%	27%	19%
35-44 years	30%	20%	19%
45-54 years	15%	20%	19%
≥55 years	10%	23%	33%
Educational attainment (university degree) [a]	74%	80%	31%
Household income quintiles [b]			
≤$35,000	12%	10%	20%
$35,001 - $65,000	25%	10%	21%
$65,001 - $105,000	21%	23%	19%
$105,001 - $165,000	24%	23%	19%
>$165,000	18%	33%	21%

[a] Data is for Australians aged 20-64 years (May 2018) (Australian Bureau of Statistics, 2017b)
[b] Gross household income per week multiplied by 52 weeks (Australian Bureau of Statistics, 2015)
[c] Data from the Australian Bureau of Statistics dataset (Australian Bureau of Statistics, 2017a).

2.3.2. Perceptions of sustainable food systems and sustainable chicken meat production systems

2.3.2.1. Relative importance of the four pillars of sustainability to food systems

In the online survey (Stage 1), participants were asked to consider and rank the importance of the four pillars of sustainability – environmental, social, economic and cultural – to their definition of a 'sustainable food system'. The majority of participants (75%) identified the environmental pillar as the most important followed by economic (20%) and social (14%)

dimensions (see Table 2.3). The cultural dimension, which is a relatively recent addition (Soini & Dessein, 2016), was the least important pillar for the majority of participants. As the remainder of this results section focuses on the findings from Stages 2-3 of the study, in Table 2.3 we have provided a comparison between the rankings of the participants in Stage 1 (n=87) and the participants completing some or all of Stages 2-3 (n=30). No significant differences in the rankings were found between the larger sample of participants in Stage 1 and the smaller sample of participants that completed Stages 2-3.

Table 2.3. Percentage of participants ranking each sustainability pillar as the most important pillar to their definition of a sustainable food system and comparison of samples.

	Most important ranking (%)			Mean rank score		
	Stage 1 Participants (n=87)	Stage 2-3 Participants (n=30)	P-value	Stage 1 Participants (n=87)	Stage 2-3 Participants (n=30)	P-value
Environmental	75%	69%	0.835	3.61	3.55	1.000
Economic	20%	21%	0.959	2.54	2.48	0.717
Social	14%	10%	0.960	2.69	2.69	0.792
Cultural	2%	0%	0.574	1.48	1.31	0.285

Q. The following characteristics are often used to describe SUSTAINABLE food systems. Rank the FOUR characteristics in terms of their importance to your definition of a 'sustainable food system.

2.3.2.2. Importance of sustainability when purchasing chicken meat

During the interviews, participants (n=30) were asked to indicate how important (0=not at all important to 10=extremely important) sustainability is to them when buying chicken meat products. The mean importance score of sustainability to participants in their chicken meat purchasing decisions was 5 out of 10 (medium importance). One-third (n=10) of participants indicated that sustainability was of high importance (score ≥7/10); 50% (n=15) said it was of medium importance (score 4-6/10) and 17% (n=5) said it was of low importance (score <4/10).

2.3.2.3. Perceived associations between chicken meat and sustainability

During the interviews (Stage 3), participants were asked "*what comes to mind when you see the word sustainable on chicken meat*?". Table 2.4 shows the factors discussed, grouped by the

level of importance participants placed on sustainability when purchasing chicken meat products. Most participants were able to discuss some factors that they associated with sustainability and chicken meat. Answers were generally balanced across the low, medium and high importance groups for the majority of dimensions, considering the share of participants in each group: low (17%, n=5), medium (50%, n=15) and high (33%, n=10).

The environmental impact dimension of sustainability was most often discussed by participants. When discussing environmental impact, participants often compared the impact of chicken production to other food-producing animals (e.g., cows and fish). Participants generally perceived chicken production to have a relatively lower environmental impact. For example, one participant believed that chicken meat would be more sustainable than beef due to lower methane emissions and less land-use demand; and would be more sustainable than fish due to reductions in the fish supply that her family members had observed when fishing.

> …well chicken doesn't produce much methane because they don't fart, I don't think. I've never really considered it. Yeah, less sustainable. (...) So, the cows obviously produce more methane and then in terms of how they're killed, I just think that it's less sustainable, also because of how big they are. They obviously need more room and then they're also grazing on farm or land. (...) I just think we're over-fishing in a lot of places (…), you can tell because (…) my husband and my dad love crabbing and squidding and fishing, and over the years, even a short amount of time, there's just less things in the ocean because people are just catching them all and they don't have time to reproduce. (Participant #9, Medium importance, female, 30y, university degree, income Q5)

Animal welfare was the dimension mentioned second-most frequently. Participants showed general perceptions that sustainability encompasses animal welfare.

> So, I equate sustainable with ethical so like whether the welfare of the chicken is the primary concern. (Participant #36, Low importance, female, 26y, university degree, income Q4)

Economic and social dimensions were also discussed. The affordability of the product was discussed in terms of the cost-effectiveness of production (affordability for producers) or of the final product (affordability for consumers). Additionally, one consumer hinted at making trade-offs between dimensions (environmental and economic).

> To me, as I said, sustainability is more economic than anything else. It's also got to be sustainable for the producers in Australia. (Participant #53, High importance, female, 64y, university degree, income Q4)

> I was thinking about environmental concerns more than my personal sustainability (laughs), so obviously buying a higher costing chicken breast is less sustainable (laughs) for me personally, if you could think about it like that. But I was thinking more of environmental concerns. (Participant #62, High importance, female, 28y, university degree, income Q2)

A few participants also expressed the view that use of antibiotics in chicken meat production is not sustainable. Lack of antibiotic use was believed to be associated with better animal welfare and/or positive human health outcomes.

Labels, including those not used in the eye-tracking task, were also mentioned when discussing sustainability and chicken meat. One male participant discussed a label which he had seen on red meat products that addresses total life-cycle impact (carbon neutrality). While he perceived this label positively, he believed the label was unlikely to be adopted by the chicken meat industry due to a perception that the total life-cycle impact of chicken was negative relative to beef and lamb. He explained that he believed that chicken meat production can be positive on gross greenhouse gas emissions, but when compared to beef and lamb it is more negative as it does not have sequestering potential. This highlights that some participants

are aware of the complexity of sustainability related issues with regards to the different environmental implications of different livestock production systems.

> …there's a wholesaler in Melbourne that's actually started promoting carbon neutral meat (for beef and lamb) and so they source meat from people that have actually measured their carbon footprint and then they've calculated the downstream carbon use and then offset the total which I think is excellent. I know if I was in the chicken industry I might not want to go too far down that track because at the moment the chicken industry has shown, because they talk about gross emissions, and gross emissions chicken meat is fantastic compared to beef and lamb but on cycle emissions, it doesn't have any sequestering in it. It's just out. Whereas the beef and lamb industry have huge sequestering that they can do. (Participant #89, Medium importance, male, 47y, university degree, income Q4)

Table 2.4. Dimensions discussed when asked "what comes to mind when you see the word sustainable on chicken meat?" (n=30).

		Level of importance placed on sustainability				
Dimensions	Categories (examples of the most relevant type of answers)	Low (n=5)	Medium (n=15)	High (n=10)	Total (n=30)	% (n=30)
Environmental pillar / impact	Less use of water	1	2	3	**6**	**20**
	Reduced environmental impact	1	2	2	**5**	**17**
	Less use of land / without destroying	1	1	1	**3**	**10**
	Less production of waste / food waste		1	1	**2**	**7**
	Less food miles (shorter distance from farm to point of purchase)		1	1	**2**	**7**
	Reduced carbon emissions caused by food production		1		**1**	**3**
	Using less packaging		1		**1**	**3**
	Reduced chemicals used in food production		1		**1**	**3**
Animal Welfare	Animal welfare friendly food production practices, indicated by specific labels (e.g., Free-range and RSPCA)	2	3	3	**8**	**27**
	Animal welfare friendly food production practices, no specific examples or labels cited		2	2	**4**	**13**
	Antibiotics not being used improves animal welfare		1	1	**2**	**7**
	Don't think animal welfare relates to sustainability		1		**1**	**3**
Economic and Social pillars / impacts	Farmers maintaining production and profits		3	3	**6**	**20**
	Affordable for consumers	1	1	2	**4**	**13**
	Fair working conditions and wages for food producers (e.g., Grown in Australia label, cited once)		1	2	**3**	**10**
Information on labels	Other examples cited: organic (n=1), carbon neutral (n=1) and sustainable (n=1)	1	2		**3**	**10**
	Current labels don't help to decide	1	1		**2**	**7**
	Don't look for information on labels			2	**2**	**7**
	Sustainability is not in the 'back of the head' while shopping		1		**1**	**3**
	Look for information on labels			1	**1**	**3**
Antibiotic use	Antibiotics not being used improves animal welfare		1	1	**2**	**7**
	Antibiotics not being used improves the healthiness of foods		1		**1**	**3**
Farmland conservation	Farmland conservation for multiple generations (will sustain for a long period of time)	1	1	2	**4**	**13**
Healthier for consumers	Healthier food products		3		**3**	**10**
Don't know	Don't know / No thoughts		1		**1**	**3**

2.3.3. Factors consumers use to assess the sustainability of chicken meat products

Table 2.5 provides the metrics from the 10 eye-tracking choice tasks, including the average fixation time, the average fixation count, the average fixation duration, the average visit count

and the average visit duration for the AOIs (labels and price). Of the sustainability labels considered in this study, the Free-Range logo was most frequently fixated on, followed by the Antibiotic Free and Free-Range text claims. As a point of comparison, we also provide the metrics for the Grown in Australia label (country of origin labelling information is required on all packaged meat sold in Australia), price, cut and meat appearance.

Curiously, the ‘Grown in Australia’ label was fixated on by the majority of participants, even though this label was present on all of the products included in the eye-tracking tasks. This could be an indication that origin is an important factor used to signal sustainability.

Table 2.5. Eye-tracking data from sustainability choice tasks expressed as mean ± standard deviation (n=28).

Labels /claims (areas of interest)	Free-Range, text	Free-Range, logo	RSPCA Approved, logo	Antibiotic Free, text	Grown in Australia	Price	Cut	Meat appearance
Number of choice tasks in which label is shown	7	5	7	5	10	10	10	10
Average % fixated each time label shown [1]	90% [c,d]	96% [d]	71% [b]	94% [d]	94% [d]	88% [c,d]	76% [b,c]	44% [a]
Average fixation count (number)	3.12 ± 1.68 [c,d]	4.03 ± 1.94 [d]	2.20 ± 1.45 [b,c]	3.94 ± 1.69 [d]	2.14 ± 0.87 [b,c]	2.01 ± 1.14 [b]	1.14 ± 0.64 [a,b]	0.38 ± 0.26 [a]
Average fixation duration (seconds)	0.66 ± 0.40 [d,e]	0.89 ± 0.46 [e]	0.46 ± 0.30 [c,d]	0.79 ± 0.33 [e]	0.41 ± 0.17 [b,c]	0.38 ± 0.23 [b,c]	0.22 ± 0.13 [a,b]	0.06 ± 0.05 [a]
Average visit count (number)	2.36 ± 1.26 [d]	2.33 ± 1.00 [d]	1.30 ± 0.72 [b,c]	2.53 ± 1.07 [d]	1.63 ± 0.58 [c]	1.43 ± 0.71 [b,c]	0.94 ± 0.52 [a,b]	0.34 ± 0.19 [a]
Average visit duration (seconds)	0.69 ± 0.41 [d,e]	0.95 ± 0.49 [f]	0.50 ± 0.33 [c,d]	0.83 ± 0.35 [e,f]	0.43 ± 0.18 [b,c]	0.40 ± 0.25 [b,c]	0.22 ± 0.13 [a,b]	0.06 ± 0.06 [a]

[a,b,c,d] Values followed by different letters are significantly different ($p < 0.05$) based on results of Tamhane's T2 multiple comparison test.

[1] The 'Average % fixated each time label shown' values were calculated for each AOI based on how many times it appeared in the 10 choice tasks. Example interpretation for Free-Range, text: on average, 90% of participants fixated on this label when it was shown in a choice task.

2.3.4. Perceptions and use of sustainability labels and prices when assessing the sustainability of chicken meat products

Table 2.6 shows the participants' perceived associations between each of the sustainability labels and price, and the sustainability of chicken meat products. The main results for each sustainability label and price are presented in the subsections below.

Table 2.6. Perceived association between the labels and price and the sustainability of chicken meat products (n=30).

Dimensions	Categories (examples of the most relevant type of answers)	RSPCA Approved		Free-Range		Antibiotic Free		Price	
		n	% (n=30)	n	% (n=30)	n	% (n=30)	n	% (n=30)
Related to sustainability in general	It is accredited / trusted, which influences the positive association with sustainability	4	13	4	13	3	10	1	3
	Extra factor if combined with other labels	3	10			4	13	10	33
	General positive association with sustainability/ better than other labels	1	3	6	20	3	10		
Not related to sustainability	Not related to sustainability and not trusted	4	13	5	17	2	7		
	Not trusted / believed the label has low standards	3	10			2	7		
	Not related to sustainability, only with animal welfare	7	23					3	10
	Not related to sustainability because of the higher land requirements of this farming husbandry method when compared to non-free-range			3	10	5	17		
	Not related / nothing to do with sustainability					1	3		
Animal Welfare	Animal Welfare friendly production practices	4	13	6	20	1	3		
	Not in cages / more space	2	7	3	10			2	7
	Happy animals			3	10	7	23		
	Good feed	1	3			5	17		
Environmental pillar / impact	Perceived association between this label and environmental sustainability	5	17	6	20	1	3		
	Reduced use of chemicals and antibiotics			3	10	1	3		
	Chickens are walking outdoors and fertilizing soil			3	10			13	43
Healthier for consumers	Healthier products for consumers			3	10			2	7
Economic and social pillars / impacts	Not sustainable because of its smaller scale			2	7			2	7
	Not sustainable because of the potential to lose chickens in the open field			1	3			4	13
	Farm is run properly and can continue in business	1	3			1	3		
Don't know	Don't know / No thoughts	5	17	1	3	1	3		

2.3.4.1. RSPCA Approved Farming Scheme

Most participants (87%) were aware of the RSPCA Approved label and there was a common perception that farmers who care about animal welfare issues are also more likely to care about the environment.

> I was thinking that they might be more sort of 'earthy' (laughing). (Participant #79, Low importance, female, 42y, university degree, income Q5).

> I would like to think something that's bad for the chickens is also going to be bad for the environment. So environmentally I would say that you're probably better off with that stamp. (Participant #61, Low importance, male, 36y, no university degree, income Q4).

The association with sustainability was also influenced by participants' trust (or lack of trust) in the RSPCA label, with higher trust in the label positively associated with sustainability. However, despite trusting the label, one participant mentioned that he prioritizes the overall amount of meat produced, over the label, when thinking about sustainability.

> You can be like very nice in the RSPCA approved farming, but if you kill way too much then it's not, and then it's not sustainable. (Participant #17, Low importance, male, 22y, university degree, income Q1).

Results of the interviews also suggested that some participants associated RSPCA Approved labels with aspects of sustainability that are not explicitly considered in the production system/labelling criteria (i.e., they make "wrong" inferences). For example, despite some participants' perceptions, the RSPCA Approved label alone does not guarantee that animals have access to the outdoors; rather it only guarantees that meat chickens were raised in a housing system that conforms to RSPCA welfare standards. The RSPCA Approved logo must carry specific words which indicate that the birds had access to an outdoor area to

guarantee the chicken meat comes from animals that had access to an outdoor range (see Table 2.1).

2.3.4.2. Free-Range

The majority of the participants (90%) were aware of the Free-Range label and most perceived free-range chicken meat products to be more sustainable. Positive associations between Free-Range and sustainability related predominantly to the perceived positive animal welfare implications of free-range production systems. Further, similar to the RSPCA Approved label, participants assumed that animal-friendly farmers are more likely to also consider the environmental impact of their production practices. Free-Range was also considered more environmentally sustainable, due to reduced use of chemicals in production and the perceived positive impact of free-ranging chickens on soil health.

> I guess I just assume that if a farm is a free-range farm then the people that are running that farm are more likely to be a bit more concerned with treating the animals better and maybe they're concerned with sustainability and the environmental impact as well. (Participant #16, High importance, male, 34y, university degree, income Q5)

> I'd like to think that free-range isn't going to be washing a ton of chemicals down the drain. Because if you've got a battery farm (…) you need to wash it down (…). You have diseases going through (…). I just don't feel that battery farms and things give too much care into things like that. (Participant #62, High importance, female, 28y, university degree, income Q2)

Conversely, some participants believed Free-Range was not related to sustainability due to the perception that free-range systems would occupy more land, thus reducing the environmental sustainability of production. Likewise, a few participants believed free-range production systems were less economically sustainable due to perceptions that they are smaller scale and the potential loss (e.g., to predators) of chickens when raised in open fields.

> I guess if they're also free-range that takes up land, and that land has to be farmed, so that's clearing land for that. (Participant #44, High importance, female, 32y, university degree, income Q3)

> Sort of knowing that free-range is certainly way more exposed to fox predation (…) I think that's probably it, and the potential to lose more chickens and makes them more expensive in the long-run. (Participant #27, Medium importance, female, 23y, university degree, income Q1)

2.3.4.3. Antibiotic Free

Despite only 23% of participants indicating they were aware of the Antibiotic Free label prior to the study, chicken meat products with this label were commonly perceived to be more sustainable. Positive associations between Antibiotic Free labelled chicken meat and sustainability mainly related to perceptions participants had about the negative impacts of antibiotic use in chicken meat production on human health, the environment and animal welfare. The human health dimension was most frequently discussed with key concerns relating to antibiotic resistance, in addition to general/unspecified health concerns.

> So, the antibiotics was an easy one to make a decision. It's not sustainable to use antibiotics because the unintended long-term consequences are, to me, the most important thing in terms of the sustainability question. That's what sustainability is all about, yes you can do this today, but what's going to happen in 50 years' time? Overuse of antibiotics is going to cause problems in 50 years' time. (Participant #89, Medium importance, male, 47y, university degree, income Q4)

> I was probably thinking about the antibiotics staying in the environment, whether they actually dissipate or whether they're still there the whole time. I don't know enough about antibiotics, but that's what I was thinking (…) It could be that never-ending circle, you eat the chicken meat and then it comes out in your excretions and then goes in the waterways and keeps on. (Participant #34, High importance, female, 67y, university degree, income Q5)

> With the sustainability, well, I guess antibiotic use in chicken just springs to mind a warehouse crammed full of chickens, that are all – because they don't have any room or any sunlight or air or anything – they all need to be pumped full of antibiotics. So as a general rule, I don't really want to support that model. (Participant #62, High importance, female, 28y, university degree, income Q2)

In contrast, several participants perceived Antibiotic Free chicken meat products to be less sustainable. This view was expressed from an animal welfare perspective – whereby antibiotic use was considered important for maintaining the health of chickens; and from an economic perspective – whereby antibiotic use was considered important for maximizing production efficiency/reducing chicken losses to illness.

> If they use antibiotics, probably it helps a bit with the life or the quality of the chicken. (Participant #18, Medium importance, female, 48y, university degree, income Q4)

> I do remember thinking that if they raised them with antibiotics it would actually be more sustainable. Again, related to output of production. (Participant #70, Low importance, female, 47y, university degree, income Q4)

Notably, some participants recognized that the Antibiotic Free label helped them to assess the sustainability of the product, despite there being no explicit reference to sustainability on the label. In some cases, participants considered the antibiotic labels together with the other labels present to form their overall perception of sustainability, such that if they associated the other labels with sustainability then they were more likely to believe that Antibiotic Free labelling also contributed to the sustainability of the chicken meat. Conversely, others said it did not help them to decide which was more sustainable.

> But I suppose if it doesn't tell me directly on the label that it's sustainable, then I look at other elements of the label that might suggest that as well as these qualities (...) and that they're not full of antibiotics, then if you accept those things are true, then you could probably put into that bundle that the production of that meat that I'm looking at, was sustainable along the line. But that's a supposition. (Participant #80, Low importance, female, 63y, university degree, income Q5)

Only two participants said that they had no opinion on the topic of sustainability.

> I don't have strong opinions on antibiotics (laughing) and maybe I should and I don't know what sustainable really means, yeah. (Participant #79, Medium importance, female, 42y, university degree, income Q5)

2.3.4.4. Price

Participants commonly associated higher prices with higher sustainability. This association appeared to be due to beliefs that more sustainable practices would incur higher production costs. In particular, environmentally friendly and animal friendly production practices were expected to be costlier for producers and ultimately, also more costly for consumers. This is consistent with findings of previous Australian and Italian studies showing that some consumers are willing to pay a price premium for higher animal welfare standards (Musto *et al.*, 2014; Napolitano *et al.*, 2008; Taylor & Signal, 2009; Vecchio & Annunziata, 2012).

> Probably just more money that goes into it – the chickens need more space, more farmland, more money, you know if they're not using as many antibiotics then maybe more chickens die (…). I guess that if I saw that it was more expensive then I automatically assume that maybe it was more sustainable. (Participant #25, Medium importance, male, 27y, university degree, income Q1)

> Yes, one would imagine so because it would be more expensive to do the right thing by the environment than to just jam them into a cage and, you know, put all the entrails into

> the river so I'm paying for that. (Participant #80, Low importance, female, 63y, university degree, income Q5)

In contrast, some participants perceived higher priced products to be less sustainable, explaining that most consumers would not be able to afford to purchase higher priced products in the long-term. This suggests that consumer affordability is a key aspect of sustainability for some participants. Additionally, several participants did not perceive any associations between price and sustainability.

> To make it sustainable, I'd be looking at the price because I think nobody can, in general, the public can't continue to pay $18 kilo (…) so that wouldn't be sustainable long-term. (Participant #53, High importance, female, 64y, university degree, income Q4)

> I found myself leaning to price a fair bit, (…) because I wasn't quite sure from a business perspective how you're going to be able to sustain a business if you're not selling a product and if there's $21 chicken regardless of how many stamps you put on it versus a $9 sticker (…) you're going to irrespective look at that $9 chicken over the $20 chicken. (Participant #61, Low importance, male, 36y, no university degree, income Q4)

> If I'm looking at sustainability only, then price is not important. (Participant #36, Low importance, female, 26y, university degree, income Q4)

2.4. Discussion

This is the first known study to examine consumers' perceptions and understanding of sustainability in relation to chicken meat. This study provides new insight on the role that production-related credence attributes and meat product pricing play in forming perceptions of chicken meat product sustainability. Overall, most participants were able to discuss some factors that they associate with sustainability and chicken meat. Not surprisingly, a broader range of factors were mentioned and discussed by those participants who placed more

importance on sustainability in their chicken meat purchasing decisions. Environmental aspects of chicken meat production were most frequently cited when discussing chicken meat sustainability. Further, most participants who discussed the environmental impact of chicken meat production, perceived chicken meat production to be more sustainable than production of other animal foods.

Insights were generated regarding participants' use of labelling/credence attributes to inform perceptions of sustainability or to evaluate the sustainability of chicken meat products. Considering the results of the eye-tracking experiment, most labels were noticed (fixated on) by participants. This suggests that lack of exposure to sustainability labels is not likely to be a barrier to the use of the labels (Grunert, 2011). However, the eye-tracking task was conducted in a lab environment and not in a real-life shopping setting (e.g., in a retail outlet) where often other distractions exist and limitations are placed on attention/information processing.

The RSPCA Approved and the Free-Range labels were both primarily used by participants to signal social aspects (i.e., animal welfare) and environmental aspects of sustainability. Importantly, some participants made incorrect inferences about the production systems underpinning these labels. For example, several participants had misperceptions about RSPCA Approved chicken meat with regards to animals having outdoor access. Likewise, environmentally friendly practices are not explicitly considered in the production system/labelling criteria for either the RSPCA Approved Farming Scheme or most Free-Range production systems (RSPCA Approved Farming Scheme, 2020). Yet, both labels were known and trusted by the majority of participants, highlighting the need for ensuring clear communication around these labels to avoid misleading and losing the trust of consumers, and to maintain their value in the market. Integrating environmentally sustainable practices into the certification standards underlying these labels, and/or communicating the environmental benefits associated with existing practices, could help to ensure that practices more closely

align with consumer perceptions. Building on recognition and trust could be a good strategy for increasing customer loyalty and profitability.

Chicken meat products with Antibiotic Free labels were commonly perceived to be more sustainable from environmental and social (both animal and human health) standpoints. However, with respect to economic aspects, some participants mentioned that the production efficiency could be adversely impacted by an antibiotic-free production system. It may be important to provide consumers with more accessible information about how antibiotic use relates to the sustainability of meat production systems. However, it will be challenging to communicate given the complexity of the environmental, economic and health-related issues associated with antibiotic use in chicken meat production (Cervantes, 2015; Leinonen *et al.*, 2012).

Product price was also found to influence participants' judgment of sustainability and in fact consideration of price led to participants discussing fair prices for farmers and how the price consumers pay may ultimately influence whether or not the farmers are able to stay in business. Overall, participants expected environmentally friendly and animal friendly production practices to be costlier for producers. While some participants said they would expect to pay a premium for such practices, others noted that products would only be sustainable if they remained affordable. Although previous researchers (Shao *et al.*, 2017) have noted that market and economic issues are not of direct interest to consumers when considering sustainability, in our study, economic issues were considered by some participants when making decisions around sustainable meat purchases.

2.4.1. Key implications

Overall, the information on sustainability perceptions that emerged from this research leads to some recommendations for those involved with the design, use and/or communication of

sustainability labels and information related to these labels. For instance, results show that there is a perception among some participants that 'doing the right thing' might cost more and previous studies show that inclusion of on-package sustainability information can lead to higher willingness to pay (Meise *et al.*, 2014). Therefore, producers/marketers must clearly communicate their sustainable actions to consumers, particularly the ones that they already do and that consumers may not currently be aware of (Clark *et al.*, 2016; Musto *et al.*, 2016; Van Loo *et al.*, 2014; Vanhonacker & Verbeke, 2014; Vanhonacker *et al.*, 2008)

Retailers could help consumers who are concerned about sustainability make more informed chicken meat purchase decisions by simplifying the assessment process at point-of-purchase. Lowering consumers' search costs for sustainability information could be achieved by providing access to relevant information at the point-of-purchase, such as through a QR code, mobile app and/or on-site promotional materials (Grunert, 2011). For example, previous research has found that a video with narration may be an effective presentation format for conveying such information (Musto *et al.*, 2015).

There is often a certain halo effect triggered by trusted sustainability labels, and this holds even for social sustainability indicators (Aschemann-Witzel *et al.*, 2019). For example, in this study, some participants wrongly associated environmentally friendly production practices with RSPCA Approved and Free-Range products. These misperceptions often contribute to consumers' overall positive perceptions of sustainability associated with some labels. This could become an issue for industry if participants lose trust in these labels upon learning the correct meaning. This highlights the importance of companies being transparent and clearly communicating to consumers the production standards underlying each accreditation program. For example, stakeholders in the RSPCA Approved or Free-Range programs may need to partner with existing trusted environmental accreditation programs. This action would help

these programs to avoid losing the trust of consumers who might feel they have been misled if/when they learn that their perceptions are more favorable than reality (Sirieix *et al.*, 2013).

2.4.2. Strengths/limitations

A greater understanding of how consumers perceive and evaluate sustainability in the context of food and meat products can help to identify new strategies for promoting behavior change. Increasing consumer demand for more sustainably produced meat products could potentially lead to more environmentally friendly/sustainable production practices. Study limitations include conducting the eye-tracking tasks in a lab environment, which may produce different results to a real-life setting. However, the lab environment allowed the researchers to conduct in-depth interviews to better capture nuances in consumers' use, perceptions and understanding of the labels, which may not have been possible in a supermarket setting. Thus, the present study contributes new findings to the growing consumer literature on perceptions of sustainability and understanding of eco-labelling.

Further research on consumers' willingness to pay for 'sustainable' meat products – and specifically, for different aspects of sustainability (e.g., environmental and animal welfare concerns) – can provide additional usable insight for producers/marketers. Future studies could compare consumers' current knowledge and behavior both before and after providing information on different themes (e.g., environmental impact, animal welfare, health) (Musto *et al.*, 2015). Future research could also test the impact of different information/messaging on personal motivation to purchase more sustainable meat products.

2.5. Conclusions

Results of this exploratory, multi-method study suggest that the environmental pillar of sustainability is most important to Australian consumers' definition of a 'sustainable food system', followed by the economic, social and cultural pillars. In general, Australian consumers

incorrectly interpret many of the production-related sustainability labels in the market. However, results suggest that consumers' use of production-related credence labels to inform their perceptions/judgements of the sustainability of a meat product is less likely to be limited by their lack of awareness and understanding of the label, and more likely to be limited by the relatively lower importance they place on sustainability in their meat purchase decisions. The insights generated by this study can help to inform the communication and marketing strategies of stakeholders seeking to increase consumer interest in sustainability and influence consumers' decision to purchase more sustainable meat products.

Chapter 3: Statement of Authorship

Title of Paper	Consumers' perceptions and willingness to consume lab-grown meat versus conventionally raised meat and plant-based protein alternatives.
Publication Status	Unpublished- currently under review.
Publication Details	Manuscript submitted to "*Food Quality and Preference*" on 19/05/2021; revised and resubmitted on 11/10/2021.

Principal Author

Name of Principal Author (Candidate)	Lívia Garcez de Oliveira Padilha
Contribution to the Paper	Contributed to primary survey, data collection, data analysis and interpretation, wrote manuscript.
Overall percentage (%)	60
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 20/05/2021

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Dr Lenka Malek
Contribution to the Paper	Contributed to primary survey instrument and study design, supervised data collection and interpretation, guided the development of the manuscript and data analysis, and critically edited the manuscript.
Signature	Date 20/05/2021

Name of Co-Author	Professor Wendy Umberger
Contribution to the Paper	Obtained funding for the research, contributed to primary survey instrument and study design, supervised data

	collection and interpretation, guided the development of the manuscript and data analysis, and critically edited the manuscript.
Signature	Date 20/05/2021

Chapter 3: Consumers' perceptions and willingness to consume lab-grown meat versus conventionally raised meat and plant-based protein alternatives.

Abstract

Concerns over the impact of global meat production and consumption patterns are leading to increasing interest in alternative sources of protein. This study provides new insight into consumers' perceptions of different protein products and factors associated with acceptance of lab-grown meat. We measured and compared 1078 Australian consumers' perceptions of conventionally raised meat (chicken and beef), plant-based meat alternatives and lab-grown meat products across six attributes: health, safety, affordability, eating enjoyment, animal welfare and environmental friendliness. Perceptions of the health and affordability of conventionally raised chicken were statistically highest. For all attributes, plant-based meat alternatives were perceived more positively than lab-grown meat, and with respect to animal welfare and environmental friendliness, plant-based products were perceived highest relative to all products. Despite average negative perceptions for all attributes, except for animal welfare, around one-quarter of consumers still indicated a willingness to consume lab-grown meat. Multinomial logistic regressions were used to explain factors associated with consumers' willingness to consume lab-grown meat products. Factors associated with willingness to consume the lab-grown meat products were positive perceptions related to eating experience (enjoyment), safety, animal welfare and healthiness; familiarity; higher consumption frequency of conventionally raised chicken meat; tertiary education; and younger age. Although lower environmental impact has been proposed as one of the main benefits of lab-grown meat, perceived environmental friendliness was not significant in either model.

Keywords: Lab-grown meat. Plant-based protein. Alternative protein sources. Perceptions. Consumer behavior.

3.1. Introduction

Growing concerns about the negative impacts of producing and consuming animal-sourced food products (e.g., sustainability, animal welfare, health) have stimulated some consumers to reduce their consumption of meat, or even eliminate meat from their diets altogether (Malek & Umberger, 2021b; Onwezen *et al.*, 2021; Parodi *et al.*, 2018). Consumers interested in replacing meat with other sources of protein now have a variety of non-animal-based 'meat' alternative product options to choose from (Onwezen *et al.*, 2021; Parodi *et al.*, 2018). For example, plant-based alternative 'meat' products have been available in retail outlets and restaurants for several years, and demand is growing in many countries (Curtain & Grafenauer, 2019; Onwezen *et al.*, 2021). Recently, there has been increasing attention and interest in lab-grown 'meat' products (also known as *in vitro* meat, cultured meat and clean meat), which are derived from a process that involves extracting animal stem cells and culturing them into muscle tissue on an industrial scale (Post, 2014; Post *et al.*, 2020).

The lab-grown meat industry, which is still in its infancy, aims to satisfy the growing global demand for meat by providing 'sustainable' (e.g., more environmentally friendly and animal- friendly production methods) alternatives for consumers who want to keep eating meat. Lab-grown meat (herein referred to as LGM) products are developed to mimic the sensory (i.e., appearance, texture, flavor and odor) and nutritional properties of conventional meat (Bhat *et al.*, 2019; de Boer & Aiking, 2019; Parodi *et al.*, 2018). LGM products first became available to consumers in Singapore in late 2020; and the first commercial lab-grown meat factory opened in Israel in 2021 with the capacity of producing 500 kgs of meat per day (Future Meat,

2021; The Guardian, 2020). Among other factors, consumers' perceptions of the intrinsic and extrinsic attributes of LGM, relative to those of conventional meat and plant-based alternatives, will influence its ability to compete and gain market share (Tuorila & Hartmann, 2020).

Both plant-based and LGM alternatives offer consumers potential benefits over conventional meat products (Chriki & Hocquette, 2020). For example, plant-based products are animal-friendly as their production is not reliant on animals. However, LGM products are not completely 'animal-free', and there are ethical aspects related to the current production of LGM (Dilworth & McGregor, 2015; Stephens *et al.*, 2018). Considering the nutritional aspects of 'meat' alternatives, plant-based and LGM products can offer similar nutrients (e.g., iron, zinc and B-vitamins) to conventional meat; however, there may also be nutritional shortcomings (Curtain & Grafenauer, 2019; van Vliet *et al.*, 2021).

The relative environmental footprint of plant and LGM alternatives compared to conventional meat depends on the production system used to produce each product (van Vliet *et al.*, 2020). Speculative life cycle assessments (LCAs) of LGM products showed a 'substantially lower environmental footprint' for lab-grown meat (Tuomisto *et al.*, 2014; Tuomisto & Teixeira de Mattos, 2011). However, subsequent studies reported mixed results (e.g., Lynch & Pierrehumbert, 2019), depending upon the type of energy used in the LGM production process and the land use compared to conventional methods. Because production of LGM has been shown to be energy intensive, the environmental benefits depend upon manufacturers using clean and renewable energy sources (Lynch & Pierrehumbert, 2019; Mattick *et al.*, 2015; Post *et al.*, 2020; Tuomisto *et al.*, 2014; Tuomisto & Teixeira de Mattos, 2011). Regarding land use, LCAs have estimated that LGM production would use less land relative to conventional meat production (Tuomisto *et al.*, 2014; Tuomisto & Teixeira de Mattos, 2011).

Consumers' perceptions of novel LGM products relative to conventionally raised meats and plant-based alternatives have not been fully investigated (Bryant *et al.*, 2019; de Boer *et al.*, 2014; Gómez-Luciano *et al.*, 2019; Onwezen *et al.*, 2021). No known published studies have simultaneously compared consumers' perceptions of conventionally raised meat, plant-based meat alternatives and LGM on the range of attributes considered in this study. Yet, consumers will likely have alternative protein options to choose from when making decisions in a real-life shopping scenario. Further, no previous work has considered the specific type (e.g., chicken versus beef) of LGM in models of willingness to consume or purchase (Choudhury *et al.*, 2020). Thus, a greater understanding of consumers' perceptions of key attributes (e.g., environmental impact, animal friendliness) of LGM relative to those of competing or substitute products; and the relationship between perceptions and consumers' willingness to consume LGM will provide insights on the market issues and opportunities for LGM and alternative protein products.

3.1.1. Objectives

To contribute to the existing body of literature on consumer behavior related to meat alternatives, including LGM, the objectives of this study are 1) to measure and to compare consumers' perceptions of six key product attributes (e.g. health, safety, affordability, eating enjoyability, animal welfare and environmental friendliness) across five different protein products, including two 'conventionally raised' meat products (chicken and beef), 'lab-grown chicken', 'lab-grown beef' and 'plant-based protein alternatives'; and 2) to understand the factors (e.g. perceptions of LGM, familiarity with LGM, meat consumption frequency, and socio-demographic characteristics) that are associated with a higher willingness to consume lab-grown chicken and lab-grown beef.

Australia presents an interesting context for this consumer research. Per capita consumption of meat in Australia is among the largest in the world. Yet, there is increasing

demand in Australia for alternative sources of protein, with a growing number of Australians choosing to reduce their meat consumption (adopting 'flexitarian' dietary preferences) (Malek & Umberger, 2021a). An understanding of consumers' relative perceptions of the attributes of conventional meat and alternative protein products and predictors of behavior will be important for stakeholders in the Australian meat industry as they consider competitive marketing strategies for the future (MLA, 2020). This understanding is also vital for the development of new industries (e.g., focused on plant-based meat alternatives and LGM production), which are already beginning to be established in Australia (Lawrence *et al.*, 2019). In our comparisons of conventional meat with plant-based and LGM products, we considered conventional chicken and beef products as they are widely consumed globally, including in Australia (IBISWorld, 2018; OECD, 2020).

3.1.2. Conceptual framework and hypotheses

The complex range of factors that influence food choices can be broadly categorized into: 1) product-related factors, 2) person-related factors, and 3) contextual factors (Chen & Antonelli, 2020; Randall & Sanjur, 1981; Sobal & Bisogni, 2009). In the present study, we focus on product-related factors (perceptions of product attributes) and person-related factors (including consumption behavior, familiarity and socio-demographics) that previous studies have found to be associated with acceptance of LGM and/or consumption of meat substitutes (Bryant *et al.*, 2019; de Boer & Aiking, 2011; de Boer *et al.*, 2014; Elzerman *et al.*, 2015; Gómez-Luciano *et al.*, 2019; Hoek *et al.*, 2004; Hoek *et al.*, 2011b; Siegrist & Hartmann, 2019; Verbeke, 2015; Verbeke *et al.*, 2015).

Previous research has also found that some consumers exhibit ambivalent attitudes towards food products and novel technologies (Malek *et al.*, 2019; Sparks *et al.*, 1992). Importantly, consumers with more ambivalent attitudes tend to be more amenable to behavior change than those with less ambivalent attitudes (Armitage & Conner, 2000). Attitudes, which

are shaped by perceptions, are known to be key predictors of behavioral intention (Ajzen, 1991). In the present study, willingness to consume LGM products is a proxy for behavioral intention. Thus, we would expect consumers who are willing to consume LGM (reflecting a positive attitude) to have more positive perceptions; consumers who are unwilling to consume LGM (reflecting a negative attitude) to have more negative perceptions; and consumers who are neither willing nor unwilling to consume LGM (i.e., 'not sure') to have either neutral perceptions (reflecting a neutral attitude) or a combination of positive and negative perceptions (reflecting an ambivalent attitude). Therefore, a greater understanding of the psychosocial and socio-demographic characteristics that differentiate consumers with distinct attitudes and behavioral intentions towards LGM can provide insights on how to design communication strategies for influencing adoption of LGM products when they become widely available. This is particularly true for those consumers who are undecided about consuming LGM products versus those who indicate they are currently willing to consume LGM.

Combined, these factors form the basis of our conceptual framework. Our hypotheses regarding the influence of the factors, or explanatory variables (perceptions of LGM; familiarity with LGM; current protein consumption and socio-demographic characteristics) on willingness to consume LGM, are presented in the following paragraphs.

Product perceptions

Consumers' food purchase and consumption choices are determined by their expectations about the utility that the food product will provide (Loureiro & Umberger, 2007). Consumers' expectations are influenced by their beliefs about specific attributes of the food product relative to potential substitutes (Font-i-Furnols & Guerrero, 2014; Michel *et al.*, 2020).

Consumers' perceptions of protein alternatives (including plant-based proteins, LGM, insect proteins, mycoproteins) with respect to attributes related to human health and

environmental impact (Parodi *et al.*, 2018) and sustainability (Gómez-Luciano et al., 2019) have been previously compared. However, no known study has examined consumers' perceptions of the broad range of attributes, including health, environmental impact, and animal welfare considered in this study. Further, few studies have explored consumers' perceptions of conventionally raised meat compared to alternative protein sources (Gómez-Luciano *et al.*, 2019; Siegrist & Hartmann, 2019; Verbeke *et al.*, 2015). Considering the existing literature, we provide new insight on consumers' perceptions of six attributes for conventional meat, plant-based and LGM alternatives.

Consumers are likely to be heterogeneous in their perceptions regarding the attributes of a food products (e.g., conventionally raised meat versus plant-based and/or LGM products). Their perceptions, combined with the value they place on attributes, will influence their relative demand for each of the products (Font-i-Furnols & Guerrero, 2014; Michel *et al.*, 2020). Previous studies suggest that consumers' perceptions of product attributes generally play a more important role in willingness to purchase alternative protein products such as LGM compared to other factors such as food neophobia (Gómez-Luciano *et al.*, 2019; Verbeke *et al.*, 2015). Perceptions of the healthiness, nutrition, and safety of LGM have been shown to be helpful in explaining consumers' willingness to consume LGM in the other countries, e.g., the UK, Spain and Brazil (Bryant *et al.*, 2019; Gómez-Luciano *et al.*, 2019). *Further*, *a* recent review highlighted that the widespread acceptance of LGM will largely depend on the sensory appeal and the affordability, with consumers viewing affordability as a major barrier to purchasing LGM (Bryant & Barnett, 2020; Laestadius & Caldwell, 2015; Verbeke *et al.*, 2015).

Some of consumers' main motivations for partial or total meat avoidance and for their consumption of plant-based protein products also correspond to the proposed benefits of LGM (e.g., environmental impact and animal welfare) (Bhat *et al.*, 2019; Bryant & Barnett, 2018, 2020; Hartmann & Siegrist, 2020; Hoek *et al.*, 2011a; Janssen *et al.*, 2016; Malek *et al.*, 2019).

Therefore, one could expect that consumers' positive perceptions of proposed key attributes of LGM, may positively influence their willingness to consume LGM.

Based on the findings of the literature discussed above, we hypothesize the following:

Hypothesis 1 (H1): Perceptions of environmental friendliness and animal friendliness will be more favorable for plant-based alternatives and LGM, relative to conventionally raised meat.

Hypothesis 2 (H2): Positive perceptions of the health, safety, affordability, enjoyment, environmental friendliness, and animal friendliness of LGM will be positively associated with consumers' willingness to consume LGM.

Familiarity

Familiarity with meat substitutes (including LGM and plant-based meat alternatives) has previously been shown to have a significant positive influence on consumers' willingness to consume the novel products (Bryant *et al.*, 2019; Hoek *et al.*, 2011a; Mancini & Antonioli, 2019; Verbeke, 2015). Therefore, we hypothesize:

Hypothesis 3 (H3): Familiarity with LGM will be positively associated with consumers' willingness to consume LGM.

Consumption of meat

Several studies have shown that being an omnivore (consuming at least some meat) positively influences consumers' willingness to consume meat substitutes, including lab-grown meat (Arora *et al.*, 2020; Bryant *et al.*, 2019; de Boer & Aiking, 2011; Hwang *et al.*, 2020; Michel & Siegrist, 2019). Therefore, variables representing respondents' consumption frequency of chicken, beef, lamb and pork were included as explanatory factors in the present study. Overall, we hypothesize that:

Hypothesis 4 (H4): Current consumption of conventionally raised meat will be positively associated with consumers' willingness to consume LGM.

Socio-demographic characteristics

Based on the literature, we expect several socio-demographic characteristics to be significantly associated with willingness to consume LGM. These include gender, age, education, household income and location (urban versus rural). Previous research has found males to be more likely to consume LGM than females (Gómez-Luciano *et al.*, 2019; Grasso *et al.*, 2019; Hwang *et al.*, 2020; Shaw & Mac Con Iomaire, 2019; Slade, 2018; Zhang *et al.*, 2020). Younger consumers were found to be more likely to accept LGM (Mancini & Antonioli, 2019; Shaw & Mac Con Iomaire, 2019; Slade, 2018; Zhang *et al.*, 2020). In previous studies, consumers who completed higher levels of formal education were more likely than those with less formal education to be willing to consume LGM and plant-based meat alternatives (de Boer & Aiking, 2011; de Boer *et al.*, 2014; Gómez-Luciano *et al.*, 2019; Grasso *et al.*, 2019; Mancini & Antonioli, 2019; Slade, 2018; Zhang *et al.*, 2020). A higher socioeconomic status was shown to be an indicator of higher willingness to consume LGM in four countries (Gómez-Luciano *et al.*, 2019). Finally, Irish consumers residing in urban areas were more likely to be willing to *consume* LGM *(Shaw & Mac Con Iomaire, 2019)*. Considering the results of these previous studies, we hypothesize:

Hypothesis 5 (H5): Several socio-demographic characteristics will be positively associated with consumers' willingness to eat LGM: male gender, younger age, tertiary education, higher household income, and living in an urban location.

3.2. Material and methods

3.2.1. Data collection and questionnaire

A cross-sectional online survey was administered to Australian food shoppers in October and November 2018. Participants were required to be aged 18 years or over and be jointly or primarily responsible for their household's food shopping. A market research company (Dynata™) provided the consumer panel and administered the survey. Sample quotas were set for gender, age and location to ensure respondents were nationally representative with respect to these characteristics. Ethics approval was obtained from a University Human Research Ethics Committee (number H-2016-156).

The survey instrument was developed after a review of the literature available at the time the study was conducted. In addition to socio-demographic information, the survey included questions to assess respondents' household food purchase behavior; personal food consumption behavior; food choice values; food production and consumption concerns; attitudes and perceptions regarding conventionally raised and alternative protein products; familiarity with the concept of LGM; behavioral intentions regarding LGM; and trusted sources of food safety information. Questions and scaling relevant to the present research are described below and further details are provided in Tables 3.1-3.2.

Table 3.1. Description of dependent variables (n=1060)

Variable	**Coding**	**Chicken**	**Beef**
Willingness to eat…	No – Definitely not	31%	33%
	No – Probably not	18%	16%
	Not sure	23%	27%
	Yes – Maybe	21%	20%
	Yes – Definitely	6%	4%
MNL models			
Willingness to eat…	0 = no ('no – definitely not' or 'no – probably not');	49%	49%
	1 = undecided ('not sure');	23%	27%
	2 = yes ('yes-maybe' or 'yes-definitely')	27%	24%

Table 3.2. Description of exploratory variables (n=1060)

Variable	**Coding**		
Perceptions of LGM	**7-point scale**	**Lab-grown chicken, mean ± SD**	**Lab-grown beef, mean ± SD**
Healthy	-3 (Not...) to 3 (Very...).	-0.73 ± 1.64	-0.78 ± 1.59
Enjoyable to eat	-3 (Not...) to 3 (Very...).	-1.03 ± 1.66	-1.03 ± 1.66
Safe	-3 (Not...) to 3 (Very...).	-0.56 ± 1.73	-0.54 ± 1.71
Affordable	-3 (Not...) to 3 (Very...).	-0.68 ± 1.57	-0.74 ± 1.54
Environmentally friendly	-3 (Not...) to 3 (Very...).	-0.07 ± 1.76	-0.09 ± 1.76
Animal friendly	-3 (Not...) to 3 (Very...).	0.40 ± 1.83	0.37 ± 1.83
		Mean ± SD or %	
Familiarity with LGM	0 = 'Have not heard of it' or 'Have heard of it, but know very little or nothing about it, 1 = 'Know enough about it that I could explain it to a friend	20%	
Chicken consumption frequency	0 = Never, …9 = Every day.	4.06 ± 1.86	
Pork consumption frequency	0 = Never, …9 = Every day	2.25 ± 1.81	
Beef consumption frequency	0 = Never, …9 = Every day	3.34 ± 1.85	
Lamb consumption frequency	0 = Never, …9 = Every day	2.24 ± 1.74	
Male	0 = female; 1 = male	51%	
Age	Years	46.56 ± 16.50	
Tertiary education	0 = no; 1 = yes	37%	
Household income	0 = ≤$35,000, 1 = $35,001 - $65,000, 2 = $65,001 - $105,000, 3 = $105,001 - $165,000, 4 = >$165,001	1.58 ± 1.24	
Location	0 = country area; 1 = metropolitan area	67%	

Socio-demographic questions which assessed the respondents' gender, age and area of residence were asked at the beginning of the survey as they were used for screening and sample stratification. Participants' educational attainment and other household characteristics (e.g., household income after taxes) were asked at the end of the survey (Table 3.2).

Respondents' consumption frequency of conventionally raised meat products (beef, chicken, lamb and pork) and plant-based protein products was measured using ten response options (Table 3.2).

Respondents indicated how familiar they were with each of seven different terms used to describe 'lab-grown meat' in the literature and wider media. Three response options were presented: 'Have NOT heard of it'; 'Have heard of it but know very little or nothing about it'; or 'Know enough about it that I could explain to a friend' (Table 3.2). Following Verbeke (2015), the 'Know enough about it that I could explain to a friend' category was used to indicate familiarity; a score of one was assigned if this response was selected for at least one of the seven terms presented.

After assessing familiarity, respondents were provided with definitions of the terms 'traditional' (hereafter referred to as 'conventionally raised'), 'plant-based', and 'lab-grown' [4] Then, to assess behavioral intention, respondents were asked to indicate their willingness to eat chicken and beef products that were produced using the lab-grown method by selecting one of five response options: 'No – definitely not'; 'No – probably not'; 'Not sure'; 'Yes- maybe'; 'Yes – definitely' (Table 3.1).

Following the behavioral intention questions, respondents were asked to rate their perceptions of conventional meat, plant-based protein, lab-grown beef and lab-grown chicken products on six attributes (healthy, safe, affordable, enjoyable to eat, environmentally friendly, animal friendly) using a seven-point semantic differential scale (Table 3.2).

3.2.2. Statistical analyses

[4] Foods produced using TRADITIONAL LIVESTOCK FARMING SYSTEMS AND FISHING METHODS include: beef, lamb, chicken, pork, kangaroo, other meat (e.g., veal, rabbit, goat); dairy; eggs; fish and seafood. Please note: Livestock are domesticated animals raised in an agricultural setting to produce food such as meat, eggs and milk. PLANT-BASED food products are made from: beans, peas, lentils; grains and/or nuts. E.g., tofu, tempeh, seitan, Quorn, veggie/bean burgers, 'Beyond Burger', 'Minced' 100% plant-based, soy/almond/oat /macadamia milk. The term 'LAB-GROWN' refers to products created by the new process of extracting cells from animals without causing suffering to the animals and then growing the cells in a controlled cell culture condition. In August 2013, scientists unveiled (and tasted) the world's first lab-grown hamburger patty. There are companies in the US, Europe and Israel creating meat and even dairy products in the laboratory. Currently they are not commercially available, though research is being conducted to introduce lab-grown food products in the near future, possibly by 2019.

One-way analysis of variance (ANOVA) with post-hoc Tamhane's T2 multiple comparison tests, were used to compare consumers' perceptions of the six attributes (health, safety, affordability, eating enjoyability, animal welfare and environmental friendliness) across five different food products ('conventionally raised' chicken, 'conventionally raised' beef, 'lab-grown chicken', 'lab-grown beef' and 'plant-based protein alternatives').

Multinomial logistic regression (MNL) models were estimated to examine the factors that explained different levels of willingness (unwilling/undecided/willing) to consume lab-grown chicken and beef products. For the MNL analyses, we categorized participants as 'unwilling' if they selected 'No – Definitely not' or 'No – Probably not', 'undecided' if they selected 'Not sure', and 'willing' if they selected 'Yes – Maybe' or 'Yes – Definitely'. Of particular interest was determining if respondents who were 'unsure' about their willingness to eat lab-grown meat were in fact unique in any of the predictors relative to those that responded otherwise. The model revealed the factors that were significantly and independently associated with willingness to eat lab-grown meats (chicken and beef) for each group of respondents, relative to the reference group.

All explanatory variables are described in Table 3.2. The same explanatory variables were used in both MNL models (chicken and beef), except for the perception variables, which differed based on the respective chicken or beef model (i.e., in models examining willingness to consume lab-grown chicken, all perception variables were specific to lab-grown chicken). All data analyses were performed in STATA (version 14.2). Statistical significance was set at $\alpha = 0.05$ (two-tailed) level. As there were concerns about collinearity among explanatory variables, collinearity diagnostics were considered. Multicollinearity was not an issue in the models (smallest tolerance value = 0.80).

3.3. Results

The survey was completed by 1078 respondents. The socio-demographic characteristics of the participants are presented in Table 3.3, alongside general population values for Australian adults. The study sample matches the general Australian adult population with respect to gender, age and location. However, relative to the general population, the sample comprises a smaller proportion of participants in the top income quintile (i.e., household income within the top 20% of population values). Overall, 49% of the sample was female, 67% lived in an urban area, and 37% were university educated.

Table 3.3. Socio-demographics characteristics of the sample (n=1060) compared to the Australian population

	Total sample (%)	Australian population [a] (%)
Gender (Female)	49	49
Age (years)		
18-24 years	12	9
25-34 years	17	19
35-44 years	17	19
45-54 years	18	19
Over 55 years	36	34
Live in metropolitan area	67	67
State / territory		
New South Wales	33	32
Victoria	26	26
Queensland	20	20
Western Australia	9	11
South Australia	8	7
Australian Capital Territory	1	2
Tasmania	3	2
Northern Territory	1	1
Annual household income before tax [b]		
≤$35,000	24	20
$35,001 - $65,000	27	21
$65,001 - $105,000	23	19
$105,001 - $165,000	18	19
>$165,001	8	21
Education attainment (Bachelor's degree or above)	37	31[c]

[a] Data from Australian Bureau of Statistics dataset (Australian Bureau of Statistics, 2017a).
[b] Gross household income per week multiplied by 52 weeks (Australian Bureau of Statistics, 2015).
[c] Based on data from the Australian Bureau of Statistics (2017b).

Chicken meat consumption frequency was the highest, followed by beef (Table 3.2). On average, plant-based meat alternatives were consumed least frequently – less than once a month, on average. In the present study, 76% of participants described their dietary preference as 'Omnivore' (I eat most animal products including meat, fish, seafood and/or dairy); 20% identified themselves as 'Semi-Vegetarian/Flexitarian' (I am cutting back on meat but not

avoiding it completely); and 4% and 0.6% said they were a 'Full-time Vegetarian' (I do not eat meat but am still eating other animal products) or a 'Vegan' (I do not eat any animal products), respectively.

Overall, 20% of participants reported they were familiar with at least one of the seven LGM terms (i.e., with the concept of LGM); 31% had not heard of any of the terms; and 5% had heard of at least one of the terms but knew very little or nothing about it. After receiving a description of LGM, about one-quarter of consumers indicated they were willing to eat lab-grown chicken (27%, the sum of 21% 'yes-maybe' and 6% 'yes-definitely') or lab-grown beef (24%, the sum of 20% 'yes-maybe' and 4% 'yes-definitely') (Table 3.1). Males comprised 58% of those willing to consume lab-grown chicken and 58% of those willing to consume lab-grown beef.

3.3.1. Perceptions of LGM

Overall, LGM was perceived negatively by Australian consumers on all attributes apart from animal friendliness (Table 3.4 and Table 3.5). The perception scores obtained for LGM for four of the six product attributes (healthy, affordable, safe, and enjoyable to eat) were significantly lower when compared to other substitute products (conventionally raised and plant-based).

3.3.1.1. Comparing conventionally raised chicken, lab-grown and plant-based alternatives

Several statistically significant differences in perceptions of attributes were identified between conventional chicken meat and the lab-grown and plant-based alternatives. There was an overall negative perception of lab-grown chicken meat, which was perceived to be the least healthy, affordable, environmentally friendly, safe and enjoyable to eat (Table 3.4) relative to conventionally raised and plant-based alternatives. Compared to lab-grown and plant-based chicken meat, consumers viewed conventionally raised chicken meat as the most healthy,

affordable and enjoyable to eat, but the least animal-friendly. Plant-based products were rated highest of the protein alternatives with respect to animal-friendly and environmentally-friendly.

Table 3.4. Respondents' perceptions of attributes for conventionally raised chicken meat, plant-based alternative and lab-grown chicken expressed as mean ± standard deviation (n=1078)

Attribute (-3 to 3 scale)	**Conventionally raised chicken**	**Plant-based alternative**	**Lab-grown chicken**	***F/ Welch-value***	**df1, df2**	**P-value**
Healthy	0.87 ± 1.40^{c}	0.47 ± 1.61^{b}	-0.72 ± 1.64^{a}	304.317	2, 2142.656	<0.001
Affordable	0.75 ± 1.37^{c}	-0.02 ± 1.39^{b}	-0.67 ± 1.57^{a}	256.469	2, 2146.538	<0.001
Environmentally friendly	0.21 ± 1.38^{b}	0.45 ± 1.46^{c}	-0.07 ± 1.76^{a}	28.189	2, 2133.780	<0.001
Animal friendly	-0.51 ± 1.63^{a}	0.91 ± 1.67^{c}	0.40 ± 1.83^{b}	204.960	2, 2149.339	<0.001
Safe	0.77 ± 1.47^{b}	0.69 ± 1.58^{b}	-0.56 ± 1.71^{a}	218.903	2, 2144.680	<0.001
Eating enjoyability	1.05 ± 1.68^{c}	-0.30 ± 1.66^{b}	-1.03 ± 1.66^{a}	431.497	2 (df)	<0.001

[a,b,c,d] Different letters indicate significant differences between means based on results of Tamhane's T2 multiple comparison test (P<0.05).

3.3.1.2. Comparing conventionally raised beef, lab-grown and plant-based alternatives

Consumer perceptions of conventionally raised beef and the lab-grown and plant-based alternatives are shown in Table 3.5. Like the chicken comparison, the lab-grown beef option was perceived to be the least healthy, affordable, safe and enjoyable to eat when compared to the substitute products (conventionally raised and plant-based). Yet, in contrast to the chicken comparison, lab-grown beef was believed to be as environmentally-friendly as conventionally raised beef. Another noteworthy finding is that perceptions of plant-based alternatives did not differ significantly relative to conventionally raised beef regarding health perceptions. All mean differences in respondents' perceptions of attributes can be found on Table S3.1 (please see appendix).

Table 3.5. Respondents' perceptions of attributes for conventionally raised beef, plant-based alternative and lab-grown beef expressed as mean ± standard deviation (n=1078)

Attribute (-3 to 3 scale)	**Conventionally raised beef**	**Plant-based alternative**	**Lab-grown beef**	***Welch-value***	**df1, df2**	**P-value**
Healthy	0.58 ± 1.49^{b}	0.47 ± 1.61^{b}	-0.77 ± 1.59^{a}	179.865	3, 2390.969	<0.001
Affordable	-0.05 ± 1.39^{c}	-0.02 ± 1.39^{c}	-0.74 ± 1.54^{a}	53.56	3, 2390.991	<0.001
Environmentally friendly	-0.13 ± 1.56^{a}	0.45 ± 1.46^{b}	-0.10 ± 1.76^{a}	36.302	3, 2388.117	<0.001
Animal friendly	-0.58 ± 1.67^{a}	0.91 ± 1.67^{c}	0.37 ± 1.83^{b}	208.067	3, 2391.397	<0.001
Safe	0.78 ± 1.55^{b}	0.69 ± 1.58^{b}	-0.54 ± 1.70^{a}	159.473	3, 2391.636	<0.001
Eating enjoyability	0.95 ± 1.79^{c}	-0.30 ± 1.66^{b}	-1.02 ± 1.66^{a}	316.321	3, 2391.517	<0.001

[a,b,c,d] Different letters indicate significant differences between means based on results of Tamhane's T2 multiple comparison test ($P<0.05$).

3.3.1.3. Comparing perceptions for consumers willing, unwilling and undecided about eating LGM

On average, consumers who were willing to consume LGM had positive perceptions of LGM with respect to the six attributes (see Table S3.2 and S3.3 in appendix). The opposite (negative perceptions) was found for those who were unwilling to consume LGM. Those who were undecided about consuming LGM had mixed perceptions such that, on average, they had negative perceptions of attributes that confer personal benefits (healthy, affordable, safe and enjoyable) and positive perceptions of attributes that confer pro-social benefits (environmentally friendly and animal friendly). Similar results were found for both lab-grown chicken and beef.

3.3.2. Predictors of willingness to eat LGM

Results of the MNL models with relative risk ratios (RRR) are presented in Table 3.6. The pseudo R^2 values of both the lab-grown chicken (0.2952) and beef (0.3104) models are within the range of 0.20-0.40 which 'represent an excellent fit' according to McFadden (1979).

Table 3.6. Results of multinomial logistic regressions explaining consumers' willingness to eat lab-grown chicken and lab-grown beef (n=1060)

Comparison groups	**Willing to eat vs. Unwilling to eat (base)**		**Undecided vs. Willing to eat (base)**		**Undecided vs. Unwilling to eat (base)**	
	Lab-grown chicken[1]	**Lab-grown beef[2]**	**Lab-grown chicken[1]**	**Lab-grown beef[2]**	**Lab-grown chicken[1]**	**Lab-grown beef[2]**
	Relative Risk Ratios					
Lab-grown healthiness[3]	1.709***	1.770***	0.917	0.939	1.567***	1.663***
Lab-grown eating enjoyability[3]	2.003***	2.041***	0.774**	0.705***	1.551***	1.439***
Lab-grown safety[3]	1.250*	1.253*	0.932	0.939	1.165	1.177
Lab-grown affordability[3]	0.953	0.961	1.037	1.078	0.988	1.036
Lab-grown environmentally friendliness[3]	1.131	1.202	0.932	0.927	1.053	1.114
Lab-grown animal friendliness[3]	0.962	1.008	0.858	0.770**	0.825*	0.776**
Familiarity with LGM	2.120**	1.429	0.368***	0.613*	0.781	0.876
Chicken consumption frequency	1.196**	1.100	0.822**	0.851*	0.984	0.935
Pork consumption frequency	0.964	1.108	1.115	1.064	1.076	1.179**
Beef consumption frequency	1.072	1.182*	0.924	0.909	0.990	1.074
Lamb consumption frequency	1.054	1.066	1.069	1.157*	1.127	1.234**
Male	1.047	1.061	0.964	0.971	1.009	1.030
Age	0.974***	0.969***	0.999	0.999	0.973***	0.968***
Tertiary education	1.105	1.015	0.596*	0.534**	0.658*	0.542**
Income	1.035	1.041	0.896	0.953	0.927	0.992
Urban area	0.974	0.682	0.890	1.216	0.867	0.830
Constant	0.003***	0.002***	54.712***	71.482***	0.181**	0.130***

*P<0.05, **P<0.01, ***P<0.001

[1] Lab-grown chicken: Pseudo R2 = 0.2952; Model Wald $\chi2(32) = 330.34$, p <0.001.

[2] Lab-grown beef: Pseudo R2 = 0.3104; Model Wald $\chi2(32) = 335.14$, p <0.001.

[3] Perception variables were specific to the meat being modelled (i.e., in the lab-grown chicken model, all perceptions variables were specific to lab-grown chicken).

3.3.2.1. Willingness to eat lab-grown chicken meat

Results of the MNL model showed that several perception variables (perceptions of healthiness, eating enjoyability, safety and animal friendliness) were significantly and independently associated with willingness to eat lab-grown chicken meat. The significant perception variables differed depending on the groups being compared. Participants with higher healthiness and enjoyability perception scores were significantly more likely to be willing to eat lab-grown chicken (two times more likely for every one-point increase in

perception score) or to be undecided (1.8 and 1.4 times more likely for every one-point increase in healthiness and eating enjoyability perception score, respectively), than to be unwilling to eat lab-grown chicken meat. Each one-point increase in the safety perception score was associated with a 25% increase in the participant's likelihood of being willing, rather than being unwilling. Undecided participants were more likely to have lower expectations about the eating enjoyability of lab-grown chicken, relative to willing participants (each one-point increase reduced the chance of being undecided by 26%); and were more likely to perceive lab-grown chicken to be less animal friendly than those who were unwilling to eat lab-grown chicken (Table 3.6).

Familiarity with lab-grown meat and consumption frequency of chicken meat were also significantly associated with willingness to eat lab-grown chicken meat. Participants who were willing to eat lab-grown chicken, were more likely to be familiar with lab-grown meat and were more likely to consume chicken more frequently relative to both those who were unwilling or who were undecided. All other consumption frequency variables were not significant.

Of the socio-demographic variables, age and education were found to be significant. Compared to those unwilling to eat lab-grown chicken, both those who were willing or who were undecided were more likely to be younger than those who were unwilling (a one-year increase in age was associated with a respective 2.4% and 2.6% reduction in the likelihood of a respondent being willing or undecided). Undecided participants were less likely to be university-educated relative to both those who were willing (41% less likely) or who were unwilling (44% less likely) to eat lab-grown chicken.

3.3.2.2. Willingness to eat lab-grown beef

Similar to the chicken model perceptions of the healthiness, eating enjoyment and safety were positively associated with willingness to eat lab-grown beef relative to being unwilling to eat lab-grown beef. Additionally, participants who were undecided about consuming lab-grown beef were more likely to perceive lab-grown beef to be less animal-friendly than those who were either willing or unwilling to eat lab-grown beef.

Familiarity with LGM increased likelihood of being willing to eat lab-grown beef, relative to being unwilling but not relative to being undecided. Significant associations were found between consumption frequency of different types of meat (chicken, beef, pork and lamb) and willingness to consume lab-grown beef. Specifically, participants who consumed beef more frequently were more likely to be willing to eat lab-grown beef than to be unwilling. Further, results indicated that participants who were undecided about consuming lab-grown beef less frequently consumed chicken than those willing to consume lab-grown beef, and more frequently consumed pork and lamb than unwilling participants.

With respect to statistically significant socio-demographic variables, results of the lab-grown beef model match those of the lab-grown chicken model. Participants who were willing to eat lab-grown beef or who were undecided, were more likely to be younger than those who were unwilling. Additionally, undecided participants were less likely to be university- educated than both those who were willing or unwilling to consume lab-grown beef.

3.4. Discussion

Table 3.7 provides a summary of the results with respect to the five hypotheses.

Table 3.7. Summary of findings

	Hypothesis	Findings	
		MNL models ('willing' vs. 'unwilling' vs. 'undecided')	
		Lab-grown chicken	Lab-grown beef
H1	Perceptions of environmental friendliness and animal friendliness will be more favorable for plant-based alternatives and LGM, relative to conventionally raised meat.	Partially supported: Plant-based was perceived to be higher for both environmental friendliness and animal friendliness, but only animal friendliness of lab-grown chicken was perceived higher than conventional meat.	Partially supported: Plant-based was for both perceptions, but only animal friendliness of lab-grown chicken was perceived higher than conventional meat.
H2	Positive perceptions of LGM will be positively associated with consumers' willingness to consume LGM.	Partially supported: Lab-grown chicken healthiness, eating enjoyability, and safety were positive and significant	Partially supported: Lab-grown beef healthiness, eating enjoyability, safety and animal friendliness
H3	Familiarity with LGM will be positively associated with consumers' willingness to consume LGM.	Supported (willing vs. undecided and unwilling)	Supported (willing vs. undecided and unwilling)
H4	Current consumption of conventionally raised meats will be positively associated with consumers' willingness to consume LGM.	Partially supported: Chicken consumption (willing vs. unwilling and undecided)	Partially supported: Chicken consumption (willing vs. undecided) Beef consumption (willing vs. unwilling) Pork and lamb consumption (undecided vs. unwilling)
H5	Several socio-demographic characteristics will positively influence willingness to consume LGM: male gender, younger age, tertiary education, higher income, and living in urban location.	Partially supported: Higher education (willing and unwilling vs. undecided) and younger age (willing and undecided vs. unwilling)	Partially supported: Higher education (willing and unwilling vs. undecided) and younger age (willing and undecided vs. unwilling)

3.4.1. Perceptions of conventionally raised meats and potential meat alternatives

Information on consumers' perceptions of the conventionally raised meats and potential meat substitutes (plant-based alternatives and LGM) with respect to the attributes considered in this study can help stakeholders from relevant industries better understand the core strengths and weaknesses of their products relative to competitors. Notably, for all attributes considered,

plant-based meat alternatives were perceived more positively than lab-grown chicken and beef products. The same pattern was found in a recent cross-country study (United Kingdom, Brazil, Spain and Dominic Republic), where the 'plant-based' option surpassed the 'lab-grown' option in terms of health, safety and nutrition (Gómez-Luciano *et al.*, 2019). This suggests that compared to lab-grown meat products, plant-based alternatives have a greater potential to replace meat in the diet of consumers.

However, considering all products evaluated, conventionally raised chicken received the most favorable scores for health and affordability. This is perhaps not surprising considering that, in Australia, per capita consumption of chicken has increased over the last decade and per capita chicken consumption is the highest of any meat in Australia (OECD, 2020; Wong *et al.*, 2015). The negative consumer perceptions of the affordability of conventionally raised beef may be associated with the decreased consumption of beef. In particular, previous Australian research identified affordability concerns as the most common reason consumers reduced their consumption of beef (Malek *et al.*, 2018).

Apart from affordability, health concerns are also commonly identified as a main reason for reducing meat consumption (Malek *et al.*, 2018; Neff *et al.*, 2018). The finding that both plant-based alternatives and LGM are perceived to be less healthy than conventionally raised chicken and beef, suggests that consumers are unlikely to replace all of the meat in their diet with these products (Malek & Umberger, 2021a).

On average, both conventionally raised chicken and beef were perceived negatively with respect to animal friendliness. This result is not surprising in light of the ongoing public debate and negative media attention regarding farm animal welfare issues in Australia (Hampton *et al.*, 2020); and the obvious need for animal slaughter in the production of conventionally raised meat, but not in the production of plant-based nor LGM.

LGM was only perceived positively in terms of its animal friendliness. This is not surprising, since LGM has been proposed to be 'free from animal suffering and death' (Bhat *et al.*, 2019). The LGM option was perceived to be less environmentally friendly than conventionally raised chicken, but equally as environmentally friendly as conventionally raised beef. This is interesting considering one of the main arguments in favor of LGM products is an environmental advantage relative to conventional livestock meat products (Bhat *et al.*, 2019). However, evidence to date from LCAs indicates that LGM products will not necessarily be environmentally superior to conventionally raised beef (FAO, 2020; Lynch & Pierrehumbert, 2019). This aligns with the consumer perceptions reported here.

Overall, plant-based alternatives were viewed as the most environmentally friendly and animal-friendly when comparing conventionally raised, plant-based and lab-grown options. However, they were perceived to be less enjoyable to eat than conventionally raised meat products. Given that taste continues to be a key food choice driver in Australia, consumer perceptions of the palatability of plant-based meat alternatives may be a barrier to substituting conventionally raised meat with plant-based alternatives (Dana *et al.*, 2021). However, perceptions are amenable to change, and perceived eating enjoyability could change overtime with new experiences and greater exposure to plant-based products (Graça *et al.*, 2019; Michie *et al.*, 2011).

3.4.2. Factors associated with higher willingness to consume lab-grown chicken and beef

The results of our regression analyses suggest that eating enjoyment, safety, animal friendliness and healthiness should be prioritized in the production and marketing of LGM. Results also revealed key differences in predictors of lab-gown meat consumption for beef and chicken, which could help to improve future development of marketing strategies. For example, higher beef consumption was associated with a higher willingness to consume lab-grown beef,

between willing versus unwilling consumers, but the same association was not found for lab-grown chicken.

Despite environmental impact being one of the main proposed benefits of LGM highlighted by producers, perceptions of the environmental friendliness of LGM were not found to be associated with willingness to consume the LGM products. Thus, based on our findings, perceptions of the products' environmental friendliness do not appear to play an important role in determining consumers' behavioral intentions towards LGM. This is not surprising considering recent research showing that health is the main motivation for adopting meat reduced diets (Malek & Umberger, 2021b).

Our finding that familiarity with LGM is significantly positively associated with consumer acceptance is consistent with results of Bryant et al.'s (2019) cross-country comparison. Companies that produce LGM are beginning to put more effort into communication strategies to inform the market about their new products and the potential benefits they offer (Lamb, 2020). If these efforts are successful in increasing consumers' familiarity with LGM products, they could contribute to greater consumer acceptance.

Consistent with previous research, we found that more educated and younger consumers tend to be more willing to consume LGM (Mancini & Antonioli, 2019; Slade, 2018). However, we also show that more educated consumers (i.e., those with a tertiary education), were more likely to have either a positive or negative behavioral intention than to be undecided. Undecided consumers comprise around one-quarter of the sample, and without a strong behavioral intention in either direction, they could be more easily influenced towards or away from consuming LGM, compared to those who have already decided that they would be willing or unwilling to consume the product.

Notably, a higher consumption frequency of conventionally raised chicken was found to be significantly positively associated willingness to consumer both lab-grown chicken and beef; and the coefficient on consumption of conventionally raised beef was positive and significant in the lab-grown beef model. These results align with the assumption that meat eaters will likely be the first to consume the new product (Bryant *et al.*, 2019). These results suggest some potential for LGM to become a substitute for conventional meat, especially if key product-related attributes reach consumers' expectations.

3.4.3. Study limitations and future research

The large variation in perception scores in our study indicates heterogeneity among consumers. This could be investigated in future research to better understand consumer segments with unique perceptions of conventionally raised meat and meat alternatives, and propensity to consume different types of meat alternatives.

Limitations of this study include the measurement of behavioral intention (willingness to consume LGM) rather than actual behavior; this limits our ability to predict actual future behavior. This limitation is intrinsic to novel products that are not yet available to consumers, which was the case with LGM products at the time our research was conducted in Australia (and they are still not available in Australian markets). As LGM is now commercially available in some markets, future research could explore consumers' actual experience with LGM products (e.g., eating enjoyability), and their willingness to consume again.

Social desirability and memory bias are common limitations associated with online survey data collection (Tourangeau & Yan, 2007). To mitigate issues with social desirability bias, participants were assured of their anonymity during the first screen of the survey. Also, the descriptions of the products that were provided to respondents may have influenced their responses to questions designed to measure product perceptions. To reduce potential bias, the

product descriptions did not provide information on any alleged benefits or risks of the products.

Additionally, our model is limited to exploring associations between willingness to consume LGM and selected individual-related and product-related factors. Other factors that have recently been found to influence LGM acceptance either directly or indirectly, but were not considered in the present study, include perceived naturalness of LGM, food neophobia, food disgust sensitivity and trust in the food industry (Siegrist & Hartmann, 2020). Another limitation to the research is that the dependent variable in our analysis was specified as three different levels of willingness (unwilling/undecided/willing), despite the fact that our original variable was measured on a five-point scale. Although this strategy may have implied a possible loss of information, we believe this approach is justified empirically as it is aligned with previous research. Nonetheless, our research findings provide new insight on key product related perceptions associated with different degrees of LGM acceptance (particularly, animal welfare and environmental impact). These findings could be used to help inform the design of information campaigns/interventions, which could be tested in future research.

3.5. Conclusions

The study contributes to the literature by exploring and comparing Australian consumers' perceptions of conventionally raised meat (chicken and beef), LGM and plant-based alternatives. Plant-based alternatives have the greatest potential to replace meat in the diet of consumers, particularly for those concerned about environmental and animal welfare issues. Relative to conventionally raised chicken and beef and plant-based protein products, LGM is perceived to be significantly less healthy, affordable, safe and enjoyable to eat. Overall, the current market potential for LGM appears to be low. However, LGM may be accepted by some consumers if marketing campaigns can improve negative perceptions related to attributes such as palatability, healthiness and safety; this is because barriers have been found to be more

powerful than motives in influencing consumers' willingness to eat LGM (Verbeke *et al.*, 2021). The insight provided by this study can help to inform the design of targeted approaches for developing the market if LGM products are introduced in the Australian market.

Chapter 4: Statement of Authorship

Title of Paper	Food choice drivers of potential lab-grown meat consumers in Australia
Publication Status	Published
Publication Details	Garcez de Oliveira Padilha, L., Malek, L., & Umberger, W. J. (2021). Food choice drivers of potential lab-grown meat consumers in Australia. *British Food Journal, 123*(9), 3014-3031. doi:10.1108/BFJ-03-2021-0214

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Name of Principal Author (Candidate)	Lívia Garcez de Oliveira Padilha
Contribution to the Paper	Contributed to primary survey, data collection, data analysis and interpretation, wrote manuscript.
Overall percentage (%)	60
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 20/05/2021

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Dr Lenka Malek
Contribution to the Paper	Contributed to primary survey instrument and study design, supervised data collection and interpretation, guided the development of the manuscript and data analysis, and critically edited the manuscript.
Signature	Date 20/05/2021

Name of Co-Author	Professor Wendy Umberger
Contribution to the Paper	Obtained funding for the research, contributed to primary survey instrument and study design, supervised data collection and interpretation, guided the development of the manuscript and data analysis, and critically edited the manuscript.
Signature	Date 20/05/2021

Chapter 4: Food choice drivers of potential lab-grown meat consumers in Australia

Abstract

Purpose:

To examine the market potential for lab-grown meat (LGM) in Australia by: 1) determining consumers' willingness to consume LGM; 2) exploring heterogeneity in both consumers' willingness to consume LGM and food choice values; and 3) characterizing unique consumer clusters (segments) using socio-demographic, behavioral and psychosocial factors.

Design/methodology/approach:

Latent class cluster analysis was conducted using online survey data obtained from a nationally representative sample of 1078 Australian food shoppers.

Findings:

Six consumer clusters were identified, each distinct in their degree of willingness to consume LGM and in their food choice values. Three clusters (49% of consumers) indicated some willingness to consume LGM. One segment, 'Prospective LGM eaters' (12%), appeared 'very willing' to consume LGM. These consumers were more likely to be younger (<35 years); university-educated; and have greater prior awareness of LGM; stronger beliefs regarding the potential self- and society-related benefits of growing demand for LGM; and higher trust in diverse information sources.

Practical implications:

Insights on the characteristics of each cluster provide useful information for the industry on how to tailor product development and marketing strategies to address the needs of consumers with the greatest potential to consume LGM.

Originality/value:

This is the first consumer research on the topic of LGM to explore market opportunities for LGM in Australia, using a nationally representative consumer sample.

Keywords: Lab-grown meat; Cultured meat; Alternative protein sources; Food choice values; Consumption behavior; Meat reduction; Dietary preferences; Perceptions; Segmentation.

4.1. Introduction

Lab-grown meat (also known as cultured meat, in vitro meat and clean meat) is a 'novel' or 'future' food product that is designed to have the same sensory and nutritional characteristics as conventional meat, with the main point of difference being the production method (Parodi *et al.*, 2018). Lab-grown meat (herein referred to as 'LGM') is made with technology, originally used in regenerative medicine, to restore dysfunctional or injured organs. The process involves extracting muscle-specific stem cells and culturing them in a nutrient dense serum[5] to grow a sufficient number of cells into muscle tissue (Post, 2012, 2014; Post *et al.*, 2020). While some technical barriers remain, the lab-grown process is now a potentially feasible way to produce meat (Parodi *et al.*, 2018).

Since the first recorded human consumption of LGM in 2013, this technologically complex alternative to conventional meat production has gained media and academic attention (Bryant & Barnett, 2018, 2020; Goodwin & Shoulders, 2013; Laestadius & Caldwell, 2015). The interest in this product has grown in response to increasing societal concerns about the sustainability of conventionally raised (including both pasture-raised and intensively-raised) meat products. In fact, in 2020, The Singapore Food Agency gave regulatory approval for a

[5] Fetal bovine serum (FBS) is the most widely used serum-supplement for the in vitro cell culture.

lab-grown chicken meat product, GOOD Meat Cultured Chicken (produced by Eat Just, Inc., a United States based company) to be sold for human consumption in Singapore (The Guardian, 2020). In late December 2020, Good Meat Cultured Chicken became the first commercially available LGM product when a restaurant in Singapore began making it available to customers (Business Wire, 2020).

Although conventional meat products provide humans with rich sources of protein and other nutrients, there are concerns about the impact of conventional meat production methods on the environment (e.g., greenhouse gas emissions; land and water use and degradation, energy use). These concerns are growing as global demand for protein increases due to population growth (particularly in emerging economies), rising disposable incomes and urbanization. Additionally, some consumers are concerned about other issues associated with conventional meat production, such as environmental impact, animal welfare, human health and food safety concerns (e.g., hormone use and antibiotic resistance) (Apostolidis & McLeay, 2016; Clark *et al.*, 2020; Godfray *et al.*, 2018; Parodi *et al.*, 2018; Theurl *et al.*, 2020).

The key factors that may positively differentiate LGM products from conventional meat products relate to environmental impact, animal welfare, health and food security. With respect to the alleged environmental advantage of LGM in comparison to conventional meat production, the results from speculative life cycle assessments have been mixed. LGM production has been shown to be more energy intensive, therefore, environmental benefits are dependent on the type of energy used in the LGM production process, with clean and renewable energy sources offering the greatest environmental benefits (Lynch & Pierrehumbert, 2019; Mattick *et al.*, 2015; Post *et al.*, 2020; Swartz, 2021; Tuomisto *et al.*, 2014; Tuomisto & Teixeira de Mattos, 2011). Life cycle assessments generally concur that production of LGM would use less land than conventional production methods (Tuomisto *et al.*, 2014; Tuomisto & Teixeira de Mattos, 2011)). However, it is important to note that about one-third of global

agricultural land area is used for cropland, while the remaining two-thirds consist of meadows and pastures, and is primarily used for grazing livestock since it is not suitable as cropland (FAO, 2020). From an animal welfare perspective, LGM production is considered more animal friendly as it does not require intensive production methods or slaughter of animals (Dawkins, 2008; Leroy & Praet, 2017).

Considering the health dimension, studies suggest the nutritional profile of LGM is similar to conventionally raised meat (Parodi *et al.*, 2018), and could also be improved (e.g., by enriching the meat with omega-3 fatty acids) (Mancini & Antonioli, 2019). Additionally, the need for antibiotic use in LGM production could be reduced or eliminated as the technology advances[6] (Stephens *et al.*, 2018). In the long-term, LGM production is also expected to contribute to improvements in food security through increased and more affordable supply of high-quality protein, with industrial, large-scale production of LGM expected to lower future costs (Post, 2012; Post *et al.*, 2020).

Consumer acceptance of LGM will determine the future demand for this novel food (Hocquette, 2016; Sharma *et al.*, 2015). Therefore, an understanding of the factors that help explain or predict consumer acceptance of LGM is critical to developing the market for LGM. Australia presents a particularly interesting market context for exploring the potential demand for LGM, as per capita meat consumption in Australia is consistently among the highest in the world, averaging 92 kg in 2019 (OECD, 2020).

Exploring consumer acceptance of LGM is especially interesting as this product involves novel technology, and differs substantially from existing meat-substitutes, which are primarily plant-based. If an emerging food technology such as LGM continues to evolve and scale-up, there may be diverse socio-economic, political, environmental and cultural implications for

[6] Currently, it is common practice to add antibiotics to cells in cultures to prevent infection (Stephens et al. 2018).

consumers, the industry and even food regulators/policymakers if consumers substitute conventional meat with alternative protein sources such as LGM. Such impacts may contribute to or reconfigure existing political economies in the global food system (Bryant, 2020; Stephens *et al.*, 2018, p. 161).

The existing LGM literature covers several topics ranging from technological advances (Datar & Betti, 2010; Post, 2014; Sharma *et al.*, 2015; Stephens *et al.*, 2018), analysis of public reaction to news (Goodwin & Shoulders, 2013; Laestadius & Caldwell, 2015) to consumer behavior and marketing research (Bogueva & Marinova, 2020; Dupont & Fiebelkorn, 2020; Hwang *et al.*, 2020; Siegrist & Hartmann, 2020). Previous consumer studies have examined consumer acceptance of LGM (Bryant & Barnett, 2020); however, only a few have examined consumer heterogeneity (Arora *et al.*, 2020). Considerable preference heterogeneity for meat alternatives (including LGM) has been shown to exist, and researchers have called for exploration of this heterogeneity (Van Loo *et al.*, 2020). Therefore, a more formal investigation of heterogeneous groups would be beneficial.

Food choice values are an important individual factor underlying consumer preference heterogeneity, particularly for novel food products such as LGM (Sobal & Bisogni, 2009; Symmank *et al.*, 2017). Therefore, understanding the differences in acceptance of LGM and the underlying food choice values that exist within the population is key to identifying potential market segments. Knowledge of the target markets' main food choice values will be pivotal to the nascent LGM industry when tailoring successful strategies for market development (Grunert & van Trijp, 2014; Solomon, 2014). Conventional livestock industries could also benefit from insight on the underlying factors that might motivate consumers to substitute conventional meat products for LGM products.

To address these knowledge gaps, the present study had the following objectives: 1) to determine consumers' willingness to consume LGM; 2) to explore heterogeneity in both consumers' willingness to consume LGM and food choice values; and 3) to characterize unique consumer clusters (segments) using socio-demographic, behavioral (e.g., food consumption), and psychosocial factors (e.g., familiarity with and beliefs regarding LGM, and trusted information sources). In line with the preference heterogeneity reported in the literature (Van Loo *et al.*, 2020) we hypothesized the existence of multiple consumer segments that differ in their willingness to consume LGM (H1). Further, based on previous studies showing a range of motivations for meat reduction and avoidance (Malek *et al.*, 2018; Malek & Umberger, 2021a), we expected diverse food choice values among consumers with similar levels of willingness to consume LGM, such that distinct segments may be identified that comprise of consumers with similar willingness to try LGM, but different food choice values (H2). Additionally, we expected willingness to consume LGM to be associated with current meat consumption behavior, i.e., consumers who are omnivores are more likely to be willing to consume LGM (H3).

4.2. Methods

4.2.1. Data collection

A cross-sectional online survey was completed in October and November 2018 by 1,078 Australian consumers. Eligible participants were Australian residents aged 18 years or older, who did the majority of or shared the responsibility for household food shopping. Quotas were set to obtain a nationally representative sample with respect to age, gender and location (both metropolitan versus other areas, and distribution by state/territory). A market research company (Dynata^{TM}) provided the consumer panel and administered the survey. The University of Adelaide Human Research Ethics Committee (approval number H-2016-156) provided ethics approval.

In addition to *socio-demographic and household characteristics* (see Table 4.1), the comprehensive questionnaire assessed: household food purchase behavior; personal food consumption behavior; food choice values; food production and consumption concerns; awareness, perceptions and intentions regarding LGM; and trusted sources of food safety information. Questions regarding LGM were drawn from the literature (Hocquette *et al.*, 2015; Slade, 2018; Verbeke *et al.*, 2015; Wilks & Phillips, 2017).

To assess *behavioral intention towards LGM* when it becomes available, respondents indicated, using a five-point Likert-like scale, their willingness to: 'eat LGM occasionally', 'eat LGM regularly', 'replace some meat for LGM' and 'replace all meat for LGM' (the latter two items were only presented to self-identified omnivores and flexitarians/semi-vegetarians – not to full-time vegetarians or vegans).

Consumers' *food values* have been found to be significantly associated with actual food purchases (Lusk, 2011; Lusk & Briggeman, 2009; Onozaka *et al.*, 2011). Thus, respondents were asked to consider the importance of 15 food values (termed "characteristics" in the survey) when grocery shopping for food (Table 4.2). First, they were asked to select up to five characteristics, and then they were asked to allocate 100 points among their chosen characteristics. The original list of food values from Lusk and Briggeman (2009) was adapted to fit the Australian context. Four additional items were included after considering the literature on how consumers differentiate new meat products (Grunert *et al.*, 2004; Loh & Tang, 2018).

Dietary preferences were assessed by asking respondents to identify themselves as one of the following: omnivore, semi-vegetarian/flexitarian, full-time vegetarian and vegan. *Consumption frequencies* of various meat products (see Table 4.3) and plant-based alternatives were measured using 10 response options, ranging from 'Never' to 'Every day'.

Respondents' *awareness and understanding* of six terms used frequently in the literature and by media to describe 'lab-grown meat' (see Table 4.4) (Bryant & Barnett, 2019) were assessed using three response options: 'Have NOT heard of it'; 'Have heard of it, but know very little or nothing about it'; or 'Know enough about it that I could explain to a friend'. After these questions, definitions of conventional/traditional meat and the term 'lab-grown' were provided [7]. To avoid biasing responses, no information on any potential benefits of LGM was provided (Bekker *et al.*, 2017; Verbeke *et al.*, 2015).

Respondents' *beliefs regarding future impacts of LGM* were assessed using 12 statements drawn from Wilks and Phillips (2017), Slade (2018) and Hocquette *et al.* (2015) (see Table 4.5). As food safety has been shown to be a key concern influencing consumer acceptance of new food technologies (Fernbach *et al.*, 2019), questions were included to assess respondents' *willingness to take food safety risks* and their level of *trust in 18 different sources of food safety information* (see Table 4.6).

4.2.2. Data analysis

Latent class cluster analysis was conducted using LatentGOLD (version 5.1). Clusters were identified using 17 variables: two ordinal variables (scored from -2 to 2) indicating intention to consume LGM ('occasionally' and 'regularly') and 15 nominal food value variables indicating whether each value was selected as one of the five most important (0 = 'no', 1 = 'yes'). Performance of the models was checked for up to 10 clusters, using the minimum Bayesian information criterion (BIC) and researcher judgement for selection (Nylund *et al.*, 2007).

[7] Participants were shown the following description of LGM: "The term 'LAB-GROWN' refers to products created by the new process of extracting cells from animals without causing suffering to the animals and then growing the cells in a controlled cell culture condition. In August 2013, scientists unveiled (and tasted) the world's first lab-grown hamburger patty. There are companies in the US, Europe and Israel creating meat and even dairy products in the laboratory. Currently they are not commercially available, though research is being conducted to introduce lab-grown food products in the near future, possibly by 2019".

Post-hoc comparisons of latent clusters were performed in IBM SPSS Statistics, version 25. Chi-squared tests, including z-tests with adjusted P-values (Bonferroni method) were used to compare categorical variables (e.g., dietary preferences) and one-way analysis of variance (ANOVA) was used for comparison of continuous and interval-scaled variables (e.g., food consumption). The one-way ANOVA was considered a robust test against the normality assumption because all our clusters comprised more than 30 cases (Hair *et al.*, 2006). Statistical significance was set at $\alpha = 0.05$ (two-tailed) level.

4.3. Results

4.3.1. Socio-demographic characteristics of the sample

A total of 1,078 Australian consumers completed the survey. Characteristics of the sample are shown in Table 4.1, alongside general population values.

Table 4.1. Socio-demographic characteristics, by cluster

	C1 (%)	C2 (%)	C3 (%)	C4 (%)	C5 (%)	C6 (%)	Total sample (%)	Australian population[3] (%)	χ^2	p-value	Phi[4]	CV[5]
Gender (Female)	49.2^{a,b,c}	63.2^{c}	60.9^{b,c}	47.4^{a,b}	47.7^{a,b,c}	36.3^{a}	50.8	50.7	33.726	0.001	0.177	0.125
Age (years)												
≤ 34	15.3^{a}	16.1^{a}	25.5^{a,b}	34.8^{b,c}	40.7^{c}	50.8^{c}	29.2	20.5	103.265	0.001	0.310	0.219
35 – 54	37.7	32.3	34.2	41.3	29.1	31.5	35.1	26.8				
≥ 55	47.0^{a}	51.6^{a}	40.4^{a,b}	23.9^{c}	30.2^{b,c}	17.7^{c}	35.7	23.5	103.265	0.001	0.310	0.219
Live in metropolitan area	56.4^{a}	68.4^{a,b}	67.1^{a,b}	69.6^{b}	73.8^{b}	73.4^{b}	67.3	67.0	18.880	0.002	0.132	0.132
University degree (n = 1060)[1]	29^{a}	38^{a}	30^{a}	36^{a}	41^{a,b}	57^{b}	37.0	30.9	30.639	0.001	0.170	
Employment status[2]												
Employed	47.9^{a}	49.0^{a}	54.0^{a}	56.1^{a,b}	57.0^{a}	71.8^{b}	54.9	-	41.009	0.000	0.195	0.138
Unemployed	22.9	20.0	24.8	28.7	23.3	19.4	23.7	-				
Retired	29.2^{a}	31.0^{a}	21.1^{a,b}	15.2^{b}	19.8^{a,b}	8.9^{b}	21.4	-				
Household income before tax												
≤$35,000	29.2	27.1	26.7	23.0	19.2	13.7	23.8	19.6	30.535	0.062	0.168	0.084
$35,001 - $65,000	29.7	27.1	25.5	23.5	31.4	26.6	27.3	21.3				
$65,001 - $105,000	17.8	19.4	25.5	28.7	23.3	25.8	23.3	18.9				
$105,001 - $165,000	15.7	18.1	18.0	17.0	18.0	20.2	17.5	18.7				
>$165,001	7.6	8.4	4.3	7.8	8.1	13.7	8.1	21.5				
Children under 12y in household	15.3^{a}	13.5^{a}	17.4^{a}	18.3^{a}	25.0^{a,b}	37.1^{b}	20.0	-	33.767	0.001	0.177	0.177
Pets in household	48.3^{a}	61.3^{a,b}	49.7^{a,b}	53.0^{a,b}	54.7^{a,b}	66.1^{b}	54.5	-	14.994	0.010	0.118	0.118

^{a,b,c,d} In each row, values followed by the same letter are not statistically significantly different (at P<0.05).

[1] Based on data from Australians aged 20-64 years (May 2018) (Australian Bureau of Statistics, 2017b). Number of respondents to this question slightly less due to an error from the survey company leading to missing data (n=18).

[2] Employed= 'Working full-time', 'Working part-time', 'Both working and studying'; Unemployed= 'A full-time student' (and not working), 'A part-time student (and not working)', 'Engaged in full-time home duties', 'Not in paid work but looking', 'Retired', 'On a pension (other than age pension)'.

[3] Data from Australian Bureau of Statistics dataset (Australian Bureau of Statistics, 2017a).

[4] Phi coefficient indicates strength of association.

[5] CV = Cramer's V effect size statistic.

The majority of the consumer were omnivores (76%), followed by flexitarians (20%), full-time vegetarians (4%) and vegans (1%). Approximately one-half (49%) of Australian consumers are, to some extent, willing to consume LGM. Also, the majority was not aware of LGM before the study, ranging from "in vitro meat" (77%) with the lowest awareness to artificial meat (53%), with the highest awareness.

4.3.2. Consumer clusters

A six-cluster solution was identified to be the best fit. For each cluster, the percent of consumers willing to consume LGM and the mean importance consumers placed on food choice values by point allocation are provided in Table II. Overall, three clusters have a low willingness to consume LGM (Clusters 1-3), two are somewhat willing (Clusters 4-5), and one cluster (Cluster 6) shows a relatively high propensity to consume LGM.

The importance of food choice values varied among clusters and significantly influenced segment membership (parameter estimate p-values based on Wald tests were <0.05 for all food choice values except for 'food safety'). Clusters were named according to their level of willingness to consume LGM and the importance placed on food choice values. The bottom panel of Table 4.2 shows the average importance consumers placed on food choice values by point allocation.

Table 4.2. Variables used for clustering. Data are the mean willingness to consume lab-grown meat and the mean importance placed on food value by point allocation (1-100), by cluster

	Cluster 1 LGM-averse: Self-focused	**Cluster 2** LGM-averse: Health & society-focused	**Cluster 3** Somewhat Unwilling: Safety focused	**Cluster 4** Somewhat willing: Self-focused	**Cluster 5** Somewhat willing: Society-focused	**Cluster 6** Prospective LGM Eaters	**Total sample**	***F/Welch's F*[1]**	**Degrees of freedom[2] (df2)**	**p-value**
N	236	155	161	230	172	124	1078			
Share of total sample	21.9%	14.4%	14.9%	21.3%	16.0%	11.5%	100%			
	Mean	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**			
Willingness to eat LGM[3]:										
Occasionally	-1.91[a]	-1.86[a]	-0.84[b]	0.41[d]	0.23[c]	1.44[e]	-0.52	1525.197	5	0.001
Regularly	-2.00[a]	-2.00[a]	-1.19[b]	-0.08[c]	-0.06[c]	1.37[d]	-0.77	1707.898	5	0.001
Food choice values (0 to 100 points)										
Price	23.25[b]	9.59[a]	22.31[b]	24.73[b]	13.31[a]	14.33[a]	18.85	29.411	465.415	0.001
Taste	24.69[c]	8.13[a]	19.46[c]	24.64[c]	11.23[a,b]	14.06[b]	18.14	34.503	465.464	0.001
Health and nutrition	10.41[a]	19.06[c]	15.17[b,c]	11.85[a,b]	14.24[a,b]	13.76[a]	13.67	5.582	456.455	0.001
Food safety	6.94[a]	8.76[a,b]	11.53[b]	8.00[a,b]	7.12[a,b]	10.41[a,b]	8.54	2.626	456.286	0.023
Country of origin	9.09[b]	14.13[c]	5.98[a,b]	3.24[a]	9.50[b,c]	3.73[a]	7.55	16.229	466.044	0.001
Naturalness	3.71[a,b]	9.35[c]	5.25[a,b]	3.01[a]	6.35[b,c]	6.40[a,b,c]	5.33	11.036	443.003	0.001
Impact on animals	1.34[a]	10.75[b]	2.19[a]	0.55[a]	10.41[b]	8.08[b]	4.88	22.670	409.060	0.001
Appearance	5.63[b,c]	1.41[a]	4.64[b,c]	6.60[c]	2.55[a,b]	4.90[b,c]	4.51	10.084	463.391	0.001
Convenience	5.69[c,d]	0.03[a]	4.06[c]	8.17[d,e]	1.67[b]	4.52[b,c,d]	4.39	59.638	406.332	0.001
Familiarity	5.98[c,d]	1.35[a]	5.17[b,c,d]	6.03[c,d]	1.84[a,b]	3.65[a,b,c]	4.28	14.467	457.925	0.001

Table 4.2 continues.

Continued Table 4.2.

Food tolerance/restrictions	1.43[a,b]	4.30[b,c]	0.73[a]	0.84[a]	5.46[c]	4.29[a,b,c]	2.58	6.068	409.557	0.001
How the food was produced	0.21[a]	6.38[c]	0.99[a]	0.83[a]	3.16[b]	3.98[b,c]	2.25	18.770	415.586	0.001
Environmental impact	0.34[a]	3.82[c,d]	1.06[a,b]	0.34[a]	5.51[d]	2.41[b,c]	2.01	14.430	421.074	0.001
Fairness	0.91[a]	2.90[b]	1.07[a]	0.81[a]	4.17[b]	2.52[a,b]	1.91	5.748	442.318	0.001
Novelty	0.38[a,b]	0.02[a]	0.38[a,b]	0.34[a,b]	3.47[b]	2.97[a,b]	1.11	5.207	439.678	0.001

[a,b,c,d] In each row, values followed by the same letter are not statistically significantly different (at $P<0.05$).

[1] Welch-test was used in cases where the assumption of homogeneity of variances was violated (Levene-test).

[2] Degrees of freedom: df1=5.

[3] Items scored on a five-point scale where -2=not at all willing to do this, -1=somewhat unwilling, 0=neither willing nor unwilling, 1=somewhat willing, 2=very willing to do this.

Three clusters (C1-C3, 51% of participants) had a low willingness to consume LGM. Two of these three clusters C1 ('LGM-averse: Self-focused', 22%) and C3 ('Somewhat unwilling: Safety focused', 15%) were more self-focused than C2 ('LGM-averse: Health & society-focused', 14%). For example, compared to C2, respondents in C1 and C3 placed more importance on food values related to direct personal benefits, including price, taste, appearance, convenience and familiarity (Table 4.2). In contrast, a higher share of respondents in C2 appear to be "society-focused", placing more importance on the socially oriented food values: 'impact on animals' and 'environmental impact' (Table 4.2).

Additionally, of the two self-focused clusters, C3 was somewhat less averse to consuming LGM. Compared to the more averse self-focused cluster (C1), consumers in C3, on average, placed more importance on the health and nutrition and the safety of food products (Table 4.2).

Two clusters (37% of participants) were somewhat willing to consume LGM: C4 ('Somewhat willing: Self-focused', 21%) and C5 (Somewhat willing: Society-focused, 16%). Compared to C5, the 'Somewhat willing: Self-focused' segment C4, is comprised of more consumers who, on average, were more driven by price, taste, appearance, convenience and familiarity (Table 4.2). In contrast, 'Somewhat willing: Society-focused' consumers in C5 placed relatively more importance on impact on animals, country of origin, naturalness, environmental impact, food tolerance/restrictions, fairness and production method (Table 4.2). Interestingly, C5 consumers placed more importance on environmental impact of food products, than all other clusters (although not significantly greater than consumers in C2) (Table 4.2).

The smallest cluster, C6 ('Prospective LGM Eaters', 12%), was made up of consumers who expressed the highest willingness to consume LGM. The key factor (segmentation

variable) that distinguished C6 from all other clusters, was a higher willingness to consume LGM. On average, the food choice values of consumers in C6 were similar to those of C2 and C5 with regards to placing less importance on price and taste, relative to other clusters (Table 4.2).

Overall, these findings support our first and second hypotheses that there exist multiple consumer segments that differ both in their willingness to consume LGM and their food choice values.

4.3.3. Socio-demographic characteristics

Significant differences between clusters were found with respect to gender, age, location, education, employment status and household composition (Table 4.1). While the total sample of consumers was 51% females, the 'LGM-averse: Health & society-focused' segment (C2) had the highest share of females (63%) and the 'Prospective LGM Eaters' segment (C6) had the highest share of male consumers (64%). Consumers most averse to LGM (C1 and C2) tended to be older in age (≥ 55 years), while the clusters more willing to consume LGM had a larger share of younger consumers (< 34 years: 41% in C5 and 51% in C6). C6 had a higher proportion (57%) of consumers who had completed a university degree. Compared to all other clusters apart from C4, consumers in C6 were also more likely to be employed. Regarding household composition, children less than 12 years of age were significantly more common in C6 than C1-4. In addition, pet-ownership was more common in C6 than in C1 (66% versus 48%).

4.3.4. Dietary preferences, behavior and intention

Significant differences in self-identified dietary preferences between clusters included: a higher share of omnivores in C4 (85%), compared to C2 (63%) and C5 (66%); and a higher share of flexitarians (27%) in C5, compared to C1 and C4 (14%) (Table 4.3). Compared to all other

clusters, ‘Prospective LGM Eaters’ (C6) had the highest consumption frequency of all meat types. These findings support our third hypothesis that willingness to consume LGM is associated with current meat consumption behavior. Additionally, from C1 to C6, there was an increasing willingness to substitute ‘some’ or ‘all’ of the conventionally-raised meat they currently consume with LGM. The ‘Prospective LGM Eaters’ (C6) segment was the only segment willing to perform both behaviors.

Table 4.3. Dietary preferences and behavior, by cluster

	C1 (%)	C2 (%)	C3 (%)	C4 (%)	C5 (%)	C6 (%)	Total sample (%)	χ^2	p-value	CV*
Self-identified dietary preferences										
Omnivore	80.5[a,b]	62.6[c]	80.7[a,b]	85.2[b]	66.3[c]	71.0[a,c]	75.6	64.156	0.001	0.141
Flexitarian	14.0[a]	24.5[a,b]	18.0[a,b]	14.3[a]	26.7[b]	25.8[a,b]	19.6			
Full-time Vegetarian	4.7[a,b,c]	11.6[c]	1.2[a,b]	0.4[b]	5.8[a,c]	2.4[a,b,c]	4.2			
Vegan	0.8	1.3	0.0	0.0	1.2	0.8	0.6			
								Welch-value [2]	**p-value**	**Degrees of freedom[3] (df2)**
Consumption frequency (0 to 28 times per month scale)[1]										
Beef	6.52[a,b]	4.85[a]	6.14[a,b]	6.67[b]	6.87[b]	9.65[c]	6.67	8.013	0.001	459.038
Chicken	8.11[a,b]	7.41[a]	8.25[a,b]	9.31[b,c]	9.39[a,b,c]	11.69[c]	8.90	6.331	0.001	460.126
Pork	2.95[a]	3.05[a]	3.44[a]	3.57[a]	4.35[a]	6.82[b]	3.84	6.718	0.001	449.347
Lamb	2.81[a]	2.86[a]	2.88[a]	3.15[a]	4.75[b,c]	7.02[c]	3.69	8.780	0.001	449.782
Plant-based meat alternatives	1.21[a]	3.51[b,c]	2.01[a,b]	1.63[a,b]	4.73[c,d]	6.90[d]	2.96	16.311	0.001	442.007
Behavioral intention (- 2 to +2 scale) n=1026[4]										
Replace some meat for LGM	-1.83[a]	-1.71[a]	-0.80[b]	0.21[c]	0.10[c]	1.17[d]	-0.55	666.008	0.001	423.740
Replace all meat for LGM	-1.95[a]	-1.91[a]	-1.33[b]	-0.53[c]	-0.26[c]	1.01[d]	-0.92	449.696	0.001	395.460

[a,b,c,d] In each row, values followed by the same letter are not statistically significantly different (at P<0.05).

[1] Frequency of consumption options recoded as per month (0= 'Never'; 1= 'Less than once per month'; 2= '1-3 times per month'; 4= '1 day per week'; 8= '2 days per week'; 12= '3 days per week'; 16= '4 days per week'; 20= '5 days per week'; 24= '6 days per week'; 28= 'Every day').

[2] Welch-test was used in cases where the assumption of homogeneity of variances was violated (Levene-test).

[3] Degrees of freedom: df1= 5.

[4] Behavioral intention options recoded as (-2 = 'not at all willing to do this' and 2 = 'very willing to do this'). Calculated based on n=1026 as this question was not answered by full-time vegetarian or vegan respondents.

* CV = Cramer's V effect size statistic.

4.3.5. Awareness of lab-grown meat terms

Overall awareness and between-cluster differences in awareness of the six LGM terms are shown in Table 4.4. Thirty-one percent of consumers surveyed were not aware of any of the six LGM terms assessed. Consumers were most aware of the term ‘artificial meat’ (47%), followed by ‘lab-grown meat’ (44%) and ‘synthetic meat’ (43%). Of the clusters, ‘Prospective LGM Eaters’ (C6) had the highest awareness of each term, and C1 consumers were less aware of each term than consumers in both C5 and C6.

Table 4.4. Awareness of lab-grown meat terms, by cluster

		C1 (mean)	C2 (mean)	C3 (mean)	C4 (mean)	C5 (mean)	C6 (mean)	Total sample (mean)	χ^2	p-value	CV[2]
Awareness[1]											
Lab-grown meat	Not aware	70.8^{a}	65.2^{a,b}	63.4^{a,b,c}	54.3^{b,c}	48.8^{c}	23.4^{d}	56.4	155.104	0.001	0.268
	Aware	26.7^{a}	27.7^{a,b}	32.3^{a,b}	40.9^{b}	40.7^{b}	43.5^{b}	34.9			
	Very aware	2.5^{a}	7.1^{a,b}	4.3^{a,b}	4.8^{a,b}	10.5^{b}	33.1^{c}	8.7			
In vitro meat	Not aware	92.4^{a}	83.2^{a,b}	80.7^{b}	81.7^{b}	65.7^{c}	40.3^{d}	76.8	209.711	0.001	0.312
	Aware	6.8^{a}	13.5^{a,b}	18.0^{b,c}	17.0^{b,c}	29.1^{c,d}	33.9^{d}	18.3			
	Very aware	0.8^{a}	3.2^{a}	1.2^{a}	1.3^{a}	5.2^{a}	25.8^{b}	4.9			
Cultured meat	Not aware	73.3^{a}	70.3^{a}	66.5^{a,b}	65.2^{a,b}	54.1^{b,c}	37.1^{c}	62.9	108.373	0.001	0.224
	Aware	22.9^{a}	24.5^{a,b}	28.6^{a,b}	32.6^{a,b}	39.5^{b}	37.9^{b}	30.4			
	Very aware	3.8^{a}	5.2^{a}	5.0^{a}	2.2^{a}	6.4^{a}	25.0^{b}	6.7			
Artificial meat	Not aware	65.7^{a}	55.5^{a,b}	54.5^{a,b}	59.6^{a}	41.9^{b}	24.2^{c}	52.7	119.198	0.001	0.235
	Aware	29.2^{a}	36.1^{a,b}	39.8^{a,b}	36.5^{a,b}	47.1^{b}	45.2^{b}	38.0			
	Very aware	5.1^{a}	8.4^{a}	5.6^{a}	3.9^{a}	11.0^{a}	30.6^{b}	9.3			
Synthetic meat	Not aware	72.5^{a}	61.3^{a,b}	59.6^{a,b}	62.2^{a,b}	48.3^{b}	27.4^{c}	57.7	147.147	0.001	0.261
	Aware	24.2^{a}	31.6^{a,b}	36.0^{a,b}	36.5^{a,b}	42.4^{b}	42.7^{b}	34.7			
	Very aware	3.4^{a,b,c}	7.1^{c}	4.3^{a,b,c}	1.3^{b}	9.3^{a,c}	29.8^{d}	7.6			
Clean meat	Not aware	81.4^{a}	71.0^{a,b}	70.2^{a,b}	69.6^{b}	58.1^{b}	38.7^{c}	67.1	113.875	0.001	0.230
	Aware	14.8^{a}	21.9^{a,b}	24.8^{a,b}	24.8^{a,b}	30.8^{b}	31.5^{b}	23.9			
	Very aware	3.8^{a}	7.1^{a}	5.0^{a}	5.7^{a}	11.0^{a}	29.8^{b}	9.0			

^{a,b,c,d} In each row, values followed by the same letter are not statistically significantly different (at $P<0.05$).

[1] Not aware= 'Have NOT heard of it'; Aware= 'Have heard of it, but know very little or nothing about it'; Very aware= 'Know enough about it that I could explain it to a friend'.

[2] CV = Cramer's V effect size statistic.

4.3.6. Beliefs regarding future impacts of lab-grown meat

The mean agreement rating for statements regarding future impacts of meeting consumer meat demand with lab-grown meat, by cluster, are provided in Table 4.5. The only statement with positive average agreement ratings for all clusters was related to the potential negative impact on farmers and fishermen. For all items apart from 'Be a short-term solution', 'Prospective LGM Eaters' (C6) had the highest agreement ratings of all clusters, and the LGM-averse clusters (C1 and C2) had the lowest average agreement ratings. Overall, 'Prospective LGM Eaters' (C6) had the most positive views regarding the impact of meeting demand for meat with LGM, with improvements in animal welfare conditions and sustainability receiving the highest agreement ratings, while C1 and C2 had the least positive views.

Table 4.5. Mean agreement rating for statements regarding future impacts of meeting consumer meat demand with lab-grown meat, by cluster

	C1 (mean)	C2 (mean)	C3 (mean)	C4 (mean)	C5 (mean)	C6 (mean)	Total sample (mean)	Welch-value[1]	Degrees of freedom[2] (df2)	p-value
Have a negative impact on farmers and fishermen	0.98[a,b]	1.05[a,b]	0.95[a,b]	0.74[a]	0.71[a]	1.31[b]	0.93	4.227	465.104	0.001
Improve animal welfare conditions	-0.14[a]	0.08[a]	0.58[b]	0.90[b]	0.92[b]	1.70[c]	0.60	37.115	464.561	0.000
Be more sustainable	-0.29[a]	-0.12[a]	0.46[b]	0.87[c]	0.83[c]	1.82[d]	0.51	50.485	459.465	0.001
Have less negative environmental impact	-0.30[a]	-0.13[a]	0.40[b]	0.70[b,c]	0.81[c]	1.65[d]	0.45	39.742	460.230	0.001
Be able to solve world famine (food security) problems	-0.27[a]	-0.18[a]	0.50[b]	0.67[b]	0.74[b]	1.60[c]	0.44	38.107	463.720	0.001
Reduce the human contribution to climate change	-0.49[a]	-0.39[a]	0.42[b]	0.61[b,c]	0.81[c]	1.47[d]	0.33	41.212	460.384	0.001
Be more ethical	-0.63[a]	-0.55[a]	0.25[b]	0.70[c]	0.66[c]	1.74[d]	0.27	66.741	464.262	0.001
Be a long-term solution	-0.57[a]	-0.52[a]	0.25[b]	0.60[c]	0.63[c]	1.70[d]	0.26	61.485	461.964	0.001
Be a short-term solution	-0.09[a]	0.02[a,b,c]	0.34[b,c]	0.13[a,b,c]	0.20[a,b,c]	0.59[c]	0.16	4.089	454.639	0.001
Be a realistic alternative to farmed meat	-0.85[a]	-0.68[a]	0.14[b]	0.62[c]	0.58[c]	1.74[d]	0.16	85.771	466.036	0.001
Have more negative environmental impact	-0.17	0.03	-0.16	-0.28	-0.06	0.20	-0.10	2.045	452.620	0.071
Be more beneficial for human health	-1.14[a]	-1.13[a]	-0.10[b]	0.21[c]	0.38[c]	1.59[d]	-0.14	95.627	457.432	0.001

[a, b, c, d] Different letters indicate significant differences between means based on ANOVA tests (at $P<0.05$).

[1] Welch-test was used in cases where the assumption of homogeneity of variances was violated (Levene-test).

[2] Degrees of freedom: df1= 5.

4.3.7. Food safety risk and trusted information sources

Clusters differed significantly with respect to their readiness to take food safety risks and their trusted sources of food safety information (Table 4.6). On average, consumers in C6 were most willing to take food safety risks, followed by C3-C5, and C1 and C2 were least willing. Overall, the top three most trusted sources of information were the CSIRO[8], doctors/medical professionals and consumer organizations, while celebrity chefs were least trusted. Significantly higher trust levels for most sources were found for 'Prospective LGM Eaters' (C6) compared to all other clusters.

[8] The CSIRO- Commonwealth Scientific & Industrial Research Organization is an authority commonly cited to be trusted by Australians; especially after its book *The CSIRO Total Wellbeing Diet* became a bestseller (Noakes, 2012).

Table 4.6. Food safety risk and level of trust in information sources by consumer clusters (ANOVA tests).

	C1 (mean)	C2 (mean)	C3 (mean)	C4 (mean)	C5 (mean)	C6 (mean)	Total sample (mean)	*F/ Welch-value*[1]	Degrees of freedom[2] (df2)	p-value
Prepare to take food safety risks (0 to 10 scale)	3.14[a]	2.92[a]	4.29[b]	4.37[b]	4.46[b]	6.28[c]	4.11	29.611	-	0.001
Trusted information sources (- 3 to +3 scale)										
Farmers	0.92[a,b]	1.10[b,c]	0.99[a,b]	0.78[a,b]	0.69[a]	1.42[c]	0.95	7.169	462.756	0.001
Farmer Associations	0.76[a,b]	0.74[a,b]	0.89[a,b]	0.72[a]	0.56[a]	1.18[b]	0.79	3.903	460.911	0.002
Food Processors	0.24[a]	0.08[a]	0.35[a]	0.39[a]	0.24[a]	0.97[b]	0.35	6.657	460.359	0.001
Food Industry Associations	0.81[a]	0.83[a]	0.94[a]	0.80[a]	0.76[a]	1.41[b]	0.89	5.113	462.056	0.001
Supermarkets	0.09[a]	0.09[a]	0.25[a]	0.34[a]	0.45[a]	1.07[b]	0.34	9.691	463.021	0.001
Independent or local food stores	0.52[a]	0.50[a]	0.49[a]	0.50[a]	0.55[a]	1.06[b]	0.58	3.684	460.274	0.003
Universities	0.50[a]	0.71[a]	0.71[a]	0.72[a]	0.76[a]	1.56[b]	0.77	14.021	464.855	0.001
CSIRO	1.32[a]	1.43[a]	1.39[a]	1.25[a]	1.15[a]	1.81[b]	1.36	6.236	469.549	0.001
Other research organization	0.48[a]	0.69[a]	0.81[a]	0.77[a]	0.66[a]	1.34[b]	0.75	9.687	464.327	0.001
Government/government agencies	0.78[a]	0.94[a]	1.11[a]	0.95[a]	0.72[a]	1.68[b]	0.98	11.131	467.338	0.001
Consumer organization	0.94[a]	1.15[a]	1.06[a]	0.95[a]	0.98[a]	1.55[b]	1.07	5.479	463.786	0.001
Environmental organization	0.09[a]	0.93[b]	0.63[b]	0.56[b]	0.76[b]	1.34[c]	0.64	16.143	463.649	0.001
Animal rights organization	0.17[a]	0.81[b]	0.57[a,b]	0.46[a,b]	0.68[b]	1.34[c]	0.60	13.954	466.589	0.001
Animal protection organization	-0.12[a]	0.74[c,d]	0.32[b,c]	0.29[b,c]	0.54[b,c]	1.24[d]	0.42	17.078	462.731	0.001
Doctors/medical professionals	1.27[a]	1.26[a]	1.32[a,b]	1.19[a]	1.08[a]	1.66[b]	1.27	4.267	-	0.001
Dietitians and nutritionists	0.80[a]	0.85[a,b]	0.96[a,b]	0.92[a]	0.92[a,b]	1.29[b]	0.93	2.319	460.627	0.043
Celebrity chefs	-0.57[a]	-0.53[a,b]	-0.14[b]	-0.23[a,b]	-0.06[b]	0.77[c]	-0.19	12.795	459.350	0.001
Family/Friends/Work colleagues	0.52[a]	0.60[a,b]	0.56[a,b]	0.57[a,b]	0.56[a,b]	0.98[b]	0.61	2.336	460.549	0.041

[a, b, c, d] Different letters indicate significant differences between means based on an ANOVA (at P<0.05).

[1] Welch-test was used in cases where the assumption of homogeneity of variances was violated (Levene-test).

[2] Degrees of freedom: df1= 5

4.4. Discussion

The present study provides insight on the differences that exist between consumers with respect to their willingness to consume LGM and their food choice values. This is the first consumer research to use a nationally representative consumer sample to explore market opportunities for LGM in Australia. We identified six clusters with distinct levels of willingness to consume LGM and distinct food choice values. We also found informative differences between clusters with respect to socio-demographic, behavioral and psychosocial characteristics.

4.4.1. Consumer acceptance and awareness of lab-grown meat among Australian consumers

We found that 25% of Australians are willing to consume LGM 'occasionally' and 15% 'regularly' (Table 4.2). This result is similar to another study that investigated LGM acceptance in Australia (Bogueva & Marinova, 2020). Although their study was exploratory and not nationally representative of Australians, Bogueva and Marinova (2020) found that 28% of the young people sampled were willing to try LGM. However, the share of our sample that is accepting of LGM is lower than the values reported in studies conducted in other countries (Bryant *et al.*, 2019; Van Loo *et al.*, 2020; Wilks & Phillips, 2017). The highest willingness to try values were found in India and China (61% each) (Bryant *et al.*, 2019). Considering published studies with nationally representative samples only, our comparatively lower values could be attributed to between-country differences, as well as differences in the terms and descriptions used for LGM products (Bryant & Barnett, 2019); and how questions are posed with respect to the extent of engagement with the product. In contrast to other studies (Bryant *et al.*, 2019; Mancini & Antonioli, 2019), our definition of LGM did not provide participants with information on any alleged benefits of LGM. This, too, may have contributed to the lower consumer acceptance (willingness) found in our study relative to other studies.

Consistent with previous studies, our results show that familiarity with new food technologies is positively associated with behavioral intention, with significantly greater

awareness of LGM found among ‘Prospective LGM Eaters’ (C6), the cluster most willing to consume LGM (Bryant *et al.*, 2019; Dupont & Fiebelkorn, 2020; Mancini & Antonioli, 2019; Weinrich *et al.*, 2020). Of the terms assessed in our study, consumers were most familiar with ‘artificial meat’ (47%) and ‘lab-grown meat’ (44%); however, the majority of terms used to define this ‘future food’ are not yet widely recognized by the Australian public.

As one aim of our research was to understand consumer market segments with potential interest in LGM products, our questions assessed willingness to eat LGM occasionally and regularly, as well as willingness to replace ‘some’ and ‘all’ conventionally-raised meat for LGM. Similar to Wilks and Phillips (2017), we found a higher share of consumers indicating a willingness for the lower engagement option (in our sample 25% were willing to ‘eat occasionally’ versus 15% were willing to ‘eat regularly’). This suggests that further engagement may depend on the strength of motivating factors (e.g., animal welfare concerns), the ability to provide an opportunity for consumers to gain experience with the product, and ultimately, consumers’ satisfaction with the product.

4.4.2. Clusters’ profiles and implications for stakeholders

Socio-demographic similarities with other studies were found, particularly regarding ‘Prospective LGM Eaters’ (C6). Consistent with previous US research showing associations between male gender and openness to trying/consuming LGM, we found a significantly higher share of males in the ‘Prospective LGM Eaters’ (Bryant *et al.*, 2019; Van Loo *et al.*, 2020; Wilks & Phillips, 2017). We also found that the ‘Prospective LGM Eaters’ were more likely to be younger and university educated, with similar findings reported in studies from North-America, Canada, Italy and Australia (Bogueva & Marinova, 2020; Mancini & Antonioli, 2019; Slade, 2018; Van Loo *et al.*, 2020) but not in other North-American, Chinese or Indian samples (Bryant *et al.*, 2019; Wilks & Phillips, 2017).

Future demand for LGM is more likely to be driven by omnivores rather than by vegetarians or vegans, this is based on our finding that the most willing segment to consume LGM (C6 versus other clusters) was composed of a high share of omnivores with high meat consumption frequency. Several other studies have also suggested that the most likely market for LGM will be consumers who are already eating meat (e.g., Bryant *et al.* (2019); Mancini and Antonioli (2019); Slade (2018); Wilks and Phillips (2017)).

Stakeholders seeking to strengthen positive consumer perceptions of LGM must consider how the product is positioned in the market. Our findings suggest that Australian consumers are most familiar with the terms 'artificial' or 'lab-grown meat', however, these terms have been associated with lower acceptance rates (Bryant & Barnett, 2019). Consistent with previous research, improvements in animal welfare, sustainability and environmental impact, were the most commonly perceived potential benefits from substituting conventional meat with LGM (Bryant & Barnett, 2018). However, as in other studies (Marcu *et al.*, 2015; Verbeke *et al.*, 2015; Wilks & Phillips, 2017), Australian consumers expressed concern about the impact of new LGM products on traditional agriculture. This concern is understandable in a country where the meat industry plays an important role in the economy (MLA, 2020). Consumer perceptions regarding potential negative impacts of LGM on farmers/producers will need to be addressed in order to improve market acceptability.

4.4.3. Strengths and limitations

Key contributions and strengths of this study include the use of latent class segmentation analysis to explore consumer heterogeneity; avoiding bias by not providing information on the potential benefits of LGM; and the use of a nationally representative sample (with respect to gender, age, education and location). However, it is possible that consumers more interested in the topic were more likely to participate in the survey. Additionally, social desirability and memory bias are limitations frequently associated with online survey data collection

(Tourangeau & Yan, 2007). To mitigate these issues, participants' anonymity was assured prior to commencing the survey. Comparing our sample respondents' stated meat consumption patterns (e.g., the frequency of consumption of different types of meat) to the patterns of the Australian population add credence to our findings regarding participants' stated consumption (OECD, 2020).

4.5. Conclusions and future recommendations

Approximately one-half (49%) of Australian consumers are, to some extent, willing to consume LGM. Among the 'somewhat' willing consumers (37%), two unique segments exist – one more 'self-focused' (place higher importance on price and taste), and the other more 'society-focused' (place higher importance on socially or ethically related food values). Only 12% of consumers have a high willingness to consume LGM. These 'Prospective LGM Eaters' are more likely to be younger (<35 years), university-educated, live in metropolitan areas, have greater awareness of LGM, have stronger beliefs regarding the potential positive self- and society-related impacts of meeting future meat demand with LGM; and have higher trust in diverse information sources.

Insights on the characteristics of each cluster provide useful information for the industry on how to tailor their product development and how to target their marketing strategies. To date, all of the previous research has investigated perceptions of LGM in general (i.e., without specifying the type of lab-grown meat or protein). Further research is needed to understand the types of lab-grown protein products that are likely to appeal to consumers.

A 50% reduction in red meat consumption in high meat eating countries has been highlighted as a key dietary change necessary for optimizing the health and sustainability of current food systems (Willett *et al.*, 2019). However, with just 12% of Australian adults very willing to consume LGM, our findings suggest that, in the short term, LGM is unlikely to play

a major role in shifting food systems towards more responsible production and consumption. Therefore, a continued focus on sustainable practices in both traditional livestock and alternative protein industries will continue to be important into the future.

Chapter 5: Summary of findings, market and policy implications, limitations and recommendations for future research and pathways to sustainable food systems

5.1. Summary of key findings

This thesis aims to increase understanding of Australian consumers' views and intentions regarding sustainable meat and meat substitutes. The thesis provides: new evidence for the need to provide clearer information to consumers regarding sustainability and product-related labels (Chapter 2); and new insights on consumers' perceptions of different types of meat and meat alternatives and drivers to consume lab-grown chicken and lab-grown beef (Chapter 3), and potential LGM consumers' profiles (Chapter 4). Collectively, this new knowledge and better understanding of these topics can help to inform strategies aimed at encouraging individuals to gradually change towards more sustainable food consumption patterns.

The first empirical study (Chapter 2) was largely exploratory and used a multi-method approach which was divided into three stages: an online survey (Stage 1), an in-person interview where participants completed a series of eye-tracking choice tasks (Stage 2), and in-depth interviews (Stage 3). The data was collected between September 2019 and January 2020. The other two analytical chapters of the thesis (Chapter 3 and Chapter 4) were also exploratory and collected quantitative data via an online survey. The following paragraphs summarize the key findings from the three analytical chapters.

Chapter 2 addresses the following research questions: What are consumers' perceptions of sustainable food systems and sustainable chicken meat production systems? What (if any) factors do consumers use to assess the sustainability of chicken meat products? How are three sustainability labels (text claims and logos) and prices used by consumers when assessing the sustainability of chicken meat products?

Using an exploratory approach that included both qualitative and quantitative methods to address these research questions, it was found that consumers consider the environmental dimension as the most important to their definition of a 'sustainable food system', followed by the economic, social and cultural pillars. Likewise, the sustainability of chicken meat products was most commonly associated with the environmental impact of chicken meat production. In general, Australian consumers appear to incorrectly interpret many of the production-related sustainability labels on meat products in the market. However, results suggest that consumers' use of production-related credence labels to inform their perceptions/judgements of the sustainability of a meat product is less likely to be limited by their lack of awareness and understanding of the label, and more likely to be limited by the relatively lower importance they place on sustainability in their meat purchase decisions. Overall, the finding that sustainability is of medium importance for consumers is reflected by the myriad of responses and themes mentioned during the interviews by consumers. Many interpreted sustainability as an environmental topic when regarding to chicken meat, but also related it to animal welfare aspects.

To explore consumers' perceptions of different attributes across many protein products (chicken meat being one of them), an analytical chapter was conducted. The following research questions are addressed in **Chapter 3**: What are consumers' perceptions of six key attributes (e.g. health, safety, affordability, eating enjoyability, animal welfare and environmental friendliness) across five different food products, including two 'conventionally raised' meat products (chicken and beef), 'lab-grown chicken', 'lab-grown beef' and 'plant-based protein alternatives'? Which factors (e.g. familiarity with lab-grown meat, perceptions, meat consumption frequency, and/or socio-demographic characteristics) that help predict willingness to consume lab-grown chicken and lab-grown beef?

Empirical results found that relative to conventionally raised chicken and beef and plant-based protein products, lab-grown meat is perceived to be significantly less healthy, affordable, safe and enjoyable to eat. Results indicate that around one-quarter of Australian consumers are willing to consume lab-grown meat (24% lab-grown chicken and 27% lab-grown beef). The MNL models showed a wide range of factors associated with willingness to eat lab-grown meats.

In the empirical models, factors that predicted willingness to consume lab-grown meat products were positive perceptions relative to their healthiness, eating enjoyability, safety and animal friendliness. Familiarity and higher consumption frequency of chicken meat were also significant predictors of willingness to eat lab grown meat. However, for the lab-grown beef model, consumption of other substitute protein products were significant predictors as well. Consumers with tertiary educations, and those who were younger, were more likely to be willing to eat lab-grown meat products. Overall, the current market potential for lab-grown meat appears to be low, however, it may gain market acceptability if marketing campaigns can promote benefits related to eating enjoyability, healthiness, safety and animal friendliness. Interestingly, environmental friendliness was not a significant factor for the models, despite environmental impact being one of the main proposed benefits of lab-grown meat. This result is consistent with the main finding regarding chicken meat and average importance for sustainability found in Chapter 2.

Finally, **Chapter 4** addresses the following research questions: Are Australian consumers willing to consume lab-grown meat? Is there heterogeneity in both consumers' willingness to consume the product and their food choice values? If yes, how do these unique consumer clusters (segments) differ in socio-demographic, behavioural (e.g., food consumption), and psychosocial factors (e.g., familiarity with and beliefs regarding lab-grown meat, and trusted information sources)?

Results from a latent class cluster analysis revealed six unique clusters, of which three (49% of consumers) showed some willingness to consume lab-grown meat when available on the market. One segment, 'Prospective LGM eaters' (12%), appeared 'very willing' to consume lab-grown meat. These consumers were more likely to be younger (<35 years); university-educated; live in metropolitan areas; have greater prior awareness of lab-grown meat; stronger beliefs regarding the potential self- and society-related benefits of growing demand for lab-grown meat; and they had higher trust in diverse information sources.

Overall, there was a low (25%) to medium (49%) rate of acceptability of LGM, depending mainly on how the questions were asked. For instance, for the MNL analyses (Chapter 3), we categorized participants as 'unwilling' if they selected 'No – Definitely not' or 'No – Probably not', 'undecided' if they selected 'Not sure', and 'willing' if they selected 'Yes – Maybe' or 'Yes – Definitely' for each one of the lab-grown products (chicken or beef). While in Chapter 4, three clusters (49% of consumers) indicated some willingness to consume LGM, but they responded to a different question on whether they would be willing to: 'eat LGM occasionally/regularly'. It could be said that this one segment, 'Prospective LGM eaters' (12%), that appeared 'very willing' to consume LGM comprise the group of 'willing' people that responded "Yes-Definitely" in Chapter 3. In fact, when we analysed the characteristics of these consumers, we noticed that they combine many factors associated with the 'willing' group from Chapter 3 and our supported hypotheses. Specifically, they were more likely to be younger (H5); university-educated (H5); and have greater prior awareness of LGM (H3).

Regarding the consumers understanding of sustainable production, we gained insight mainly from two analytical chapters (Chapter 2 and Chapter 4). These chapters showed that consumers usually interpreted sustainability as an environmental topic, but when it relates to meat, they also include other aspects, such as animal welfare and health (Chapter 2). Regarding the future impacts of meeting meat demand with LGM explored in Chapter 4, and it "being

more sustainable", the clusters would vary greatly in their responses (from -0.29 to 1.82 points on a 7-point scale rated from -3 to 3). The difference between the lowest and highest rating correlates with the cluster least willing to consume LGM (LGM-averse: Self-focused) and the most willing (Prospective LGM Eaters).

5.2. Market implications

Overall, the three analytical chapters convey information that help to inform the communication and marketing strategies of stakeholders seeking to increase consumer interest in sustainability and influence consumers' decision to purchase more sustainable protein products. It is clear that products like meats, such as chicken meat, can have different impact in different pillars of sustainability (e.g., environmental) according to their production systems (e.g., free range vs. conventional). Not all animals are raised the same and their impacts are different and, as this thesis showed, some consumers do reflect upon the complex issues related to production systems and the issues involved (Chapter 2),

Consumers also had different perceptions of attributes depending on the meat/protein product they were rating (conventional vs. plant-based vs. lab-grown; Chapter 3), and these results could be useful to both livestock industries and alternative protein industries because they "flesh out" the range of perceptions and even misperceptions regarding some of the attributes presented. For instance, the healthiness perception of conventional beef even though is positive (mean 0.58), it is not significantly different to the plant-based alternatives (0.47). This can be explored and better communicated to the public by the red meat industry, especially in Australia, since a study recently showed that grass-fed beef and plant-based alternatives are not nutritionally interchangeable (van Vliet *et al.*, 2021).

Chapter 4 reinforced that consumers have very different views regarding lab-grown meat meeting the demand for meat on a global level, but only one point of agreement: the potential

negative impact on farmers and fishermen. This result is particularly important from a market point of view, because it shows that consumers (even those willing to eat LGM) also care and think about the consequences to the livelihood of meat producers. In Australia, for example, this relates to social and cultural sustainability pillars investigated in Chapter 2, which were ranked third and fourth most important to consumers' definition of a sustainable food system. While these pillars seemed to have lower importance, when negative consequences to producers were framed in another context, consumers tended to agree.

Findings that emerged from the **Chapter 2** qualitative and quantitative research were translated into recommendations for those involved with the design, use and/or communication of sustainability labels and information related to these labels. For instance, results showed that there is a perception among some consumers that 'doing the right thing' (e.g., more animal friendly or environmentally friendly production practices) might cost more. This could suggest a potential premium for products that carry 'trusted' sustainability labels. Building on recognition and trust could be a good strategy for increasing customer loyalty and profitability. Integrating environmentally sustainable practices into the certification standards underlying existing labels, and/or communicating the environmental benefits associated with existing practices, could help to ensure that practices more closely align with consumer perceptions.

Positive perceptions of environmental impact and animal welfare were most commonly associated with the sustainability of chicken meat products, highlighting that these might be top issues to focus on in communications with respect to the sustainability of meat products. Given animal welfare is market-driven in countries such as Australia, the findings suggest that providing farm animal welfare information at the point-of-purchase could boost appreciation and demand for higher than conventional welfare products. Retailers could help consumers who are concerned about sustainability make more informed chicken meat purchase decisions by simplifying the assessment process at point-of-purchase. Lowering consumers' search costs

for sustainability information could be achieved by providing access to relevant information at the point-of-purchase, such as through a QR code, mobile app and/or on-site promotional materials (Grunert, 2011). For example, previous research has found that a video with narration may be an effective presentation format for conveying such information (Musto *et al.*, 2015).

Chapter 3 provides useful insights for the livestock and alternative protein industries, making available information on how consumers evaluate six attributes for different types of conventionally raised meat and potential substitutes. A wide comparison of product-related attributes can enable different industries to estimate their core strengths and weaknesses regarding competitors, either with the products that are available now or not yet on the shelves. For instance, while conventionally raised chicken meat was perceived as less environmentally friendly compared to plant-based alternatives, it was somewhat surprising that it was perceived to be more environmentally friendly than lab-grown chicken. This is not expected because a lower 'environmental footprint' is being proposed as one of the main benefits of lab-grown meat (Bhat *et al.*, 2019). There has been more frequent criticism of the environmental impact of meat from ruminant animals (e.g., cows and sheep) rather than monogastric (i.e. one stomach) animals (e.g., chicken and pig) (Lynch & Pierrehumbert, 2019; Parodi *et al.*, 2018).

Of the measures of environmental impact, greenhouse gas (GHG) emissions are of particular concern to governments and the general public due to its implications for global warming (Wiedemann *et al.*, 2016). One common measure used in these comparisons of animal-based protein products is the greenhouse gases (GHG) emissions expressed as CO_2 equivalent emissions in kg (CO_2-equivalent). Thus, looking exclusively into this environmental measure and considering how much 1 kilogram (kg) of meat can impact, there are differences among types of meat (beef, pork and poultry) and even across production systems (e.g., conventional vs. free-range) (see Table 5.1). These nuances could be targeted in communication by the industry to consumers so they can make more informed decisions.

Table 5.1. Greenhouse gas (GHG) emissions given by CO_2 equivalent (kg) per 1 kg of meat

		CO_2 equivalent (kg)
Chicken		
Australia (Wiedemann *et al.*, 2012)		
	Conventional production	1.9 to 2.4 (range)
	Free-range production	2.2
	Organic production	2.9
US (Pelletier, 2008)		1.4
Pork		
Australia (Wiedemann *et al.*, 2016)		2.1 to 4.5 (range)
The Netherlands (Groen *et al.*, 2016)		3.5 to 9.5 (range)
Beef		
Australia (Wiedemann *et al.*, 2014)		10.3 to 13.0 (range)
US		
Pasture-finished production (Pelletier *et al.*, 2010)		19.2
Feedlot-finished production (Pelletier *et al.*, 2010)		14.8
Adaptive multi-paddock (AMP) grazing production (Stanley *et al.*, 2018)		- 6.65

Overall, chicken meat seems to have the smallest environmental footprint when considering GHG, and this could be a competitive advantage to the chicken meat industry. Beef production has a higher GHG impact; this is largely due to the methane (CH_4) emissions from cows, with pigs producing relatively less methane and chickens almost none (Fiala, 2008). However, new management systems in beef production have shown some potential benefits through soil carbon sequestration. The Adaptive multi-paddock (AMP) grazing method (Rowntree *et al.*, 2020; Stanley *et al.*, 2018), for instance, was able to offset GHG emissions as shown in Table 5.1. with the negative amount of CO_2-equivalent. Other results from the logistic regressions suggest that in the production and marketing of lab-grown meat the following attributes should be prioritized: eating enjoyment, healthiness, safety and animal friendliness.

Chapter 4's use of segmentation analysis to explore consumer heterogeneity shows not only consumers' socio-demographic characteristics, but also behavioural and psychosocial

factors, which allow the industry to estimate potential demand and to target their marketing strategies to segments which offer the greatest potential for growth. Regarding communication, familiarity with the descriptor (e.g., 'lab-grown meat', 'clean meat', etc.), a straightforward advice would be for lab-grown meat producers and trusted information sources (e.g., CSIRO[9], doctors/medical professionals and consumer organizations) to communicate to the public with their most well-known descriptor, since greater familiarity tends to lead to greater acceptability. Also, improvements in animal welfare, sustainability and environmental impact, were the most commonly perceived potential benefits of meeting consumer demand for meat with lab-grown meat alternatives. In the Australian context, the new industry should give important attention to the statement receiving the highest agreement level: 'have a negative impact on farmers and fishermen', which reflected some concern from the majority of consumers. Our research provides valuable insight on the trustworthiness of 18 different information sources for each consumer segment. Partnerships with the most trusted organizations could be an essential strategy to providing consumers with information that will allow them to make more informed decisions around lab-grown meat.

This chapter also provides useful insights for conventional meat industries, which could use their current access to consumers to communicate the advantages of meat products. For example, the perceived role of lab-grown meat in addressing future food security issues varied with degree of willingness to consume lab-grown meat. The livestock industry could, therefore, emphasize the current importance of animal source foods to the world's food security, such an important factor of sustainable food systems (Adesogan *et al.*, 2019). Additionally, they could clarify misleading messages regarding the 'feed/food debate' (i.e., debate on the amount of feed animals receive to generate human food, and the proportion of this feed that is human-

[9] The CSIRO - Commonwealth Scientific & Industrial Research Organization is a governmental authority commonly cited to be trusted by Australians.

edible), and show evidence about livestock's importance on a global level. Currently, the global livestock industry consumes feed (dry matter) of which 86% is made of materials that are not eaten by humans (Mottet *et al.*, 2017).

5.3. Policy implications

Besides the market implications presented in this chapter, this thesis also provides some general recommendations regarding policies. Many of the implications mentioned in this section could be viewed as part of a 'food system transformation framework' recently developed by Fanzo *et al.* (2021), which is composed by five thematic areas related to (1) diets, nutrition, and health; (2) environment and climate; and (3) livelihoods, poverty, and equity; (4) governance; and (5) resilience and sustainability. This framework can help policy-makers to identify items to be monitored in order to achieve goals.

Findings from **Chapter 2** indicate that consumers consider environmental, economic, social and cultural characteristics in terms of their importance to their definition of a 'sustainable food system'. Therefore, all of these pillars should be considered when designing policies that intend to improve the sustainability of Australian food systems. All pillars, including the new fourth pillar (cultural), appeared to be important to consumers in Australia, where meat production and consumption play important cultural roles. Also, to reach a more sustainable food behaviour, a correct assessment of a sustainability label is essential. Other results from Chapter 2 showed that some labels were more often correctly interpreted than others. Thus, it is important to ensure that there are strategies that clearly communicate the value-add of these labels to avoid misleading and losing trust of consumers. Public resources could focus on helping local businesses to increase their communication of sustainable practices, leading more consumers to potentially buy more sustainable products - theme 1: diets, nutrition, and health.

Findings from **Chapter 3** suggested that consumers have a broad range of perceptions around conventionally raised meat (chicken and beef) and meat alternatives. Some of these perceptions can potentially negatively influence their consumption. For example, negative perceptions around the healthiness of meat could lead to a decrease in meat consumption, regarding beef, even though the majority of consumers believe it is an overall healthy meat (mean 0.58), the range of opinions (standard deviation 1.49) include negative perceptions. This could be harmful to some groups and their health outcomes[10], especially women and children, as they provide essential nutrients that are difficult to obtain in adequate quantities from plant-source foods alone (Murphy & Allen, 2003; Randolph *et al.*, 2007; van Vliet *et al.*, 2021) - theme 1: diets, nutrition, and health. Policy-makers are increasingly focusing on sustainability; therefore, more attention should be paid to these perceptions of livestock products. Animal-sourced foods play a critical role not only in improving nutrition, but in improving livelihoods and increasing food security (Adesogan *et al.*, 2019) - theme 3: livelihoods, poverty, and equity.

Chapter 3 also showed that, when compared to conventionally raised meat and plant-based alternatives, lab-grown meat was perceived negatively by Australian consumers. In particular, consumers perceived lab-grown meat to be less healthy, affordable, safe, and enjoyable to eat. These findings – especially those regarding safety perceptions – are important to inform poly-makers and regulatory agencies in the near future, when they will encounter regulatory demands for lab-grown meat. Up to date, Singapore is the only country that gave regulatory approval for a lab-grown chicken meat product to enter the market. The Singapore Food Agency allowed the lab-grown chicken produced by Eat Just, Inc. to be sold in December 2020 (The Guardian, 2020) – theme 1: diets, nutrition, and health.

[10] Iron deficiency is the most common widespread nutritional deficient in the world. Anaemia may result from a number of causes, with the most significant contributor being iron deficiency (WHO, 2015). Anaemia can be prevented and treated by eating iron-rich foods, which the best sources are red meat (e.g., beef) (WHO, 2015).

The empirical results from **Chapter 4** showed that improvements in animal welfare, sustainability and environmental impact, were the most commonly perceived potential benefits of meeting consumer demand for meat with lab-grown meat; which is consistent with previous research. In Australia, the world's most valuable beef exporter in 2019 (MLA, 2020), such perceptions should be taken into serious consideration by policy-makers, since agriculture is ranked second in GHG by sector (119.64 million tonnes) only after the 'Electricity & Heat' sector – themes (2) environment and climate; and (3) livelihoods, poverty, and equity. There are opportunities to address the GHG of agriculture through improving the sustainability of meat production. Currently, studies have shown that different methods of raising livestock can work as carbon sinks, which means they can sequester more carbon that they emit (Rowntree *et al.*, 2020; Stanley *et al.*, 2018). In beef production, for instance, methods derived from Regenerative Agriculture such as Adaptive multi-paddock (AMP) grazing, Holistic planned grazing (HPG) and Multispecies pasture rotation (MSPR) systems have shown great potential in improving the sustainability of food systems (Rowntree *et al.*, 2020; Stanley *et al.*, 2018).

5.4. Limitations and recommendations for future research

While this study contributes to the existing literature on understanding consumers' perceptions of conventionally farmed meat and alternative protein sources and consumers' willingness to eat lab-grown meat in Australia, it also has some limitations which provide opportunities for future research.

Study limitations from Chapter 2 include conducting the eye-tracking tasks in a lab environment, which may produce different results to a real-life setting. However, the lab environment allowed the researchers to conduct in-depth interviews to better capture nuances in consumers' use, perceptions and understanding of the labels, which may not have been possible in a supermarket setting. Additionally, as the eye-tracking equipment is not mobile, participation was restricted to South Australian residents who were able to physically attend

the appointment at the University. Future studies could bring part of the data collection to a real-life setting, and even compare results from both approaches.

Future research on consumers' willingness to pay for 'sustainable' meat products, specifically, for different aspects of sustainability based on real market data (e.g., environmental and animal welfare concerns) – can provide additional usable insight for producers and marketers. Future studies could also explore new labels that have environmental credentials that are easier for consumers to associate with sustainability. Since our study showed that consumers believe sustainability is related more to the environmental pillar than other pillars of sustainability, future studies could explore new labels that have environmental credentials that are easier for consumers to associate with sustainability. Additionally, future studies could compare consumers' current knowledge and behaviour to their knowledge and behaviour after providing information on different themes (e.g., environmental impact, animal welfare, health). More studies could also test the impact of different information/messaging on personal motivation to purchase more sustainable meat products; and could be extended to other states, besides South Australia.

Limitations regarding the online survey method approach and the difficulty of predicting future behaviour are important to consider in Chapter 3 and Chapter 4. Such limitations, however, could be considered intrinsic to products that are not yet available to consumers, such as lab-grown meats. Social desirability and memory bias are other limitations associated with online survey data collection and specifically, collection of self-reported consumption data (Tourangeau & Yan, 2007). To mitigate these issues, participants' anonymity was assured prior to commencing the survey. Additionally, similarity between our results and population meat consumption patterns (e.g., a high consumption of chicken) adds credence to our findings regarding participants' stated consumption (OECD, 2020). The cross-sectional nature of the survey data used in this thesis allows us to identify potential associations between covariates

and outcome variables but not strong causal inferences. Changes in perceptions and acceptance of lab-grown meat among Australian consumers were also not able to be tracked, but this could be achieved in future studies with suitable panel data.

The descriptions of the products that were provided to respondents in the questionnaire may have influenced their responses to questions designed to measure product perceptions. To reduce potential bias, the product descriptions did not provide information on any alleged benefits or risks of the products. In Chapter 3, our model was limited to exploring associations between willingness to consume LGM and selected individual-related and product-related factors. We acknowledge that other factors that have recently been found to influence LGM acceptance either directly or indirectly, were not considered in the study. They are: perceived naturalness of LGM, food neophobia, food disgust sensitivity and trust in the food industry (Siegrist & Hartmann, 2020). Future studies could include other factors that might be influencing consumers' decisions towards novel foods as LGM, such as knowledge on genetically modified foods, moral and masculinity factors (Fernbach *et al.*, 2019; Rozin *et al.*, 2012; Rozin *et al.*, 1997).

Future research could explore different scenarios in which consumers would be open to experiencing new products, such as LGM (e.g., while dining in a restaurant or eating at a friend's house); as some people may eat a certain product simply because it is being served and/or because of the social setting. As LGM is now commercially available in some markets, future research could explore consumers' actual experience with LGM products (e.g., eating enjoyability), and their willingness to consume again. This information would be helpful for informing the marketing strategies for lab-grown products, if and when they become more widely available.

5.5. Beyond this thesis: Pathways towards more sustainable food systems

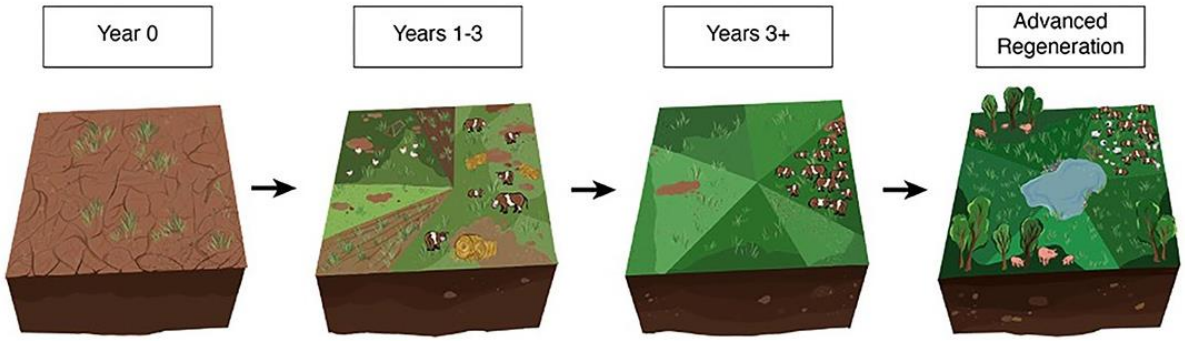
The results of this thesis suggest that consumer demand for conventional meat products is likely to persist in the future. Livestock industries should, therefore, consider ways to reduce their environmental impact by changing their production practices. There are methods of food production that generate less environmental impact and more regeneration, but these are not yet widely implemented (Kronberg *et al.*, 2021; Rowntree *et al.*, 2020; Stanley *et al.*, 2018).

With the climate crisis and the COVID-19 pandemic now posing the greatest challenges to nourishing the expanding global population, our current food systems are fast reaching a breaking point (Gliessman, 2021). Some paths to a possible solution are being identified by people and institutions all over the world (Bruil *et al.*, 2019; Savory Institute, 2021). For example, in a recent report, the Food and Agriculture Organization of the United Nations (FAO) highlighted the role of agroecology in helping shift agri-food systems to a healthier and more sustainable path (Bruil *et al.*, 2019). Agroecology is based on the application of ecological principles for the design and management of sustainable food systems while placing farmers and citizens at the centre of the governance of food (Bruil *et al.*, 2019). The FAO report discussed agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition.

A myriad of terms are used to refer to practices and systems that arguably belong to the domain of agroecology: agroforestry, regenerative agriculture, syntropic agriculture, holistic agriculture, natural agriculture, organic agriculture, permaculture, biological agriculture, among others (Andrade *et al.*, 2020). Agroecology is a big part of the scientific foundation upon which a food systems' transformation can be built (Gliessman, 2021). 'Syntropic agriculture' is an innovative approach to sustainable farming combines scalable food production and forest building. It originated in Brazil and is increasingly being adopted around the world, including in Latin America, Europe and Australia. This type of agriculture

successfully achieves productivity targets, while promoting regeneration of native ecosystems, preventing soil erosion, increasing carbon sequestration, reducing irrigation demand and stimulating soil beneficial micro fauna, which replaces the need for fertilizers and defensives (Andrade *et al.*, 2020). Approaches like this are state-of-the-art multi-trophic production systems, because they include several species of plants integrated into production with vertebrates (e.g., ruminants, pigs, poultry), invertebrates (e.g., insects, earthworms) to utilize wasted feed and recycle nutrients back to the animals (via plants or invertebrates) in the systems (Kronberg *et al.*, 2021).

Other alternative agricultural approaches, such as regenerative agriculture, could also be considered by sustainability-driven market and policy interventions. Regenerative agriculture facilitates climate change adaptation and mitigation, enhances and restores resilient systems and organic soils and is capable of producing a full suite of ecosystem services, among them soil carbon sequestration and water retention (Gosnell *et al.*, 2019). A recent study collected 20-years of data on a farm's production outputs, greenhouse gas (GHG) emissions, soil health outcomes, and land use footprints (Rowntree *et al.*, 2020). Findings showed that implementation of a regenerative system, in this case a holistic planned grazing (HPG), for several years, can dramatically improve protein production, reduce net GHG emissions, and improve soil health indicators, even though it uses considerably more land when compared with conventional methods. This transition, from a degraded cropland into a regenerated land, is shown in Figure 5.1 (Rowntree *et al.*, 2020).



Year 0: Degraded cropland is acquired; **Years 1–3:** Hay is fed to cattle grouped in moderate densities, compost is applied, grass is seeded, and cattle and poultry are grazed at low stock densities; **Years 3+:** Animal stock densities are increased (25 to 50 Mg ha−1 daily), and holistic planned grazing (HPG) is implemented, where animals are rotated often and land is rested between grazing events; **Advanced Regeneration:** Represents a regenerative landscape (no seedings, added hay or compost since year 3) including rotations of diverse animal species with improved soil health and water cycling.

Figure 5.1. The regeneration process employed by White Oak Pastures (Rowntree *et al.*, 2020, p. 4)

As already pointed out in this thesis, food systems, from production to consumption, have an important role to play in achieving the United Nations' SDGs (Adesogan *et al.*, 2019). A innovative food system is needed, one which can deliver food security and nutrition in such a way that the economic, social, environmental and cultural bases to generate food security and nutrition for future generations are not compromised (FAO, 2018). With such complex ecosystems under pressure and an increased burden on natural resources, impacting land, water and biodiversity, approaches like syntropic and regenerative agriculture can be part of these paths.

Here, at the end of this thesis, it is important to shed light on some potential allies in achieving more sustainable food systems. Agroecological approaches have been shown to be important not only in producing high-quality food, but also in helping to regenerate soil while sequestering carbon from the atmosphere. While there is no silver bullet to untangle our many societal challenges, those systems present much hope for the sustainable development path. Food systems' actors could benefit from increasing investments in agroecological

transformations in order to support and accelerate such changes. It is important, though, that future actions are not too narrowly focused on production. Urgent actions are also needed on better communicating sustainable consumption practices to consumers, reducing food waste and developing strategies of governance that improve the efficiency and resilience of the food system (Garnett *et al.*, 2013). Only with this holistic view, it is possible to look at the problems and aim for a truly sustainable food system.

Appendix

Supplementary material for Chapter 2

Interview guide - questions for sustainability choice sets

What comes to mind when you see the word **sustainable** on FOOD or in discussions around food?

How do you usually know if a product is **sustainable or NOT?**

What about CHICKEN MEAT products specifically, what comes to mind when you see the word **sustainable** on chicken meat?

How important to you is **sustainability** when you're buying chicken meat?

→ on a scale where **0=not at all important** and **10= 'extremely' or most important**

Ok, so now let's look at these heatmaps:

Do you think [insert label name] has something to do with the **sustainability** of chicken meat?

What do you think [insert label name] has to do with the **sustainability** of chicken meat?

It looks like you didn't really look at [insert label name], can you think of why that might be?

Can you think of **any other information** that wasn't shown here that you would usually use to help you know or decide if a chicken meat product is **sustainable?**

Sustainability choice sets shown to participants

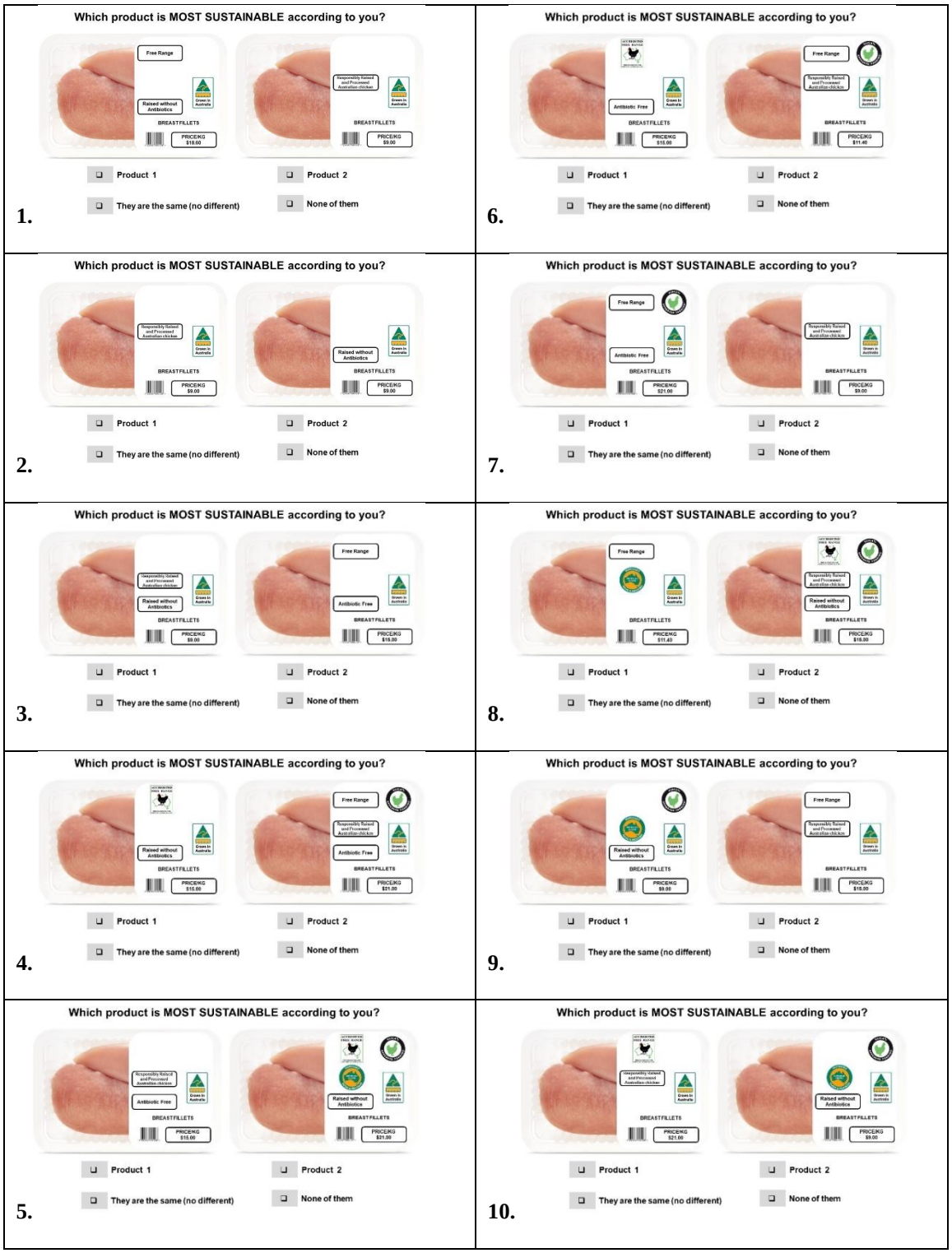


Figure 2.2. Sustainability choice sets shown to participants

Supplementary material for Chapter 3

Tables

Table S3.1. Mean difference in respondents' perceptions of attributes for lab-grown chicken/beef, conventionally raised chicken/beef, and plant-based alternatives (n=1078).

Attribute (-3 to 3 scale)	**Lab-grown chicken vs. Conventionally raised chicken**		**Lab-grown chicken vs. Plant-based alternative**		**Plant-based alternative vs. Conventionally raised chicken**		**Lab-grown beef vs. Conventionally raised beef**		**Lab-grown beef vs. Plant-based alternative**		**Plant-based alternative vs. Conventionally raised beef**	
	Mean difference	**SE**	**Mean difference**	**SE**	**Mean difference**	**SE**	**Mean difference**	**SE**	**Mean difference**	**SE**	**Mean difference**	**SE**
Healthy	-1.59***	0.06	-1.19***	0.06	-0.40***	0.06	-1.35***	0.06	-1.25***	0.05	-0.10*	0.06
Affordable	-1.42***	0.06	-0.65***	0.05	-0.77***	0.05	-0.69***	0.06	-0.72***	0.05	0.03*	0.05
Environmentally friendly	-0.28***	0.07	-0.52***	0.05	0.24***	0.06	0.03*	0.08	-0.55***	0.05	0.58***	0.06
Animal friendly	0.91***	0.08	-0.51***	0.05	1.42***	0.08	0.94***	0.08	-0.54***	0.05	1.49***	0.08
Safe	-1.33***	0.07	-1.25***	0.06	-0.08*	0.06	-1.32***	0.07	-1.23***	0.06	-0.09*	0.06
Enjoyable to eat	-2.08***	0.07	-0.73***	0.06	-1.35**	0.07	-1.97***	0.07	-0.73***	0.06	-1.25***	0.08

*P<0.05, **P<0.01, ***P<0.001

Table S3.2. Respondents' perceptions of attributes for lab-grown chicken across unwilling, undecided and willing groups.

Attribute (-3 to 3 scale)	**Unwilling (n = 535)**		**Undecided (n = 251)**		**Willing (n = 292)**		**Total (n = 1078)**	
Lab-grown chicken	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Healthy	-1.69	1.31	-0.16	1.27	0.58	1.30	-0.72	1.64
Affordable	-1.23	1.53	-0.43	1.28	0.13	1.47	-0.67	1.57
Environmentally friendly	-0.69	1.82	0.14	1.40	0.86	1.45	-0.07	1.76
Animal friendly	-0.04	1.95	0.38	1.50	1.23	1.55	0.40	1.83
Safe	-1.42	1.54	-0.12	1.34	0.62	1.51	-0.56	1.73
Enjoyable to eat	-2.01	1.19	-0.63	1.32	0.43	1.43	-1.03	1.66

Table S3.3. Respondents' perceptions of attributes for lab-grown beef across unwilling, undecided and willing groups.

Attribute (-3 to 3 scale)	**Unwilling (n = 530)**		**Undecided (n = 286)**		**Willing (n = 262)**		**Total (n = 1078)**	
Lab-grown beef	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Healthy	-1.70	1.29	-0.23	1.28	0.50	1.28	-0.77	1.60
Affordable	-1.27	1.53	-0.42	1.29	0.00	1.41	-0.74	1.54
Environmentally friendly	-0.74	1.80	0.17	1.42	0.92	1.45	-0.10	1.76
Animal friendly	-0.03	1.97	0.30	1.55	1.26	1.50	0.37	1.83
Safe	-1.40	1.53	-0.13	1.36	0.73	1.40	-0.54	1.71
Enjoyable to eat	-1.98	1.22	-0.60	1.36	0.45	1.46	-1.02	1.67

Survey questionnaire

Questions used for Chapter 3 and Chapter 4:

THE CENTRE FOR GLOBAL FOOD AND RESOURCES | THE UNIVERSITY of ADELAIDE

Thank you for participating in this survey.

Please take as much time as you need to answer the questions. The survey is likely to require 20 minutes to complete.

This study, titled: '*Understanding drivers of changing food consumption behaviour in Australia'*, is being conducted by the University of Adelaide's Centre for Global Food and Resources.

This study has been reviewed by the University of Adelaide Human Research Ethics Committee (approval number H-2016-156).

This nationwide study explores the food choices and views of Australians. Your participation in this research will help us better understand the driving factors in Australian consumers' food preferences.

Most questions only require you to check a box. A few questions ask you to type in a response. **All of your answers to the questions are strictly anonymous.** Your individual survey responses will remain confidential and no personally identified survey responses will be released to the researchers involved in this study.

No one will contact you after the survey, and no sales solicitation is involved. Your answers will be used for research purposes only. There are no foreseeable risks associated with taking part in this study. The records will be kept in a secure facility at the University of Adelaide for at least 5 years.

The results of this study may be published in the form of a journal articles, online blog posts, and conference presentations.

Please answer the questions honestly and take appropriate time to read and understand the questions so that you can give thoughtful responses.

If you have any questions, concerns or complaints, please feel free to contact:

Professor Wendy Umberger: wendy.umberger@adelaide.edu.au or (08) 8313 7263
Dr Lenka Malek: lenka.malek@adelaide.edu.au or (08) 8313 9137

If you wish to contact someone independent of the project please contact the Human Research Ethics Committee's Secretariat by email hrec@adelaide.edu.au or phone (08) 8313 6028.

Again, participation is completely voluntary. You are free to withdraw from the study at any time before submitting the survey without any explanation. Once submitted, you will be unable

to withdraw the survey information as this survey is anonymous and we will not be able to identify the information you provided as yours.

By clicking the "Yes" button below, you are indicating that you have read and understood the above information and consent to participating in this study.

Please select one answer.

- ❑ Yes
- ❑ No [TERMINATE]

PLEASE NOTE: INSTRUCTIONS FOR PROGRAMMERS ARE HIGHLIGHTED IN YELLOW

[PLEASE USE SIZE 12 FONT THROUGHOUT SURVEY]

Screener and sample quota questions

1. Which of the following categories best describes your role in **food shopping** for your **household**?
   - ❑ I do the majority of the food shopping
   - ❑ I share the food shopping
   - ❑ Someone else does the majority of food shopping for my household [SCREEN OUT]

2. What is your gender? [Only one response allowed]
   - ❑ Male
   - ❑ Female
   - ❑ X (Indeterminate/Intersex/Unspecified)

3. What is your age (in years) ____ [ENTER NUMBER IN TEXT BOX; Minimum age =18 and Max=99]

4. Where do you live?
   - ❑ Sydney metro
   - ❑ NSW other
   - ❑ Melbourne Metro
   - ❑ VIC other
   - ❑ Brisbane Metro
   - ❑ QLD other
   - ❑ Perth Metro
   - ❑ WA other
   - ❑ Adelaide Metro
   - ❑ SA Other

- ❑ Hobart Metro
- ❑ TAS other
- ❑ Canberra Metro
- ❑ ACT other
- ❑ Darwin Metro
- ❑ NT other

5. What is your postcode? [INSERT TEXT BOX]

Personal food consumption behaviour

These questions ask about your own PERSONAL food consumption behaviour and preferences

Q.4. Considering the last 12 months (1 year), how often did YOU eat the following foods, on average?

Select one option in each column

	Beef (fresh or processed including sausages)	**Chicken** (fresh or processed including sausages)	**Pork** (fresh or processed including sausages)	**Lamb** (fresh or processed including sausages)	**Kangaroo** (fresh or processed including sausages)	**Other meat** (e.g., veal, rabbit, goat, turkey, duck)	**Fish** (tinned, fresh or frozen) (e.g., salmon, tuna, barramundi, hoki, dory)	**Seafood** (tinned, fresh or frozen) (e.g., prawns, calamari, mussels, scallops, crab)
Every day	☐	☐	☐	☐	☐	☐	☐	☐
6 days per week	☐	☐	☐	☐	☐	☐	☐	☐
5 days per week	☐	☐	☐	☐	☐	☐	☐	☐
4 days per week	☐	☐	☐	☐	☐	☐	☐	☐
3 days per week	☐	☐	☐	☐	☐	☐	☐	☐
2 days per week	☐	☐	☐	☐	☐	☐	☐	☐
1 day per week	☐	☐	☐	☐	☐	☐	☐	☐
1 - 3 times per month	☐	☐	☐	☐	☐	☐	☐	☐
Less than once per month	☐	☐	☐	☐	☐	☐	☐	☐
Never	☐	☐	☐	☐	☐	☐	☐	☐

[RANDOMISE COLUMN ORDER BETWEEN RESPONDENTS BUT ONLY SHOW ‘OTHER MEAT’ COLUMN AFTER SHOWING FIRST 5 COLUMNS]

Q.5. Considering the last 12 months (1 year), how often did you eat the following foods, on average?
Select one option in each column

	Eggs	**Dairy products (milk, cheese, yogurt)**	**Plant-based dairy products** (e.g., made from soy, almond, oat, rice, macadamia)	**Legumes (beans, peas and lentils)** (e.g., baked beans, three bean mix, lentils, split peas, chickpeas, dried beans and other types of beans)	**Plant-based meat/protein alternatives** (e.g., tofu, tempeh, seitan, Quorn, veggie/bean burgers, 'Beyond Burger', 'Minced' 100% plant-based)	**Nuts and seeds** Including whole nuts and nut butters and all seeds (e.g., chia, flax/linseed, pumpkin and sunflower seeds)	**Edible insects (e.g., crickets, grass hoppers, witchetty grubs)** Whole or powder form (e.g., protein powder, energy bars, flour, cooked in meals, etc.)	**Ready meals (chilled or frozen)**
Every day	□	□	□	□	□	□	□	□
6 days per week	□	□	□	□	□	□	□	□
5 days per week	□	□	□	□	□	□	□	□
4 days per week	□	□	□	□	□	□	□	□
3 days per week	□	□	□	□	□	□	□	□
2 days per week	□	□	□	□	□	□	□	□
1 day per week	□	□	□	□	□	□	□	□
1 - 3 times per month	□	□	□	□	□	□	□	□
Less than once per month	□	□	□	□	□	□	□	□
Never	□	□	□	□	□	□	□	□

[RANDOMISE COLUMN ORDER BETWEEN RESPONDENT]

Q.6. Which of the following best describes your **current** food preferences?
Select one option only

- ❑ Omnivore: I eat most animal products including meat, fish, seafood and/or dairy
- ❑ Semi-Vegetarian/Flexitarian: I am cutting back on meat but not avoiding it completely
- ❑ Full-time Vegetarian: I do not eat meat but am still eating other animal products
  [If selected, show below options (must select at least one of the four options to proceed- can select multiple options but only if 'none of the above' is not selected)]
  - o I eat fish/seafood
  - o I eat dairy
  - o I eat eggs
  - o I don't eat any of the above
- ❑ Vegan: I do not eat any animal products

Q.11. Below are 15 characteristics of food. Select up to 5 characteristics that are **MOST IMPORTANT** to you when you are **grocery shopping for food?**

Food choice value	Description given	Adapted from Lusk and Briggeman (2009)	Adapted from Grunert et al. (2004, p. 269)
Appearance	Extent to which the food looks appealing and appetizing	**Appearance** / Extent to which food looks appealing	
Impact on animals	Extent to which animals used in food production are healthy, comfortable, well nourished, safe, able to express innate behaviour, and are not suffering from unpleasant states such as pain, fear and distress		**Interest in animal welfare**
Taste	The flavour of the food in your mouth	**Taste /** Extent to which consumption of the food is appealing to the senses	
Food Safety	Eating the food will not cause illness	**Safety** / Extent to which consumption of food will not cause illness	
Novelty	The food is something new you haven't tried before	*Included for completeness*	
Country of origin	Where the food was grown, made or packed	**Origin /** Where the agricultural commodities were grown	
Health and nutrition	Amount and type of fat, sugar, salt, protein, vitamins, minerals etc.	**Nutrition /** Amount and type of fat, protein, vitamins, etc.	
Environmental Impact	Effects of food production on the environment	**Environmental Impact /** Effect of food production on the environment	
Price	Price that you pay	**Price /** The price that is paid for the food	
Fairness/fair trade	Farmers, processors, retailers and consumers equally benefit	**Fairness /** The extent to which all parties involved in the production of the food equally benefit	
Convenience	How easy and quick the food is to buy, cook and eat	**Convenience /** Ease with which food is cooked and/or consumed	
Naturalness	No artificial colours, flavours or preservatives	**Naturalness** / Extent to which food is produced without modern technologies	
Familiarity	The food is well-known to you	**Tradition /** Preserving traditional consumption patterns	
How the food was produced (e.g., Organic, Free Range, etc.)	The methods used to grow the plants and raise the animals that are used to produce food (e.g., GMO, organic, use of chemicals/pesticides)		**Interest in organic production; Interest in products manufactured in a 'natural' way** (i.e. without the use of advanced technology)
Food tolerance/restrictions	The food fits my dietary restrictions (e.g., gluten free, lactose free, other allergies/intolerance)	*Included for completeness*	

Note: Only the first two columns were shown to participants. Third and fourth columns are included in order to show original terms and descriptions from previous studies.

[RANDOMISE ORDER OF ITEMS BETWEEN RESPONDENTS]

References from the table:

Grunert, K. G., Bredahl, L., & Brunsø, K. (2004). Consumer perception of meat quality and implications for product development in the meat sector—a review. *Meat Science, 66*(2), 259-272. doi:https://doi.org/10.1016/S0309-1740(03)00130-X

Lusk, J. L., & Briggeman, B. C. (2009). Food values. *American Journal of Agricultural Economics, 91*(1), 184-196.

[SHOW THE ITEMS SELECTED IN Q11 ON NEW SCREEN WITH Q11b]

11.b. Please allocate 100 points among the characteristics based on the importance each has on your purchase decision when grocery shopping for food. [ONLY SHOW ITEMS SELECTED IN Q11A, IF ONLY ONE ITEM SELECTED IN Q11 THEN SKIP AND AUTOCODE Q11B]

Please enter a number in the corresponding box or indicate the proportion on the slider scale

11.c. Are there any **OTHER** characteristics of food (not listed) that are important to you when grocery shopping for food?

- ❑ No
- ❑ Yes (please specify) [INSERT TEXT BOX]

Food safety

These next questions ask about your views and experiences around food safety

Q.19. Are you generally a person who is fully prepared to take food safety risks or do you try to avoid taking food safety risks?

Please tick a box on the scale, where the value 0 means: 'unwilling to take risks' and the value 10 means: 'fully prepared to take risk'.

0 Unwilling to take any risks	1	2	3	4	5	6	7	8	9	10 Fully prepared to take risks

Information sources

In the next two questions we want to find out what information sources you trust

Q.20. How much do you **TRUST** the following people/organisations to provide accurate information about **FOOD SAFETY?**

	Do not trust at all 1	**2**	**3**	**Neutral 4**	**5**	**6**	**Trust completely 7**
Farmers (e.g. an individual farmer)							
Farmer Associations (e.g. Cattle Council Australia, Australian Eggs, Grain Producers Australia)							
Food Processors (e.g. dairy, meat or grain processor)							
Food Industry Associations (e.g. Australian Food and Grocery Council, Dairy Industry Association of Australia)							
Supermarkets (e.g. Coles, IGA, Woolworths, Aldi)							
Independent or local food stores (e.g. butcher, bakery, fruit and vegetable shop)							
Universities							
CSIRO- Commonwealth Scientific & Industrial Research Organization							
Other research organisation							
Government/government agencies (e.g. FSANZ-Food Standards Australia New Zealand)							
Consumer organisation (e.g. Choice)							
Environmental organisation (e.g., Landcare, World Wide Fund for Nature (WWF), etc.)							
Animal rights organisation (e.g., RSPCA)							
Animal protection organisation (e.g., Voiceless, Animals Australia)							
Doctors/medical professionals							
Dietitians and nutritionists							
Celebrity chefs							
Family/Friends/Work colleagues							

[PLEASE RANDOMISE ORDER OF ROWS BETWEEN RESPONDENTS AND KEEP SAME ORDER FOR NEXT Q; IF POSSIBLE PLEASE ALWAYS SHOW YELLOW HIGHLIGHTED ITEMS IN SAME ORDER]

The next questions ask about your awareness and views of new food products and food production methods

Q.27. Which of the following statements best matches your awareness of each PRODUCT or TERM?

Select one option only

	Lab-grown meat	In-vitro meat	Cultured meat	Artificial meat	Synthetic meat	Clean meat	Cellular agriculture
Have NOT heard of it							
Have heard of it, but know very little or nothing about it							
Know enough about it that I could explain it to a friend							

[SHOW COLUMNS ONE AT A TIME] [RANDOMISE COLUMN ORDE BUT NOT ROW ORDER]

[BELOW INTRO ON SEPARATE SCREEN]

Thank you for completing the survey this far.

We are now going to introduce some terms to you. Please CAREFULLY read the next 3 screens because these terms will be used in the next questions.

[INTRO ON SEPARATE SCREEN]

Foods produced using TRADITIONAL LIVESTOCK FARMING SYSTEMS AND FISHING METHODS include:

- beef, lamb, chicken, pork, kangaroo, other meat (e.g., veal, rabbit, goat)
- dairy
- eggs
- fish and seafood

***Please note: Livestock** are domesticated animals raised in an agricultural setting to produce food such as meat, eggs and milk.*

[INTRO ON SEPARATE SCREEN]

PLANT-BASED food products are **made from:**

- beans, peas, lentils
- grains and/or
- nuts

E.g., tofu, tempeh, seitan, Quorn, veggie/bean burgers, 'Beyond Burger', 'Minced' 100% plant-based, soy/almond/oat/macadamia milk

[INTRO ON SEPARATE SCREEN]

The term **'LAB-GROWN'** refers to products created by the new process of extracting cells from animals without causing suffering to the animals and then growing the cells in a controlled cell culture condition.

In August 2013, scientists unveiled (and tasted) the world's first lab-grown hamburger patty. There are companies in the US, Europe and Israel creating meat and even dairy products in the laboratory. Currently they are not commercially available, though research is being conducted to introduce lab-grown food products in the near future, possibly by 2019.

Q.28

[VERSION 1 OF Q28: SHOW IF SELECTED OPTION 1 OR 2 IN Q6]

In this question we want to find out how your consumption of meat products (*produced using traditional livestock farming systems*) might change in the near future, when **lab-grown** meat becomes available.

Please indicate your willingness to do the following.

[VERSION 2 OF Q28: SHOW IF SELECTED OPTION 3 OR 4 IN Q6]

Please indicate your willingness to do the following **in the future, when lab-grown meat is available:**

Select one answer from the options below.

	Not at all willing to do this	Somewhat unwilling	Neither willing nor unwilling	Somewhat willing	Very willing to do this
Replace SOME of the meat in my diet with **lab-grown** meat [ONLY SHOW IF SELECTED OPTION 1 OR 2 IN Q6]					
Replace ALL meat in my diet with **lab-grown** meat [ONLY SHOW IF SELECTED OPTION 1 OR 2 IN Q6]					
Eat meat products (*produced using traditional livestock farming systems*) **more often** than I am **currently** [ONLY SHOW IF SELECTED OPTION 1 OR 2 IN Q6]					
Eat **lab-grown** meat **occasionally** [SHOW TO ALL RESPONDENTS]					
Eat **lab-grown** meat **regularly** [SHOW TO ALL RESPONDENTS]					

Q.29. Which of the following foods would you be willing to eat if they were produced using the **lab-grown** method?
Select one answer from the options below

	No – Definitely not	No – Probably not	Not sure	Yes – Maybe	Yes – Definitely
Beef					
Chicken					
Pork					
Lamb					
Kangaroo meat					
Horse meat					
Dog meat					

	No – Definitely not	No – Probably not	Not sure	Yes – Maybe	Yes – Definitely
Cat meat					
Duck foie gras (fatty liver)					
Other meat (e.g., veal, rabbit, goat, turkey, duck)					
Fish					
Seafood					
Eggs					
Milk					
Cheese					
Yogurt					

[DO NOT RANDOMISE ITEM ORDER BETWEEN RESPONDENTS]

Q.30. If **meat produced using traditional livestock farming systems** cost $10/kg, what is the **MOST** that you would be willing to pay per kg for **LAB-GROWN meat**?

$ [INSERT A TEXT BOX, possible number range from 0.00 to 100.00]

Q.33. In your opinion, **how [HEALTHY/ AFFORDABLE/ ENVIRONMENTALLY FRIENDLY/ ANIMAL FRIENDLY/ SAFE/ ENJOYABLE TO EAT]** do you think each of the following food options are/would be?

Please drag with your mouse/finger each box and place it on the scale below.

[PLEASE ASK THIS Q SEPARATELY FOR EACH CHARACTERISTIC HIGHLIGHTED IN YELLOW]

[DRAG AND DROP FORMAT PLEASE]

Beef	**Lamb**	**Chicken**	**Pork**	**Kangaroo meat**	**Other meat** (e.g., veal, rabbit, goat)	**Fish** (e.g., salmon, tuna, barramundi, hoki, dory)	**Seafood** (e.g., prawns, calamari, mussels, scallops, crab)	**Dairy products** (produced using traditional livestock farming systems)	**PLANT-BASED dairy products** (e.g., soy, almond, oat, rice and macadamia milk)	**PLANT-BASED meat/protein alternatives** (e.g., tofu, tempeh, seitan, Quorn, veggie/bean burgers, 'Beyond Burger', 'Minced' 100% plant-based)	**LAB-GROWN beef and lamb**	**LAB-GROWN chicken**	**LAB-GROWN pork**	**LAB-GROWN dairy products**

NOT HEALTHY						**VERY HEALTHY**
NOT AFFORDABLE						**VERY AFFORDABLE**
NOT ENVIRONMENTALLY FRIENDLY						**VERY ENVIRONMENTALLY FRIENDLY**
NOT ANIMAL FRIENDLY						**VERY ANIMAL FRIENDLY**
NOT SAFE						**VERY SAFE**
NOT ENJOYABLE TO EAT						**VERY ENJOYABLE TO EAT**

Q.35. On a global level, to what extent do you agree that **meeting demand for meat** using **LAB-GROWN meat** instead of **meat produced using traditional livestock farming systems** would:

Select one answer from the options below

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	**Strongly agree**
Have less negative environmental impact							
Have more negative environmental impact							
Reduce the human contribution to climate change							
Improve animal welfare conditions							
Be more beneficial for human health							
Be more ethical							
Be able to solve world famine (food security) problems							
Be more sustainable							
Have a negative impact on farmers and fishermen							
Be a realistic alternative to farmed meat							
Be a short-term solution							
Be a long-term solution							

[RANDOMISE ITEM ORDER BETWEEN RESPONDENTS]

Final participant characteristics

Now some final questions about you and your household

Q.49. How many people are living in your household (including yourself)?
_____ [VALID RANGE= 1-15]

Q.50. How many of them are **children under 18 years**? _____ [VALID RANGE= 0-14; NUMBER ENTERED MUST BE LESS THAN NUMBER ENTERED IN Q49]

[SHOW Q51 ONLY IF Q50>0, OTHERWISE GO TO Q52A]

Q.51. Please indicate the **age categories of your children** living at home.
Tick all that apply.

- ❑ Less than 1 year old
- ❑ 1-2 years old
- ❑ 3-4 years old
- ❑ 5-7 years old
- ❑ 8-11 years old
- ❑ 12-14 years old
- ❑ 15-17 years old

[NUMBER OF OPTIONS SELECTED CANNOT BE GREATER THAN NUMBER ENTERED IN Q50]

Q.52. Please indicate if you have any of the following PETS living in your home.
Select all that apply [ALLOW MULTIPLE CHOICES UNLESS FIRST ITEM IS SELECTED]

- ❑ I don´t have pets
- ❑ Dog
- ❑ Cat
- ❑ Bird
- ❑ Fish
- ❑ Rabbit
- ❑ Chicken
- ❑ Horse
- ❑ Rabbit
- ❑ Other species (please specify) [INSERT TEXT BOX]

Q.53.a. What is the highest level of education you have <u>completed</u>? [ONLY 1 OPTION CAN BE SELECTED]

- ❑ Below Year 10
- ❑ Year 10
- ❑ Year 11
- ❑ Year 12

- ❑ Certificate (III or IV)
- ❑ Diploma Level or Advanced Diploma
- ❑ Bachelor Degree
- ❑ Graduate Certificate or Graduate Diploma
- ❑ Postgraduate Degree (Masters or PhD)

Q.54. Currently I am... (choose the option that best describes you) [ONLY 1 OPTION CAN BE SELECTED]

- ❑ Working full-time
- ❑ Working part-time
- ❑ Both working and studying
- ❑ A full time student (and not working)
- ❑ A part time student (and not working)
- ❑ Retired
- ❑ Engaged in full time home duties
- ❑ Not in paid work but looking
- ❑ On a pension (other than age pension)

Q.55. Which one of the following categories best describes your **annual total household income (before tax)?** [ONLY 1 OPTION CAN BE SELECTED]

- ❑ Below $25,000
- ❑ $25,001 - $35,000
- ❑ $35,001 - $45,000
- ❑ $45,001 - $55,000
- ❑ $55,001 - $65,000
- ❑ $65,001 - $75,000
- ❑ $75,001 - $85,000
- ❑ $85,001 - $105,000
- ❑ $105,001- $115,000
- ❑ $115,001- $125,000
- ❑ $125,001 - $145,000
- ❑ $145,001 - $165,000
- ❑ $165,001 - $185,000
- ❑ $185,001 - $205,000
- ❑ $205,001 - $225,000
- ❑ $225,001 - $245,000
- ❑ $245,001 - $265,000
- ❑ $265,001 - $285,000
- ❑ Over $285,000

Thank you for completing this survey!

We would welcome any comments you have about this survey or additional information you would like to provide.

Please provide your comments in the space below:

If you have any questions, concerns or complaints, please feel free to contact:

Professor Wendy Umberger: wendy.umberger@adelaide.edu.au or (08) 8313 7263
Dr Lenka Malek: lenka.malek@adelaide.edu.au or (08) 8313 9137

If you wish to contact someone independent of the project please contact the Human Research Ethics Committee's Secretariat by email hrec@adelaide.edu.au or phone (08) 8313 6028.

For information on **HEALTHY EATING**
https://www.eatforhealth.gov.au/guidelines/australian-guide-healthy-eating]

For information on **FOOD SAFETY**
http://www.foodstandards.gov.au/Pages/default.aspx

Supplementary material for Chapter 4

Table S4.1. Summary of empirical clusters' results and potential strategies for the industry

Cluster	Characterising aspects	Potential target strategies for the industry
Cluster 1 *22%* LGM-averse: Self-focused	They are on the far spectrum of lab-grown meat (LGM) aversion. A higher share is retired and live outside metropolitan areas. Around 29% of the group have a university degree. They are more aware of the term 'artificial meat', despite having an overall low awareness of the terms in general.	The majority of the cluster comprises omnivores, with low consumption frequency of kangaroo, other meats and plant-based meat alternatives. They tend to be in strong disagreement with statements regarding alleged positives aspects of LGM. This cluster does not trust several information sources, and among the other clusters, trust animals' rights organizations the least. Therefore, communication that does not emphasise the potential animal welfare benefits of LGM could be more welcomed by this cluster and could help with increasing acceptance in the future.
Cluster 2 *14%* LGM-averse: Health & society-focused	C2 are strongly averse to the idea of eating LGM. Females make up 63% of the cluster. They are older with a higher proportion of retirees (31%) and only 13 have young children in the household. They are highly motivated by health and naturalness. 'artificial meat' is the term they are most familiar with.	This group comprises 63% omnivores and 12% vegetarians. There is a high consumption frequency of nuts and seeds. Most consumers believe that LGM would have a negative impact, even for the environment, and especially for human health - the food choice value they consider the most. In addition, they agree there is potential for a negative impact on farmers and fishermen. Further, when it comes to food safety information, they place more trust in farmers than they do in the government or universities. The LGM industry could build consumer confidence of the safety of LGM through collaborative partnerships with trusted sources, with the CSIRO (government science agency) and doctors most trusted.
Cluster 3 *15%* Somewhat Unwilling: Safety focused	Consumers from this cluster tend to avoid LGM as well. Females make up 64% of this cluster. For the rest of the socio-demographics they represent the 'mid-point' of the sample, with proportions very similar to the overall sample. They have similar awareness of LGM's terms to the average sample.	This cluster comprises 81% of omnivores and only 1% of vegetarians. Their consumption frequency of most foods matches the average of the overall sample. As they do not have a particularly high consumption frequency of any one particular product, a distribution channel strategy does not seem appropriate. On the other hand, a focus on the trustworthy food safety organizations would be more suitable, since food safety was the most important food choice value in this cluster. They trust the government and its agencies (e.g., FSANZ - Food Standards Australia New Zealand) more than consumer organizations (e.g., Choice). Therefore, consideration of LGM products in food standards and/or awareness that LGM products meet food safety regulations could increase acceptance of LGM in this cluster
Cluster 4 *21%* Somewhat willing: Self-focused	The second largest cluster demonstrates certain willingness to consume LGM. Males and females are equally represented (52% and 48%). Most of the consumers are in one aged category (41% aged 35-54 years) and only 15% of the group are retired. Consumers are mostly unaware of the terms, with only a few very aware of terms like 'lab-grown meat' (5%) and 'clean meat' (6%).	Consumers in this cluster are meat eaters only, with 85% omnivores and 14% flexitarians. Their consumption of plant-based meat and dairy alternatives is low, which might suggest that a focus on the 'meatiness' of LGM could entice these consumers. They tend to agree that LGM would be beneficial to human health. These aspects could be advantages and would probably mean that LGM would be well accepted - if the price and taste are acceptable. Consumers tend to trust government and its agencies and consumer organizations equally.

Table A4 continues.

Continued Table A4.

Cluster 5 *16%* Somewhat willing: Society-focused	This cluster also demonstrates some willingness to consume LGM. Consumers tend to be younger, and females make up 48% of the cluster. One quarter have children under the age of 12 years in the household. They are more aware of the terms and felt that they could convey what lab-grown meat (10%) and clean meat (11%) is to a friend.	Flexitarians consumers make up 27% of this cluster and omnivores 66%. The consumption frequency of meats (conventional and less conventional meat – such as kangaroo) is quite high - higher than C2 'LGM-averse / Health & society-focused' cluster for almost all types of meat. Consumption of plant-based meat alternatives is also high. Consumers in this cluster believe that LGM has the potential to improve animal welfare, which, given their high meat consumption frequency, could suggest that they are 'reluctant omnivores' (concerned about animal welfare issues but not enough to cease meat consumption). Emphasising the animal welfare benefits of LGM could, therefore, be a possible strategy for the industry. Communication strategies focusing on environmental and animal welfare benefits might be highly effective for this cluster. Their trust levels show that apart from the three top ranked information sources, they place the same level of trust in the food industry and environmental organizations. Therefore, partnerships with both might also be worth exploring.
Cluster 6 *12%* Prospective LGM Eaters	Although being the smallest cluster, these consumers have the highest intention to consume LGM and will likely be the early adopters when the product enters the market. The majority of consumers in this cluster are younger (aged ≤34 years). Males make up 74% of the cluster and 57% have a university degree. In general, they seem to have less budget constraints, and children under 12 years are present in 37% of their households. They have the highest awareness of all LGM terms, for instance, they are well aware of 'lab-grown meat' (44%) and convinced they could explain what it is to a friend (33%).	This cluster has 71% of omnivores and 26% of flexitarians. They have a high consumption frequency of traditional meat (beef, chicken, pork and lamb), and less conventional meats - well above other clusters. Given their high consumption of chicken, for instance, the livestock industry should pay special attention to this cluster, since a shift in demand from this group could mean a loss of market. For example, given the high value placed on convenience and high consumption frequency of ready-meals in this cluster, there could be a reduction in sale of high-value or ready-to-eat chicken products. Additionally, given this cluster has the highest consumption of plant-based meat and ready meals, similar distribution channels will likely be effective for LGM. LGM perceptions were very positive in this cluster. An important characteristic of this cluster is the high level of trust placed in most information. This characteristic is an advantage for all new communication regarding food safety of the product, since most of the organizations and people are trusted.

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