



**12 December 2024**  
**321-24**

## **Supporting document 3**

**University of Adelaide consumer literature review –  
Application A1269**

Cultured quail as a novel food

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# CONSUMERS' UNDERSTANDING, ACCEPTANCE AND BEHAVIOURS IN RESPONSE TO CELL-BASED MEAT

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A SYSTEMATIC REVIEW

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The University of Adelaide, December 2023



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## Executive Summary

To ensure that the Food Regulation System in Australia and New Zealand (NZ) is equipped to support informed decision-making by consumers regarding cell-based proteins, a greater understanding of consumers' awareness, acceptance, and behaviours in response to cell-based proteins is needed. The aim of this literature review was to assess **consumers' understanding, acceptance, and behaviours** in response to **cell-based proteins (including meat, seafood and dairy)** using a **systematic review** approach. The review was limited to studies that were conducted in English-speaking countries and published since 2012. A **total of 43 studies** met the inclusion criteria and were included in the review. All studies investigated cell-based meat (CBM), which was considered to include meat and/or seafood – most studies investigated meat, four investigated seafood, and none investigated dairy. Both qualitative and quantitative studies were included. Three studies were conducted in Australia and three in NZ, but most were conducted in the US.

The included studies examined a range of outcomes of interest including consumers' awareness of CBM; perceived benefits and risks of CBM; perceived general health and nutritional quality of CBM in comparison to conventional meat; willingness and motivators and barriers for consuming CBM; preferred and best-understood terms for differentiating CBM from conventional meat; and preferred labelling requirements. **Key findings** are presented below.

### **Consumers' awareness and knowledge of the manufacturing process and end product of CBM**

- Evidence from seven studies of mostly moderate quality, indicates **wide variation** in the proportion of consumers **aware** of specific CBM **terms** or the **concept** of CBM, ranging between **18%** and **66%**.
- Evidence from eight studies of mostly moderate or low quality, indicates **low familiarity** with CBM among consumers. Only **0-17%** of consumers feel they are **familiar or very familiar** with CBM; **8-41%** feel they are **moderately familiar**; and **50-88%** report **no or low familiarity**.
- Additionally, based on evidence from five studies of mostly moderate quality, only **5-21%** of consumers consider themselves **very knowledgeable** about CBM.
- No studies assessed consumers' objective knowledge of CBM with respect to the manufacturing process or end product.

### **Consumers' perceived benefits and risks of CBM**

#### **Perceived Benefits**

- Evidence from 11 studies of mostly moderate or low quality, indicates consumers, on average, have **neutral** views regarding personal and societal benefits of CBM. This means that they don't have a particularly strong view, likely because they feel uncertain about the benefits. However, **views varied widely among consumers**.
- Consumers, on average, are neutral/**uncertain** about the personal benefits of CBM. However, a **range of personal benefits may be perceived** by some consumers, including benefits related to health, safety, nutrition, product quality, price, taste and naturalness.

- Likewise, consumers, on average, are neutral/uncertain about the societal benefits of CBM, including benefits for the **environment, animal welfare, and future populations/food security**; however, **views can vary widely** between consumers. Consumers' perceived benefits for animals were related to the treatment of animals and/or the absence of slaughtering, however, some consumers highlighted that the same outcomes could be achieved by reducing current levels of meat consumption; further, global societal benefits were only perceived as benefits if there are no risks to human health.

### Perceived Risks

- Evidence from 18 studies of moderate and low quality, indicates consumers, on average, perceive **moderate** risks associated with consumption of CBM. These risks mainly relate to food safety, personal health, environmental and other societal risks. The two main factors underlying health concerns are **perceived unnaturalness/high level of processing** of CBM and **uncertainty regarding the current scientific understanding** of CBM. Societal risks perceived by some consumers include risks to the environment, economy, and farmers; and ethical concerns related to the use of animals, moral issues and/or genetic alteration, and suspecting hidden agendas/potential for a lack of transparency.

### Perceived health and nutritional equivalence of CBM with traditional counterparts

- Perceptions regarding the healthiness and nutritional quality of CBM compared to traditional meat were mixed. Evidence from nine studies of moderate or low quality, suggests CBM is perceived as equivalent to conventional meat in terms of healthiness and nutritional quality whereas lower quality studies tend to suggest that CBM is perceived as less healthy or nutritious. Gen Z is more likely to view CBM as comparable to conventional meat. Concerns regarding overall healthiness and nutritional quality of CBM exist based on the limited evidence available. However, it is challenging to provide a definitive conclusion given that consumers were often primed with positive information about CBM in studies.

### Consumers' willingness to consume CBM and incorporate it into their diet

- Evidence from 20 studies of mostly moderate quality, indicates consumers are either unsure or somewhat willing to consume CBM as a partial replacement for traditional proteins.

### Willingness to consume ('eat', 'taste' or 'try') CBM

- The overall evidence indicates **wide variation** between studies in consumers' **willingness to consume CBM. Findings show that 33-66%** of consumers would be **willing** to consume CBM, 12-27% are **unsure**, and 12-22% **would not try it**.
- The **framing of information** regarding CBM had **variable influence** on willingness to consume the products, with mixed findings reported. The **name** used for CBM **can influence** consumers' willingness to consume the products. The limited included studies suggest 'clean' meat is associated with greater willingness to consume CBM than is 'lab-grown' meat, and 'cell-based' seafood is preferred to 'cell-cultured' seafood.

### How is CBM likely to be incorporated into the diet?

- **In terms of willingness to eat CBM regularly:** 33-49% of consumers are **willing**, 26-38% are **unsure**, and 16-32% are **unwilling**. Generally, consumers are **more willing to**

**eat/taste/try** CBM than they are to **eat it regularly**. Consumers may be less willing to regularly consume CBM when it is described as 'lab grown meat'. Overall, a relatively low consumption frequency of CB meat and fish is anticipated by consumers (average of two to three times per year or less).

- **In terms of willingness to eat CBM as a replacement for conventional meat:** 29-53% of consumers are willing, 22-44% are unsure, and 17-49% are unwilling. Generally, **similar** proportions of consumers are willing to **both eat CBM regularly and eat it in place of conventional meat**, but **there is a preference to retain some conventional meat in the diet**.
- **In terms of willingness to eat CBM compared to plant-based meat substitutes:** 48-63% of consumers would be **more willing to eat CBM compared to plant-based meat substitutes**; 22-29% would be '**neither more nor less willing**'; and 10-26% would be **less willing**. Generally, **greater willingness to eat CBM compared to plant-based meat substitutes** is found among consumers who are **not currently eating plant-based meat substitutes**.
- **An overall conclusion statement regarding consumers' willingness to consume CBM and incorporate it into their diet cannot be drawn due to inconsistency in the evidence and concerns related to bias in the CBM definition provided.**

## Consumers' key motivations and barriers for consuming CBM

### Motivations for consumption

- The available evidence from seven studies of moderate or low quality, suggests that **both personal and societal factors** may play a role in motivating consumption of CBM, particularly **environmental benefits, animal welfare, and health and nutrition considerations**.
- Findings regarding the importance of **personal factors** in motivating consumption of CBM, indicate that, on average, **specific health and safety factors** (e.g., including no toxicity, pathogens, foodborne diseases, growth hormones and/or antibiotics) and **price** are of **moderate to high importance**; **general health considerations** and **sensory characteristics** are of **moderate importance**; and **nutrition** is of **moderate or uncertain importance**. **Novelty** was also an **important** motivator. All of these personal factors were also discussed in the context of perceived benefits of CBM.
- Findings regarding the importance of **societal factors** in motivating consumption of CBM consistently suggest that **environmental benefits and animal welfare** are, on average, of **moderate to high importance** in motivating consumption of CBM. Other societal factors that were identified as motivators of CBM consumption (but only in single and low-quality studies), were **population growth, global food security, and supporting small-scale farmers**. Except for supporting small-scale farmers, **all societal factors identified as motivators** of CBM consumption were **also identified as perceived benefits** by some consumers.
- Collectively, the findings regarding perceived benefits and motivating factors, suggest that when these societal benefits are perceived, they have the potential to motivate consumption of CBM.

### Barriers to consumption

- The available evidence from seven studies of moderate or low quality, suggests that **potential barriers to consumption of CBM relate primarily to personal factors**.



- The evidence suggests the following factors are potential barriers to consuming CBM: **feelings of disgust and unease towards CBM** underpinned by perceived unnaturalness and high level of processing of CBM; **higher price** of CBM relative to traditional meat; **negative perceptions regarding taste/sensory characteristics**; **perceiving uncertainty in scientific knowledge** and **lacking information** regarding CBM; and perceiving CBM consumption as an **act of disloyalty to one's country/local meat industries**.
- These factors were also discussed in the context of perceived risks of CBM. Societal factors that were discussed in the context of perceived risks but were not raised or examined as potential barriers to CBM consumption include risks to the environment, economy, and farmers; and ethical concerns related to the use of animals, moral issues and/or genetic alteration, and suspecting hidden agendas/potential for a lack of transparency.

### **Consumers' preferred and best-understood terms for differentiating CBM from conventional meat**

- Evidence from 10 studies of mostly moderate or low quality, indicates the following phrases/names are best understood by consumers when differentiating CBM products from conventional meat and fish: phrases and names that **contain the word 'cell'** (e.g., 'Cultivated from the cells of\_', 'Grown directly from the cells of\_', 'Cell-based' or 'Cell-cultured'); the **name 'lab-grown'**; and **descriptive phrases** (e.g., 'grown from [animal] cells', 'not farmed [or fished]'). However, these phrases/names may **decrease consumer appeal** compared to using the terms 'cultured'/'cultivated'.
- Overall, none of the names tested independently achieved 100% correct identification that the CBM product is neither wild caught nor farm raised.

### **Consumers preferred labelling requirements for CBM**

- No studies specifically assessed whether consumers expect information indicating that a product is a cell-based protein, to be available when food is not required to bear a label (e.g., food sold for immediate consumption in a restaurant). Limited evidence indicates that consumers expect to see labelling information that identifies a CBM product in general.

**Overall, limited Australian and NZ data were available to address each research question.** Further high-quality studies in Australia and NZ could provide **additional information to help determine how best to support informed decision-making by consumers** regarding cell-based proteins. In particular, the best (most understood and preferred) CBM names and descriptive phrases identified from the review could be tested for understanding and appropriateness in the Australian and NZ context. Other important knowledge gaps that could be addressed include determining: consumers' objective knowledge of cell-based proteins with respect to both the manufacturing process and the end product; how perceived risks and benefits of cell-based proteins are shaped by perceived knowledge of CBM and the information provided about the product; and consumers' expectations regarding the availability of information and terminology that will allow them to distinguish between cell-based proteins and traditional proteins, on foods that are not required to bear a label.

Lastly, the studies included in this systematic review focused primarily on cell-based meat. Thus, the review highlighted a lack of empirical evidence around consumers' responses to cell-based dairy products and limited evidence regarding cell-based seafood; both of which could be addressed in further research.

## Introduction

A range of alternative proteins are being developed to meet consumer demand for healthier and more ethical (including animal- and environmentally friendly) alternatives to traditional animal products. Some of these alternative proteins are designed to mimic the sensory characteristics of traditional animal products (e.g., meat, seafood, dairy, eggs) but do not use the same production methods. Some types of alternative proteins are already on the market (e.g., plant-based meat substitutes/analogues), and others have been approved and are available in some countries but not yet in Australia (e.g., cell-based proteins).

Cell-based proteins are produced by extracting cells from an animal, growing the cells in a nutrient medium, and further processing and shaping these cells into the end product, which aims to resemble traditional meat. This process relies on a combination of biotechnology, tissue engineering, molecular biology and synthetic processes (Food Standards Australia New Zealand, 2021).

Currently, cell-based products are only available on the market in Singapore (cell-based chicken received regulatory approval in December 2021) and have also recently been approved in the United States (US) but are not yet available (cell-based chicken received regulatory approval in June 2023). To ensure that the Food Regulation System in Australia and New Zealand is equipped to support informed decision-making by consumers regarding cell-based proteins, a greater understanding of consumers' awareness, acceptance, and behaviours in response to cell-based proteins is needed.

## Aim

The aim of this literature review is to **assess consumers' understanding, acceptance, and behaviours in response to cell-based proteins**, using a **systematic review** approach. The review includes both **cell-based meat (CBM)**, which is considered to include **seafood**, and **cell-based dairy**. Plant-based products and insects as alternative proteins are beyond the scope of this review. The review will be used by FSANZ to help inform food standards development related to cell-based proteins.

Notably, various terms are used to refer to CBM in the literature, including 'cell-cultured', 'clean', 'lab-grown', 'in-vitro', 'cultivated', and 'artificial'. However, **the term 'CBM' is used through this report**, with other terms referred to when used in specific studies.

## Objectives

1. To examine consumers' awareness and perceived benefits and risks of cell-based proteins.
2. To explore consumers' information preferences and understanding regarding the name and labelling for cell-based proteins.
3. To explore consumers' knowledge of cell-based proteins.
4. To determine consumers' motivations and behaviour in relation to the consumption of cell-based proteins.

## Research questions

### **Consumer awareness:**

1. What are the levels of consumers' awareness of cell-based proteins?

### **Consumer knowledge and perceptions:**

2. What is consumers' knowledge of the manufacturing process and end product of cell-based proteins?
3. What are consumers' perceived benefits of cell-based proteins (e.g., health, sustainability, animal welfare)?
4. What are consumers' perceived risks and/or downsides of cell-based proteins (e.g., taste, texture, health, sustainability, safety, 'unnaturalness', manufacturing process, cost)?
5. Do consumers perceive cell-based proteins as the same or different to their traditional counterparts? Are they perceived as being as healthy as, and/or nutritionally equivalent (e.g., levels of protein/fat), to their traditional counterparts?

### **Consumers' information preferences:**

6. Do consumers want a specific term to differentiate between cell-based protein and traditional protein, and what terminologies are best for consumer understanding?
7. Do consumers expect this information (i.e., that it is cell-based protein) to be available when food is not required to bear a label (e.g., food sold for immediate consumption in a restaurant)?

### **Consumer behaviour and motivations:**

8. Are consumers willing to consume cell-based proteins? If so, how are cell-based proteins likely to be incorporated into the diet (frequency, substitute or consume in addition to regular counterpart)?
9. What are consumers' key motivations for consuming or not consuming cell-based proteins (e.g., taste, health, sustainability, aversion to manufacturing process, cost etc.)?

## Methodology

### Literature search

A systematic literature search was conducted in PubMed, Scopus, Web of Science and PsycINFO to assess consumers' awareness, knowledge and perceived risks and benefits of cell-based protein, and motivation to consume cell-based protein. A full search strategy for each database was developed (see Appendix 1). The search was restricted to human studies published up to March 2023. No other restrictions applied.

### Eligibility criteria

The search initially included both cell-based and plant-based protein and dairy alternatives. It was subsequently limited to cell-based proteins (cell-based meat/seafood and dairy), publications from 2012 onwards, and studies conducted in English-speaking countries. The decision to only include studies conducted in English-speaking countries was partly due to

time constraints, but also because findings from non-English-speaking countries would not be generalisable to the Australian and NZ context.

### Inclusion criteria for cell-based meat (including seafood) and dairy

Studies that reported data on any of the following themes were eligible for inclusion in the review:

- Consumers' awareness of cell-based meat and dairy alternatives (Have they heard of these products? Do they know what they are?).
- Consumers' knowledge of the manufacturing process and end product of cell-based meat and dairy.
- Consumers' willingness to consume cell-based meat and dairy, and how they intend to incorporate them into their diet (frequency, substitute or consume in addition to traditional counterpart).
- Consumers' perceptions regarding nutritional quality and overall healthiness of cell-based meat and dairy.
- Consumers' perceptions regarding risks/downsides and benefits of cell-based meat and dairy.
- Consumers' key motivations for consuming or not consuming cell-based meat and dairy.
- Consumers' views and/or preferences regarding terminologies and labelling requirements used to differentiate cell-based proteins from traditional proteins.

## Study screening

All citations retrieved from the literature search were imported into an Endnote library and duplicates were removed. The remaining citations were exported into COVIDENCE for screening. The titles and abstracts of the publications were reviewed to determine eligibility for inclusion. Full texts of the articles were retrieved for further assessment if there was any doubt regarding eligibility of the publications based on the title and abstract. Two reviewers independently assessed all studies for eligibility. Discrepancies were resolved by discussion or involving a third reviewer.

## Study quality appraisal

The quality of each included study was assessed using the Quality Assessment with Diverse Studies (QuADS) tool (Harrison et al., 2021) as the **eligible studies included diverse study designs**. The QuADS tool consists of a total of 13 items that can be broadly categorised into the following categories:

- Theoretical/conceptual framework and research aims
- Sampling and recruitment methods
- Procedural details
- Data collection tools
- Data analyses
- Strengths and limitations

The quality of each study was graded as low, moderate or high. **Low quality** studies are those that had one or more critical flaw, defined as missing or unclear methodological details (except sample size estimation) or results, with or without non-critical weaknesses (other criteria), and may not provide any confidence in the findings. **Moderate quality** studies are those that had no critical flaws but had two or more non-critical weaknesses and can provide

some confidence in the findings. **High quality** studies are those that had no critical flaw and no more than one non-critical weakness. The quality of each study was evaluated by one reviewer.

## Evidence synthesis

Study characteristics, participant characteristics, intervention/exposure/context, comparator, outcome (key findings), and overall quality of the included studies were summarised, described, and presented in tables and text. Key findings were synthesised thematically (by research question). Meta-analysis was not performed as the data were not suitable for meta-analysis.

The **strength of evidence** was considered based on the framework for grading the strength of evidence in nutrition and public health related systematic reviews developed by the USA Dietary Guidelines Advisory Committee (Dietary Guidelines Advisory Committee, 2020). In the current report, the following were considered in synthesising the evidence: risk of bias, consistency of findings across studies, directness of the measures in relation to the research questions, and precision and generalisability of the findings to the Australian/NZ context. The evidence was **graded as: Strong, Moderate, Limited or Grade not assignable**.

## Results

### Study selection

The systematic search performed in PubMed, Scopus, Web of Science and PsycINFO identified 2228 articles of which 195 were duplicates, 1942 were ineligible, leaving 91 eligible studies. To ensure that the review was manageable within the timeframe, the review was limited to studies examining cell-based proteins, conducted in English-speaking countries, and published since 2012; this reduced the eligible studies to 37. In addition, reference lists of the eligible studies and grey literature provided by FSANZ were checked, and Google Scholar citation tracking of eligible studies was conducted to identify any additional eligible studies. A total of **43 cell-based protein studies that reported at least one of the outcomes of interest** were included in the final review (see Figure 1).

### Study characteristics

Of the 43 studies included, 34 were quantitative studies, 7 were qualitative studies, and 2 were mixed-methods studies. The study design and participant characteristics of the included studies are summarised in **Appendix 2**.

Most of the studies were online surveys conducted in the US (23/43); five studies included participants from the US and other countries (one included Australia); five studies were conducted in the UK; and the remaining studies were **conducted in Australia (3), NZ (4)**, Canada (2), Ireland (1) and Singapore (1). **Four** of the eligible studies examined **cell-based seafood** (Malerich and Bryant, 2022; Hallman and Hallman, 2020; Hallman and Hallman,

2021; Liu, 2022) and **none** examined **cell-based dairy**<sup>1</sup>. Thus, this review focuses on CBM (including seafood).

Consumers' awareness of CBM and perceived risks of CBM were the most studied topics in 20 and 18 studies, respectively. Among other themes examined were consumers' willingness to consume CBM (n=16); how CBM is likely to be incorporated into the diet (n=12); perceived benefits (n=11); preferred and best-understood terminologies and labelling requirements (n=11); and perceived general health and nutritional quality of CBM in comparison to conventional meat (n=9).

Two of the 43 studies were appraised as high quality (Anderson and Bryant 2018, Bryant et al., 2019b), 26/43 (60%) as moderate, and 15/43 (35%) as low quality due to major methodological limitations defined as missing or unclear in one or more key aspects of the methods or results (see Appendix 2).

Notably, the study design of one of the included studies was different from other studies (Laestadius and Caldwell, 2015). This study analysed online comments made on online US news articles which discussed the 2013 CBM hamburger event (a media-attended event where scientists first revealed CBM to the public and tasted the world's first CBM hamburger patty); this analysis considered 814 comments from 462 commenters, whose socio-demographic characteristics are unknown, and who are likely to hold stronger views towards CBM than non-commenters.

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<sup>1</sup> Although Juhasz et al. (2023) asked participants about cell-based dairy, this was examined in combination with other cell-based proteins (see Table 1). Therefore, no study isolated consumer perceptions about cell-based dairy in particular.

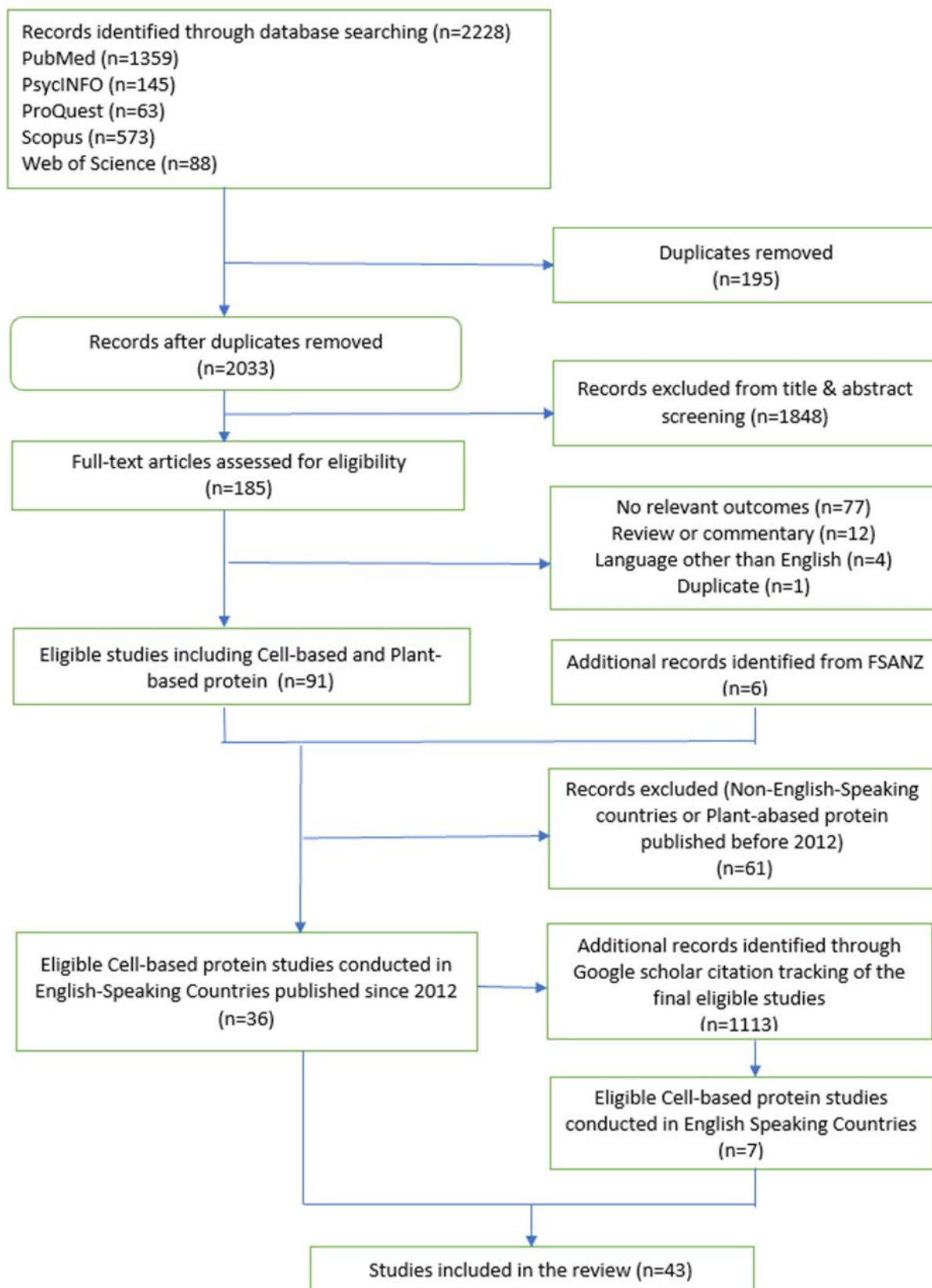


Figure 1. Flow chart of included and excluded studies in the review.



## Consumer awareness

Research Q1: What are the levels of consumers' awareness of cell-based meats?

Consumers' awareness of or familiarity with CBM was **assessed in 20 studies (reported in 19 publications)**, including **one of high quality** (Anderson and Bryant, 2018), **13 of moderate quality** (Asioli et al., 2022; Baum et al., 2022; Bryant et al., 2019a; de Oliveira Padilha et al., 2022; Garcez de Oliveira Padilha et al., 2021; Giezenaar et al., 2023; Hallman and Hallman, 2020; Hallman and Hallman, 2021; Hamlin et al., 2022; Lucius, 2020; Malavalli et al., 2021; Ruzgys and Pickering, 2020; Wilks et al., 2021), and **six of low quality** (Szejda, 2018; Szejda et al., 2021; Juhasz et al., 2023; Verbeke et al., 2015; Wilks and Phillips, 2017). **Representative samples** were used in the following **11 studies**: (Anderson and Bryant, 2018; Asioli et al., 2022; Baum et al., 2022; Bryant et al., 2019a; de Oliveira Padilha et al., 2022; Garcez de Oliveira Padilha et al., 2021; Hallman and Hallman, 2021; Wilks et al., 2021; Szejda et al., 2021; Juhasz et al., 2023; Wilks and Phillips, 2017).

Eighteen studies reported **quantitative** findings from online surveys conducted in Australia, NZ, the UK, the US, and Canada, with sample sizes ranging from 16 to 10,019; and one study reported **qualitative** findings from focus groups and an online survey with 60 participants (Verbeke et al., 2015). **Two studies focused on CB seafood (salmon)** (Hallman and Hallman, 2020; Hallman and Hallman, 2021). **Various terms** were used to describe CBM in these studies, which may **limit the reliability of direct comparisons** between studies. The results of these studies are summarised in Table 1 and in the text below.

### **Awareness of CBM – previously heard of the term (noting that different terms are used across studies)**

Seven studies asked participants about their previous awareness of CBM (i.e., if they have heard of it or not) (Anderson and Bryant, 2018; Hamlin et al., 2022; Giezenaar et al., 2023; Asioli et al., 2022; Wilks and Phillips, 2017; Garcez de Oliveira Padilha et al., 2021; Baum et al., 2022). The proportion of participants who had heard of specific CBM terms prior to the study ranged from **18% to 66%** in Australia, NZ, the UK and the US. The lowest values in this range were reported in US and Australian studies that asked about awareness of 'in vitro meat' (18-23%) (Wilks and Phillips, 2017; Garcez de Oliveira Padilha et al., 2021). Notably, this term was one of six terms assessed in the Australian study where the highest awareness was reported for the term 'Artificial meat' (47%) (Garcez de Oliveira Padilha et al., 2021). Relatively low awareness (25%) was also reported in the high-quality US study that asked about awareness of 'clean meat' and provided an 'unsure' response option, which may have reduced the proportion of participants selecting 'yes' (Anderson and Bryant, 2018). Notably, this was the only study to include an 'unsure' response option. The highest awareness (66%) was reported in a NZ study which asked about awareness of 'clean meat' (Hamlin et al., 2022); however, no other CBM terms were assessed in this study so this higher awareness of 'clean meat' relative to other studies could be attributed to other differences between studies.

Consumers' **awareness of multiple terms/names for CBM** was assessed separately in three studies, two conducted in the US (Asioli et al., 2022, Lucius, 2020) and one in Australia (Garcez de Oliveira Padilha et al., 2021). Awareness of each of the terms, 'artificial meat', 'lab-grown meat', and 'cultured meat', was assessed among consumers in both the

Australian study (Garcez de Oliveira Padilha et al., 2021) and the larger of the two US studies (Asioli et al., 2022). Similar findings were reported, such that **both the Australian and US consumers** surveyed, had most commonly heard of **'artificial meat' (47-49%)**, followed by **'lab-grown meat' (40-44%)**, and **'cultured meat' (31-37%)**. Notably, 42% of Australian consumers had also heard of 'synthetic meat', but this term was not assessed in the US study. Overall, **69% of Australian participants** indicated they had **heard of at least one of the six terms assessed**, with this proportion lower among US participants (40%), however, the US participants were presented with half as many terms (three vs. six) (Asioli et al., 2022, Garcez de Oliveira Padilha et al., 2021). The other US study assessed familiarity with 'cultured meat' and 'cellular agriculture' among 16 Muslim participants; however, these findings have limited generalisability due to the small sample size and specific cultural context (Lucius, 2020). Additionally, **40%** of Canadians surveyed reported they were **aware that CBM products exist but are not yet commercially available** (Juhasz et al., 2023). Awareness that CBM is not yet commercially available was not assessed in other studies.

### **Level of familiarity with CBM**

Eight studies assessed participants' level of familiarity with CBM and/or the concept of CBM using similar questions and response formats, enabling direct comparison of findings (Anderson and Bryant, 2018; Bryant et al., 2019a; Juhasz et al., 2023; Lucius, 2020; Malavalli et al., 2021; Szejda, 2018; Wilks et al., 2021). Familiarity was rated on a 5-point scale from 'not at all familiar' to 'very familiar'. Overall, **0-17%** of consumers surveyed in NZ, the UK, and the US felt they were **'Familiar' or 'Very familiar' with CBM**; **8-41%** indicated they were **'Moderately familiar'**; and **50% to 88%** reported **no or low familiarity** ('Not at all familiar' or 'A little bit familiar'). The specific term(s) used to refer to CBM differed across studies but did not differ between participants in individual studies (except in one study where results for the different terms were aggregated (Szejda, 2018)), nor were participants asked to report their familiarity separately for multiple terms. Therefore, while differences in terminology may be contributing to differences in familiarity levels between studies, these differences could also be due to other differences between study samples.

### **Level of knowledge about CBM**

Overall, **3-21% of participants considered themselves very knowledgeable or well-informed** about CBM (de Oliveira Padilha et al., 2022; Garcez de Oliveira Padilha et al., 2021; Hamlin et al., 2022; Juhasz et al., 2023; Ruzgys and Pickering, 2020). The proportion was on the higher end of the range (20-21%) when perceived knowledge of multiple terms was considered (i.e., when identifying the proportion of consumers who feel knowledgeable about at least one of the terms presented) (de Oliveira Padilha et al., 2022); and when consumers were asked to rate their agreement with the statement 'I consider myself very knowledgeable of cultured, cell-based, or lab-grown proteins' (Juhasz et al., 2023), which may have skewed responses to the positive end of the scale, when compared with a more neutral statement asking about level of knowledge. Notably, when assessing perceived knowledge of multiple terms among Australian consumers, consumers **felt more knowledgeable about some terms than others**. The proportion of participants who felt they 'Know enough about it that I could explain it to a friend' ranged from 5% (in-vitro meat) to 9% (artificial and lab-grown meat), which suggests that the term used to describe the concept of CBM may influence consumers' (perceived) understanding.

## Summary of findings for the different CBM terms used across studies

The **various terms** used to describe CBM in studies assessing awareness and/or familiarity (under this subheading, familiarity is considered to include perceived level of knowledge) include: 'cultured meat' (eight studies), 'lab-grown meat' (six studies), 'in-vitro meat' (five studies), 'clean meat' (five studies), 'cultivated meat' (two studies), 'cell-based meat' (two studies), 'artificial meat' (two studies), 'cellular agriculture' (two studies), 'cell-cultured meat' (one study), and 'synthetic meat' (two studies). Sometimes **multiple CBM terms were mentioned in questions** assessing awareness or familiarity, limiting the ability to determine applicability of the results to specific terms. Below is a summary of the results for the CBM terms used in multiple studies.

### ***'Cultured meat': Awareness and familiarity***

- **Awareness** of 'cultured meat' was assessed in three studies of Australian and US consumers – one high quality (Anderson and Bryant, 2018) and two moderate quality (Garcez de Oliveira Padilha et al., 2021; Asioli et al., 2022). All three study samples were representative.
  - Overall, **30-37%** of consumers had previously **heard of 'cultured meat'** in the two studies that asked about cultured meat specifically without referring to other CBM within the same question (Garcez de Oliveira Padilha et al., 2021; Asioli et al., 2022).
  - A lower awareness of cultured meat (**25%**) was reported in the study that mentioned other CBM terms in the same question; however, this was the only study to include an **'unsure' response option** (15%) (Anderson and Bryant, 2018).
- **Familiarity** with 'cultured meat' was assessed in five studies of US and Canadian consumers – one high quality (Anderson and Bryant, 2018), three moderate quality (Wilks et al., 2021; Lucius, 2020; Ruzgys and Pickering, 2020), and one low quality (Szejda, 2018). Only two of the five study samples were representative, both from the US (Anderson and Bryant, 2018; Wilks et al., 2021).
  - Overall, **0-17%** were **'Familiar' or 'Very familiar'**; **12-25%** were **'moderately familiar'**; and **50-85%** were **'Not at all familiar' or 'A little bit familiar'**.
  - A wide range of results was reported in the two studies with representative samples: 7-17% were 'Familiar' or 'Very familiar'; 7-33% were 'moderately familiar'; and 50-85% were 'Not at all familiar' or 'A little bit familiar'.
    - Notably, the study that reported a higher level of familiarity (Anderson and Bryant, 2018), referred to multiple CBM terms to participants when asking about familiarity with CBM and this may be contributing to the higher levels of familiarity reported in this study relative to the other study with a representative US sample.

### ***'Lab-grown meat': Awareness and familiarity***

- **Awareness** of 'lab-grown meat' was assessed in four studies of Australian, NZ, UK and US consumers – all moderate quality (Asioli et al., 2022; Garcez de Oliveira Padilha et al., 2021; Giezenaar et al., 2023; Baum et al., 2022). All study samples were representative, except the NZ sample (Giezenaar et al., 2023).
  - Overall, **40-44% of Australian, UK and US consumers** (representative samples) had previously **heard of 'lab-grown meat'**.

- On average, NZ consumers (non-representative sample), ‘neither agreed nor disagreed’ that they are aware of ‘cultivated meat (sometimes called: in vitro meat, lab-grown meat, and/or clean meat)’ (mean score of  $4.3 \pm 0.1$  on a scale from 1-7) (Giezenaar et al., 2023)
- **Familiarity** with ‘lab-grown meat’ was assessed in three studies of Australian, UK and Canadian consumers – two of moderate quality (Garcez de Oliveira Padilha et al., 2021; Baum et al., 2022) and one low quality (Juhasz et al., 2023). All three study samples were representative.
  - Overall, **9%** of Australian consumers felt they ‘**Know enough about it that I could explain it to a friend**’. Of the three studies, this was the only one that assessed familiarity of ‘lab-grown meat’ specifically, with the **other studies mentioning multiple CBM terms** when asking about familiarity.
    - 23% of UK consumers reported they had ‘heard about in-vitro meat (also referred to as synthetic meat or lab grown meat) and know what it means’; and 21% of Canadian consumers agreed with the statement: ‘I consider myself very knowledgeable of cultured, cell-based, or lab-grown proteins (e.g., Meat, dairy, poultry, seafood alternatives)’, with higher agreement (33%) reported among younger consumers (‘Gen Z’ defined as consumers born between 1997-2005; aged between 16-24 years).

#### ***‘In-vitro meat’: Awareness and familiarity***

- **Awareness** of ‘lab-grown meat’ was assessed in five studies of Australian, NZ, UK and US consumers – one of high quality (Anderson and Bryant, 2018), three moderate quality (Giezenaar et al., 2023; Garcez de Oliveira Padilha et al., 2021; Baum et al., 2022), and one low quality (Wilks and Phillips, 2017). Three of the five study samples were representative (Australian, UK and US consumers) (Anderson and Bryant, 2018; Garcez de Oliveira Padilha et al., 2021; Baum et al., 2022).
  - Awareness of ‘in-vitro meat’ ranged between **23% to 40%** in the representative samples of Australian, UK and US consumers. The lowest awareness (23%) was reported in the Australian study which was the only one that assessed familiarity of ‘in-vitro meat’ specifically, without mention of other terms.
  - In the low quality and non-representative US study, awareness was reported separately for males (22% had previously heard of in-vitro meat) and females (18%) (Wilks and Phillips, 2017).
  - The other study with a non-representative NZ sample mentioned other terms in addition to ‘in-vitro meat’ and found that, on average, NZ consumers ‘neither agreed nor disagreed’ that they are aware of ‘cultivated meat (sometimes called: in vitro meat, lab-grown meat, and/or clean meat)’ (mean score of  $4.3 \pm 0.1$  on a scale from 1-7) (Giezenaar et al., 2023)
- **Familiarity** with ‘in-vitro meat’ was assessed in four studies of Australian, NZ, UK and US consumers – one of high quality (Anderson and Bryant, 2018) and three moderate quality (Malavalli et al., 2021; Garcez de Oliveira Padilha et al., 2021; Baum et al., 2022). All study samples were representative, except the NZ sample (Malavalli et al., 2021).

- Among US and NZ consumers, **7-24%** were **‘Familiar’** or **‘Very familiar’**; **8-25%** were **‘moderately familiar’**; and **60-85%** were **‘Not at all familiar’** or **‘A little bit familiar’**.
  - Notably, both studies also mentioned other CBM terms when assessing familiarity.
- Additionally, **5%** of Australian consumers felt they **‘Know enough about it [in-vitro meat] that I could explain it to a friend’**; and 23% of UK consumers reported they had ‘heard about in-vitro meat (also referred to as synthetic meat or lab grown meat) and know what it means’. Notably, the Australian study was the only one that assessed familiarity of ‘in-vitro meat’ specifically, without mention of other terms.

### ***‘Clean meat’: Awareness and familiarity***

- **Awareness** of ‘clean meat’ was assessed in four studies of Australian, NZ and US consumers – one high quality (Anderson and Bryant, 2018), three moderate quality (Garcez de Oliveira Padilha et al., 2021; Giezenaar et al., 2023; Hamlin et al., 2022). Two of the four study samples were representative, one from Australia (Garcez de Oliveira Padilha et al., 2021) and one from the US (Anderson and Bryant, 2018).
  - Overall, **25-33%** of Australian and US consumers (representative samples) had previously **heard of ‘clean meat’**, compared to 59% of NZ consumers (non-representative sample). Only the Australian study (33% aware) assessed awareness of ‘clean meat’ specifically, without mention of other terms in the same question.
  - Another NZ survey found that consumers, on average, ‘neither agreed nor disagreed’ that they are aware of ‘cultivated meat (sometimes called: in vitro meat, lab-grown meat, and/or clean meat)’ (mean score of 4.3±0.1 on a scale from 1-7) (Giezenaar et al., 2023)
- **Familiarity** with ‘clean meat’ was assessed in five studies of Australian, NZ and US consumers – one high quality (Anderson and Bryant, 2018), three moderate quality (Garcez de Oliveira Padilha et al., 2021; Bryant et al., 2019a; Hamlin et al., 2022), and one low quality (Szejda, 2018). Three of the five study samples were representative, one from Australia (Garcez de Oliveira Padilha et al., 2021) and two from the US (Anderson and Bryant, 2018; Bryant et al., 2019a).
  - Among **US** consumers **5-11%** were **‘Familiar’** or **‘Very familiar’**; **8-14%** were **‘moderately familiar’**; and **75-85%** were **‘Not at all familiar’** or **‘A little bit familiar’**.
  - Additionally, **9% of Australian consumers** felt they **‘Know enough about it that I could explain it to a friend’** and **7% of NZ consumers ‘felt well informed’** about clean meat prior to the study.

### ***‘Cultivated meat’: Awareness and familiarity***

Awareness and familiarity with ‘Cultivated meat’ were each assessed in one study- one moderate quality study of NZ consumers (Giezenaar et al., 2023) and one low quality study of both UK and US consumers (Szejda et al., 2021). Only the low-quality study was conducted with representative samples (Szejda et al., 2021).

- **Awareness** was assessed among **NZ** consumers in the moderate quality study (Giezenaar et al., 2023), with consumers on average, **‘neither agreeing or**

**disagreeing' that they are aware of 'cultivated meat** (sometimes called: in vitro meat, lab-grown meat, and/or clean meat)' (mean score of  $4.3 \pm 0.1$  on a scale from 1-7).

- **Familiarity** was assessed among representative samples of **US and UK** consumers in the low quality study; and was found to be somewhat higher among US consumers.
  - Overall, **5-7% were 'Familiar' or 'Very familiar'**; **34-41% were 'moderately familiar'**; and **54-59% were 'Not at all familiar' or 'A little bit familiar'**.

#### ***'Cell-based meat': Familiarity***

- **Familiarity** with 'cell-based meat' was assessed in two low quality studies of Canadian and US consumers – only the Canadian study sample was representative (Lucius, 2020; Malavalli et al., 2021).
  - Overall, **21%** of Canadian consumers **agreed** with the statement: **'I consider myself very knowledgeable of cultured, cell-based, or lab-grown proteins (e.g., Meat, dairy, poultry, seafood alternatives)'**. 7% 'strongly agreed' and 14% 'agreed'. Notably, higher agreement (33% 'agreed' or 'strongly agreed') was reported among younger/Gen-Z consumers ('Gen Z' defined as consumers born between 1997-2005; aged between 16-24 years).
  - The US study reported combined results for participants shown one of five names to describe CBM: "clean meat," "cultured meat," "craft meat," "cell-based meat," and "slaughter-free meat"; showing that **5% were 'Familiar' or 'Very familiar' but results for 'cell-based meat' were not reported separately.**

#### ***'Artificial meat': Familiarity***

Familiarity with 'artificial meat' was assessed in two moderate quality studies of Australian and US consumers - both were representative samples and both assessed awareness of multiple terms, separately (Garcez de Oliveira Padilha et al., 2021; Asioli et al., 2022).

- **47-49%** had previously **heard of 'artificial meat'**.
- **9%** of Australian consumers felt they **'Know enough about it that I could explain it to a friend'**.

#### ***'Cellular agriculture': Familiarity***

Familiarity with 'cellular agriculture' was assessed in two moderate quality studies of NZ and US consumers - neither were representative samples (Lucius, 2020; Malavalli et al., 2021).

- **0-15%** were **'Familiar' or 'Very familiar'**; **12-25%** were **'moderately familiar'**; and **60-88%** were **'Not at all familiar' or 'A little bit familiar'**.

## Conclusions (RQ1)

- Evidence from multiple studies (most appraised as moderate quality) indicates that **18-66%** of consumers are **aware of specific CBM terms or the concept of CBM**. However, only **0-17%** of consumers **feel they are ‘familiar’ or ‘very familiar’**; and only **5-21%** **consider themselves very knowledgeable** about CBM.
- Consumers’ awareness of and familiarity with CBM appeared to differ based on the **specific term(s) used to describe CBM**. Based on evidence from two moderate quality, representative studies of Australian and US consumers which assessed consumers’ awareness of multiple specific CBM terms separately, consumers were most commonly aware of **‘artificial meat’ (47-49%)**, **‘lab-grown meat’ (40-44%)**, and **‘cultured meat’ (31-37%)**. Evidence from other studies that used a single question to assess awareness or familiarity **requires cautious interpretation** when comparing with results from other studies that may have used a different CBM term and/or may have referred to multiple CBM terms within the same question. Other factors that could be contributing to the variation in awareness/familiarity across studies includes differences in study quality (including representativeness of study samples), and different numbers of studies assessing each CBM term, among other differences between studies.
- Overall, the CBM terms which were reported to be most familiar to consumers (based on upper end of the range of familiarity results reported across studies) are: **‘lab-grown meat’** (40-44% familiar; 9% felt knowledgeable); **‘in-vitro meat’** (7-24% familiar; 5% felt knowledgeable), **‘cultured meat’** (0-17% familiar; 25-37% aware), **‘cellular agriculture’** (0-15% familiar), **‘clean meat’** (5-11% familiar; 9% felt knowledgeable; 25-59% aware), **‘cultivated meat’** (5-7% familiar), **‘cell-based meat’** (5% familiar; 21% felt knowledgeable), **‘artificial meat’** (9% felt knowledgeable; 47-49% aware).
- Overall, findings from a single nationally representative survey of **Australian consumers** which were reported in two separate studies (both of moderate quality), show **69% of Australian consumers** had previously **heard of at least one of the six CBM terms presented**, but **only 20%** of consumers **felt knowledgeable about at least one** of the CBM terms.
- Overall, findings from three **NZ studies** (all of moderate-quality, and none using representative samples) show **66% of NZ consumers were previously aware of CBM** (the concept of CBM was not completely new to them) (Hamlin et al., 2022); consumers, on average, **‘neither agreed nor disagreed’** that they are aware of CBM (Giezenaar et al., 2023); and **15-20%** felt they had a **high level of familiarity** with CBM (Malavalli et al., 2021).
- With only two studies investigating cell-based seafood, and none investigating cell-based dairy, **further research is needed** to examine consumers’ awareness of and familiarity with **cell-based seafood and dairy**.

**Table 1. Summary of results for studies assessing consumers' awareness of cell-based meat**

Quality	Reference	Country	N	Cell-based meat term/name used in study	Results (%)		
					'Not at all familiar' or 'A little bit familiar' <sup>1</sup>	'Moderately familiar'	'Familiar' or 'Very familiar'
High	(Anderson and Bryant, 2018)	US	1185	<b>Clean meat</b> Prior to this study, to what extent were you familiar with clean meat (including under another name, such as <b>cultured meat</b> or <b>in-vitro meat</b> )?	85.4	7.8	6.9
Moderate	(Bryant et al., 2019a)	US	987	<b>Clean meat</b> Prior to reading this description, how familiar were you with this new way of producing meat, called 'clean meat'?	75.1	14.1	10.8
Moderate	(Wilks et al., 2021)	US	862	<b>Cultured meat</b> How familiar are you with cultured meat?	49.8	33.4	16.7
Moderate	(Lucius, 2020)	US	16	<b>Cultured meat</b>	75	25	0
				<b>Cellular agriculture</b>	88	12	0
Low	(Szejda et al., 2021)	Multiple – US and UK	2018 (US) 2034 (UK)	<b>Cultivated meat</b> – US	59	34	7
				<b>Cultivated meat</b> – UK	54	41	5
Moderate	(Malavalli et al., 2021)	NZ	206	Are you familiar with meat analogues such as plant-based protein, insect protein, in-vitro meat (IVM), vegan fish and fishless seafood?	46	29	24
				Are you familiar with technologies such as <b>cellular agriculture/In-vitro meat (IVM)</b> technology and tissue engineering?	60	25	15
Moderate	(Hallman and Hallman, 2020)	US	3186	After reading the name they were assigned, participants were asked how familiar they were with the idea of producing just the parts of seafood that people eat, instead of catching or raising them whole	70	13	19
Moderate	(Hallman and Hallman, 2021)	US	1200	After viewing the description of the meaning behind "Cell- Based" or "Cell-Cultured," participants were asked how familiar they were with the idea of producing just the parts of seafood that people eat, instead of catching or raising them whole.	78.7	11.1	10
Low	(Szejda, 2018) (Phase 2)	US	148	Participants were asked to read a statement describing a new way of producing meat which does not involve raising and slaughtering farm animals without labelling the CBM with a name. Prior to participating in this study, how familiar were you with this new way of producing meat?	61.5	27	11.5



Quality	Reference	Country	N	Cell-based meat term/name used in study	Results (%)		
Low	(Szejda, 2018) (Phase 3)	US	338	Participants were randomly assigned to read the same product description as in Phase 2 but with one of five names to describe CBM: "clean meat," "cultured meat," "craft meat," "cell-based meat," and "slaughter-free meat". The only difference between the conditions was the name used. They were asked 'Prior to participating in this study, how familiar were you with this new way of producing meat?'	82.2	12.7	5
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	<b>Cultured meat</b> How much do you know about cultured meat?	<b>Know a little or nothing at all</b> 82	<b>Know a moderate amount</b> 16	<b>Know a lot or a great deal</b> 3
Moderate	(Hamlin et al., 2022)	NZ	254	<b>Clean meat</b> Which of the following most closely represents your prior exposure to clean meat before this study?	<b>It was completely new to me</b> 33.9	<b>I've heard of it before</b> 59.1	<b>I felt well informed</b> 7.1
Moderate	(Baum et al., 2022)	UK	302	Have you heard about <b>in-vitro meat</b> (also referred to as <b>synthetic meat</b> or <b>lab grown meat</b> )?	<b>No, I have never heard of it</b> 58.6	<b>Yes, but I do not know what it means</b> 18.5	<b>Yes, and I know what it means</b> 22.8
Moderate	(Garcez de Oliveira Padilha et al., 2021)	Australia	1078	<b>Artificial meat</b> <b>Lab-grown meat</b> <b>Synthetic meat</b> <b>Cultured meat</b> <b>Clean meat</b> <b>In vitro meat</b> <b>Any of the terms</b>	<b>Have NOT heard of it</b> 52.7	<b>Have heard of it, but know very little or nothing about it</b> 38.1	<b>Know enough about it that I could explain it to a friend</b> 9.3
Moderate	(Asioli et al., 2022)	US	625	<b>Artificial</b> (n=207) <b>Lab-grown</b> (n=208) <b>Cultured</b> (n=210) <b>Any of the terms</b> (n=625)	<b>Have NOT heard of it</b> 51.2	<b>Have heard of it</b> 48.8	
					59.6	40.4	
					69.0	31.0	
					60.0	40.0	

Quality	Reference	Country	N	Cell-based meat term/name used in study	Results (%)		
					No	Yes	Unsure
High	(Anderson and Bryant, 2018)	US	1185	<b>Clean meat</b> Have you heard the term “clean meat” before? (It has sometimes been referred to as “cultured meat” or “in-vitro meat” as well)?	59.7	25.1	15.3
Moderate	(de Oliveira Padilha et al., 2022)	Australia	1060	High familiarity with <b>lab-grown meat</b> <sup>2</sup>	80	20	NA
Low	(Wilks and Phillips, 2017)	US	673	<b>In vitro meat</b> - Males <b>In vitro meat</b> - Females	<b>No</b>	<b>Yes</b>	<b>Unsure</b>
					78	22	NA
					82	18	NA
Moderate	(Giezenaar et al., 2023)	NZ	572	<b>Cultivated meat</b> I am aware of cultivated meat (sometimes called: <b>in vitro meat</b> , <b>lab-grown meat</b> , and/or <b>clean meat</b> )	<b>Mean±SD</b>		
					4.3±0.1	1=strongly disagree, 2=disagree, 3=somewhat disagree, 4=neither agree nor disagree, 5=somewhat agree, 6=agree, 7=strongly agree	
Low	(Juhasz et al., 2023)	Canada	10,019	I consider myself very knowledgeable of <b>cultured, cell-based, or lab-grown</b> proteins (e.g., Meat, dairy, poultry, seafood alternatives) I am aware that cultured, cell-based, or lab-grown proteins exist but are not commercially available (e.g., meat, dairy, poultry, seafood alternatives)	<b>Strongly agree</b>	<b>Agree</b>	
					Total = 7% Gen Z=12%	Total=14% Gen Z=21%	Total=29%; Gen Z=31%
Low	(Verbeke et al., 2015)	UK	60	Reactions of participants when first hearing about <b>cultured meat</b> .	“None of them had heard or seen anything similar before and a few expressed shock at the idea of producing cultured meat.”		

<sup>1</sup>Used 5-point rating scale where 1=not at all familiar (I have never heard of the term), to 5= I am very familiar (I regularly read new articles and keep updated with new developments)

<sup>2</sup> Composite score considering responses for seven terms. Yes = Selected ‘Know enough about it that I could explain it to a friend’ for at least one of the seven terms (artificial meat, lab-grown meat, synthetic meat, cultured meat, clean meat, in vitro meat, cellular agriculture; No=Selected ‘Have not heard of it’ or ‘Have heard of it, but know very little or nothing about it’ for all seven terms.

## Consumer knowledge and perceptions

### Research Q2: What is consumers' knowledge of the manufacturing process and end product?

None of the included studies assessed consumers' objective knowledge of CBM with respect to the manufacturing process and end product. Familiarity with the concept of CBM and/or specific name/terms used to describe CBM were assessed in studies discussed in Research Q1. All studies that assessed familiarity assessed knowledge in a subjective sense without assessment of actual/objective knowledge.

### Research Q3: What are consumers' perceived benefits of cell-based meats (e.g., health, sustainability, animal welfare)?

Eleven studies reported consumers' perceived benefits of CBM – two studies were of **high quality** (Anderson and Bryant, 2018), five **moderate quality** (Boykin, 2019; Bryant and Dillard, 2019; Ruzgys and Pickering, 2020; Hamlin et al., 2022; Laestadius and Caldwell, 2015), and four **low quality** (Boereboom et al., 2022; Bogueva and Marinova, 2020; Tucker, 2014; Verbeke et al., 2015).

Six studies reported **quantitative** findings from online surveys conducted in the US, UK and Canada, with sample size ranging from 200 to 1185. Two studies were of high quality (Anderson and Bryant, 2018; Bryant et al., 2019b), three moderate quality (Boykin, 2019; Bryant and Dillard, 2019; Ruzgys and Pickering, 2020), and one low quality (Boereboom et al., 2022). Four of the studies surveyed representative samples (Anderson and Bryant, 2018; Bryant et al., 2019b, Boereboom et al., 2022; Boykin, 2019). Perceptions were typically assessed using survey questions that required participants to rate how strongly they agreed with statements regarding predetermined perceived benefits. Most studies used a 5-point rating scale (where 1 = strongly disagree and 5 = strongly agree), but one study used a 7-point rating scale (where 1 = strongly disagree and 7 = strongly agree), limiting direct comparison with other studies. None of these studies provided a neutral description of CBM to participants; one study did not report whether a description was provided (Boereboom et al., 2022); and the remainder presented biased and/or framed descriptions of CBM, with perceived benefits assessed after presenting the description. Thus, responses to questions about perceived benefits may have been influenced by the information provided about CBM. Quantitative results are reported in Table 2.

**Qualitative** findings were reported in six studies – three of moderate quality (Hamlin et al., 2022, Laestadius and Caldwell, 2015; Ruzgys and Pickering, 2020) and three low quality (Bogueva and Marinova, 2020; Tucker, 2014; Verbeke et al., 2015). A representative sample was used in one of the six studies (Bogueva and Marinova, 2020). Data was collected using focus group discussions, individual interviews and online surveys conducted in Australia, NZ, the UK, and Canada, with sample sizes ranging from 60 to 254. Additionally, one US study analysed online comments made on online US news articles which discussed the 2013 CBM hamburger event (a media-attended event where scientists first revealed CBM to the public and tasted the world's first CBM hamburger patty); this analysis considered 814 comments from 462 commenters, whose socio-demographic characteristics are unknown, and who are likely to hold stronger views towards CBM than non-commenters (Laestadius and Caldwell, 2015). Perceived benefits discussed in qualitative studies were in response to open-ended

questions but may have been primed by the descriptions of CBM provided to participants prior to questioning. In one study, the CBM description mentioned personal, ethical and environmental benefits (Hamlin et al., 2022); two studies used emotive language when referring to impact on animals (Ruzgys and Pickering, 2020; Verbeke et al., 2015); two studies provided framed information but potential bias could not be evaluated (Laestadius and Caldwell, 2015; Tucker, 2014); and one study did not report whether a description was provided (Bogueva and Marinova, 2020). Qualitative results are provided in Tables 3-6.

Overall, **perceived benefits** assessed in **quantitative** studies included both **societal factors (animal welfare, environmental impact, and supporting future generations/populations)** and **personal factors (taste and price)**. Perceived benefits discussed in **qualitative** studies were **similar** to those assessed in quantitative studies, with the addition of the personal factors, **nutrition, health, and safety**.

### **Animal welfare benefits**

Perceived benefits relating to animal welfare were assessed in **one quantitative study** (moderate quality, representative sample) in the US (Boykin, 2019). On average, the surveyed US consumers were found to have neutral views towards animal welfare benefits of CBM, but views varied considerably within the sample. The mean score of  $4.03 \pm 1.80$  on a scale from 1-7 shows that while consumers, on average, 'neither agreed nor disagreed' that 'lab grown meat is good for animals', around 68% of consumers gave a rating between 2.23 and 5.83 (between 'disagree' and 'agree'). This wide range of responses could be attributed to the framed blog post messages presented to participants. Each participant was shown a message that conveyed either a positive, negative or neutral view of CBM, and, thus, may have influenced their responses to questions about perceived benefits. However, only aggregated data were presented for the question about perceived animal welfare benefits; thus, it is not clear whether message framing influenced perceptions.

Benefits relating to animal ethics were recognised in five qualitative studies, only one of which reported the proportion of participants who raised the issue (5%) (Hamlin et al., 2022). Three studies were of moderate quality (Hamlin et al., 2022; Laestadius and Caldwell, 2015; Ruzgys and Pickering, 2020) and two low quality (Bogueva and Marinova, 2020; Tucker, 2014). Four studies were conducted with mostly omnivorous consumers of various ages from Australia, NZ, and Canada; and one study analysed online comments from consumers with unknown characteristics (and potentially stronger opinions than other consumers who would not be inclined to provide comments on online news articles) (Laestadius Caldwell, 2015).

From an animal ethics standpoint, CBM was perceived as advantageous relative to conventional meat because it **did not involve the slaughter of an animal** and was considered a method of producing meat that is **free of cruelty, harm, pain, and exploitation**. Overall, the perceived animal ethics benefits related to the **welfare** of the animals used for meat production and/or the overall **reduction in animals slaughtered** for meat. Notably, in two of the studies, participants were provided with a description of CBM that either mentioned ethical benefits (Hamlin et al., 2022) or used emotive language when describing impact on animals (referred to animals not being 'harmed' or 'killed') (Ruzgys and Pickering, 2020). The other studies either did not report whether participants were provided with a description of CBM, or did not present the specific description, thus potential bias could not be evaluated. Therefore, it is possible that the descriptions of CBM provided in the qualitative studies may have primed participants to discuss animal welfare benefits of CBM.

In the qualitative Australian study of young (Gen-Z) consumers, the authors noted that improved animal welfare was **identified as a benefit** of CBM production primarily by participants who **consume meat less frequently** (Bogueva and Marinova, 2020). This study further revealed that some consumers hold the view that while CBM production removes the need for 'huge exploitation' of animals for their meat, the **same outcome** could be achieved through **humans reducing their consumption of meat**, thus removing the need for CBM (Bogueva and Marinova, 2020). This indicates that for some consumers, the perceived animal ethics benefits may be conditional on perceptions of the need for CBM. Similar views were expressed by NZ consumers (Tucker, 2014) and commenters on US news articles discussing the 2013 CBM hamburger event (Laestadius and Caldwell, 2015).

Examples of quotes illustrating comments made by study participants regarding the perceived animal-ethics benefits of CBM are provided in Table 3.

**Table 2. Summary of quantitative results for studies assessing consumers' perceived benefits of cell-based meat.**

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results					
High	(Anderson and Bryant, 2018)	US	1185	Yes (bias); potential nutritional benefits + framing refers to naturalness or benefits to health, animals, and environment	Clean meat will have benefits for society. <i>No significant differences between experimental vs. control groups. Therefore, only total data presented.</i>	1=Strongly disagree, to, 5=Strongly agree	<b>Strongly agree</b> 23.5%	<b>Agree</b> 41.2%	<b>Neither agree nor disagree</b> 26.2%	<b>Disagree</b> 5.6%	<b>Strongly disagree</b> 3.5%	
High	(Bryant et al., 2019b)	US	1185	Yes (bias): benefits to human health, animals, environment	Clean meat will have benefits for society. Mean	1=Strongly disagree, to, 5=Strongly agree	<b>Total</b> 3.79	<b>Clean meat is natural</b> 3.75	<b>Conventional meat is unnatural</b> 3.82	<b>Challenging appeal to nature</b> 3.71	<b>Control</b> 3.87	<b>p-value</b> 0.14
Moderate	(Boykin, 2019)	US	238	Yes (bias): framed to be supportive, against or neutral towards CBM	"I believe lab grown meat is good for <b>animals</b> ." "I believe lab grown meat is good for the <b>environment</b> ." "I believe lab grown meat is good for <b>future generations of people</b> ".	1 = strongly disagree and 7 = strongly agree	<b>Mean±SD</b> 4.03±1.80 3.79±1.77 3.74 ±1.84					
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias): refers to animals not being 'harmed' or 'killed' (use of emotive language)	I do not see any personal benefits to eating cultured meat. Total sample, % I do not see any personal benefits to eating cultured meat. Mean±SD	1=strongly agree, to 5=strongly disagree	<b>Strongly agree</b> 10%	<b>Moderately agree</b> 16%	<b>Neither agree nor disagree</b> 16%	<b>Moderately disagree</b> 33%	<b>Strongly disagree</b> 25%	
Moderate	(Bryant and Dillard, 2019)	US	480	Yes (bias): framing used to emphasise societal benefits, high tech, or same as meat	Cultured meat is good for the <b>environment</b> , Mean±SD Cultured meat has benefits for <b>society</b> , Mean±SD	1=Strongly disagree, to, 5=Strongly agree	<b>'Societal benefits' group</b> 3.89±0.99 <sup>a</sup>	<b>'High tech' group</b> 3.40±1.08 <sup>b</sup>	<b>'Same meat group'</b> 3.97±0.94 <sup>a</sup>	<b>p-value</b> <b>0.036</b>	<b>0.468</b>	
Low	(Boereboom et al., 2022)	UK	118 Muslim 391 Non-Muslim	Not reported	Cultured meat is tastier than livestock meat Cultured meat is much more sustainable than livestock meat. Mean	1=Strongly disagree, to, 5=Strongly agree	<b>Muslim</b> 2.8	<b>Non-Muslim</b> 2.5	<b>p-value</b> 0.033			

**Note(s):** In each row, values followed by different letters are significantly different.

**Table 3. Quotes illustrating typical comments made by participants regarding perceived animal-ethics benefits of cell-based meat.**

Quality	Reference	CBM definition	Question	Results
Low	(Tucker, 2014)	Mentions positive and negative aspects of CBM but description not provided by authors	Main reasons cited as to why in vitro meat is a good thing.	Animal ethics (n = 10/69) (not problematic because not an animal per se): <ul style="list-style-type: none"> <li>“There’s no ethical problems because there’s no pain” (68m)</li> <li>“There’s no central nervous system; no brain is attached, so there’s no cruelty involved” (41f).</li> <li>“It’s the same efficiency as battery farmed, but there are less ethical issues” (67m).</li> </ul> While these benefits were recognised, nearly all participants rejected CBM due to sensory perceptions of CBM.
Moderate	(Laestadius and Caldwell, 2015)	Framed descriptions provided in articles (not provided by authors)	Content analysis of comments made on online US news articles which discussed the 2013 IVM hamburger event.	N=30 (6%) of commenters held the view that IVM will be better for animals. Most of these commenters addressed CBM’s anticipated benefits to animal welfare and reductions in the number of animals slaughtered for food. <ul style="list-style-type: none"> <li>“This is brilliant technology in its infancy. Many comments here are akin to criticizing the Wright brothers’ first airplane for not featuring in-flight movies and overhead bins for carryon luggage. The potential is that in a hundred years people may laugh at the old barbaric days when humans used to actually kill and eat mammals and fish.”</li> </ul>
<b>Predominantly younger consumers (all or majority aged 18-25 years)</b>				
Low	(Bogueva and Marinova, 2020)	Not reported		(n = 37, 16%) Improved animal welfare because of a switch to cultured meat was seen as an advantage. They described this as “this way we are not harming the animals,” “stop exploiting them.” <b>Raised mainly by those who consume meat less frequently.</b> <ul style="list-style-type: none"> <li>“Extremely necessary as we have not enough resource to sustain the planet and this way we are not harming the animals, but they are still helping us to eat using their cells to grow meat” (a few times per week meat eater, recruitment agent, age group 21–24 years)</li> <li>“Very necessary for climate change and for the animal suffering. I believe scientists [have] done it with all these considerations in mind.” (a few times per week meat eater, assistant manager, age group 21–24 years)</li> <li>“With in vitro you don’t need to kill animals to source your meat. This makes people feel good about the animals.” (a few times per week meat eater, administrator, age group 21–24 years)</li> <li>“In vitro is good for animal welfare viewpoint. Other than that, it’s still an imitation.” (a few times per week meat eater, kindergarten aid, age group 18–20 years)</li> <li>“It’s good for the animals not to be exploited for human food, but actually if the humans reduce their consumption of meat there is no need of a huge exploitation. We don’t even need inventions like cultured meat, just change of our diet will sort the issue.” (a few times per week meat eater, café staff, age group 18–20 years)</li> <li>“It’s needed source of meat without harming animals. I believe it’s humane way to produce lab grown meat instead of real meat.” (occasional meat eater, carpenter, age group 18–20 years)</li> <li>“I don’t like in vitro and plant-based meats as I care about the animal welfare and don’t want to consume anything that resembles meat.” (occasional meat eater, project officer, age group 21–24 years)</li> <li>“Cultured meat is not applicable to my diet. We have to be ethical to animals and stop exploiting them, not artificially multiplying them.” (occasional meat eater, community support worker, age group 18–20 years)</li> </ul>
Moderate	(Hamlin et al., 2022)	Yes (bias): Mentions personal, ethical and environmental benefits	Write UP TO four words, phrases, feelings or thoughts that come to mind when you see this product.	Open responses coded as ‘Ethical’ (<5%): <ul style="list-style-type: none"> <li>“I wish that slaughtering practices were more humane”, “no cruelty”, “animal”, “ethics”, “more ethical”, “ethical meat”, “good that no animals are killed”, “kind”, “cruelty free”, “compassionate”, “saving animal lives”.</li> </ul>
Moderate	(Ruzgys and Pickering, 2020)	Yes (bias): refers to animals not being ‘harmed’ or ‘killed’	Open response question “What is your opinion about the consumption of cultured meat?”	Key themes from the open response question. Animal welfare n=48 (25%) <ul style="list-style-type: none"> <li>“I think it’s a great alternative to the killing of animals”</li> </ul>

## Environmental benefits

Perceived benefits relating to the environment were assessed in **three quantitative studies** conducted in the US and UK - two of moderate quality (Boykin, 2019; Bryant and Dillard, 2019) and one low quality (Boereboom et al., 2022); one of which surveyed a representative sample (Boykin, 2019). On average, a **relatively neutral view** ('neither agree nor disagree') towards environmental benefits of CBM was found among participants in two of the studies conducted in the US (mean rating  $3.79 \pm 1.77$  on a scale from 1-7) and UK (mean ratings ranging from 3.1-3.4 on a scale from 1-5) (Boereboom et al., 2022, Boykin, 2019). Notably, around 68% of US consumers provided ratings between 2.02 – 5.56 on the scale from 1-7 (between 'disagree' and 'agree')(Boykin, 2019). This **wide range of ratings** may be due to the framed messages seen by participants, with environmental benefits or risks mentioned in the respective messages that were in support of or against CBM; however, findings were reported in aggregated form only (Boykin, 2019). Notably, the UK study compared perceptions of Muslim and non-Muslim participants and found non-Muslims had significantly lower levels of agreement with the statement, 'Cultured meat is much more sustainable than livestock meat', compared to Muslims (though still nearest to the 'neither agree nor disagree' rating) (Boereboom et al., 2022). However, it was not reported whether participants were shown a description of CBM, and neither the Muslim nor non-Muslim samples in this study were socio-demographically representative of their respective populations; thus, findings are not able to be generalised.

The **framing of messages** about CBM was found to influence perceptions of the environmental benefits of CBM among US consumers (Bryant and Dillard, 2019). Specifically, survey participants who were shown information that emphasised the **societal benefits (including environmental benefits) or the similarity of CBM and traditional meat**, had a **higher average level of agreement that CBM is 'good for the environment'** (approximating the 'agree' rating/score of 4 on the 5-point scale from 1=strongly disagree to 5=strongly agree) than those who saw information emphasising the technological aspects of CBM (average agreement rating nearer to the midpoint of the scale, labelled 'neither agree nor disagree') (Bryant and Dillard, 2019).

Environmental benefits of CBM were anticipated by participants in **four qualitative studies** – three of moderate quality (Laestadius and Caldwell, 2015; Hamlin et al., 2022; Ruzgys and Pickering, 2020) and one low quality (Bogueva and Marinova, 2020). When interview participants in **NZ** were asked what came to mind when presented with the concept of CBM, about 6% mentioned environmental benefits, including: "environmentally sustainable", "better for the planet", "eco-friendly", "clean", "non-harmful to the environment", "efficiency", "organic", "climate change", "more sustainable" (Hamlin et al., 2022). Among **Australian** participants, mixed views were expressed, with some perceiving CBM to be better for the environment than conventional meat, while others were unsure or believed this was not the case (Bogueva and Marinova, 2020). In response to an open question asking about their opinion on the consumption of CBM, 17% of Canadian participants discussed environmental benefits (Ruzgys and Pickering, 2020). Examples of quotes made by study participants regarding the perceived environmental benefits of CBM are provided in Table 4.

It is important to note that these qualitative findings are not generalisable to the broader population; rather, they represent the range of views among the sampled study participants. **All studies were conducted with predominantly younger consumers** (all or majority



aged 18-30 years) in Australia, NZ and Canada, except for one US study which analysed comments on online news articles from consumers with unknown characteristics (Laestadius and Caldwell, 2015). Further, in three of the studies, it is possible that the provided **descriptions of CBM may have primed participants** to discuss environmental benefits of CBM - in one of the studies, the CBM description mentioned environmental benefits (Hamlin et al., 2022); and in two studies this could not be determined (Laestadius and Caldwell, 2015, Bogueva and Marinova, 2020).

Overall, while qualitative findings indicate that some consumers anticipate environmental benefits of CBM, generalisable quantitative data is lacking from studies that both use representative samples of consumers and provide objective/unbiased descriptions of CBM.

**Table 4. Environmental benefits of cell-based meat perceived by participants in studies conducted in Australia, NZ, the US, and Canada.**

Quality	Reference	CBM definition	Question	Results
Low	(Bogueva and Marinova, 2020)	Not reported	Opinion about cultured meat and whether it is normal and necessary to accept and if available, consume cultured meat;	Mixed views regarding environmental benefits. Perceived as beneficial by some but others were unsure or believed cultured meat was not better for environment. <ul style="list-style-type: none"> <li>“We need to look after the environment. Lab-meat is environmentally better than livestock produced meat and better for the animals.” (occasional meat eater, acrobatics coach, age group 21–24 years)</li> <li>“In vitro meat and other alternatives are important as it can help to reduce greenhouse emissions, save animals and focus on health.” (a few times per week meat eater, installer, age group 21–24 years)</li> <li>“We need to look after the environment. Lab-meat is environmentally better than livestock produced meat and better for the animals.” (occasional meat eater, acrobatics coach, age group 21–24 years)</li> <li>“Livestock producers must make sure that livestock is environmentally sustainable. Ideas like growing meat on a plate under shelter is quite unsustainable.” (a few times per week meat eater, business owner, age group 21–24 years)</li> <li>“With the projected rapid decline in meat availability because of climate change, it’s important to be substituted with some meat alternatives but not cultured meat. You can’t ensure livestock and environmental sustainability with producing extra meat which is the cause of the problem.” (a few times per week meat eater, bartender, age group 21–24 years)“Lab meat could minimize the associations with the environmental impacts and ethical issues, but it is still resource consuming. Think about how much energy is put into it being under constant light and in a special environment. It’s not a sustainable option.” (a few times per week meat eater, remedial massage therapist, age group 18–20 years)</li> </ul>
Moderate	(Hamlin et al., 2022)	Yes (bias): Mentioned personal, ethical and environmental benefits	Write UP TO four words, phrases, feelings or thoughts that come to mind when you see this product.	Open responses coded as 'Benefit to the environment': <ul style="list-style-type: none"> <li>“environmentally sustainable”, “better for the planet”, “eco-friendly”, “clean”, “non-harmful to the environment”, “efficiency”, “organic”, “climate change”, “more sustainable”</li> </ul>
Moderate	(Ruzgys and Pickering, 2020)	Yes (bias): refers to animals not being 'harmed' or 'killed'	Open response question “What is your opinion about the consumption of cultured meat?”	Key themes from the open response question. Environment n=33 (17%) <ul style="list-style-type: none"> <li>“I would 100% try it, I believe it will be very beneficial to the environment and the future of the earth”</li> <li>“It’s not good for you or the environment”</li> </ul>
Moderate	(Laestadius and Caldwell, 2015)	Different descriptions provided in articles (not provided by authors)	Content analysis of comments on online US news articles discussing the 2013 IVM hamburger event.	N=37 (8%) of commenters held the view that IVM will be more sustainable than conventional meat production. <ul style="list-style-type: none"> <li>“I have been waiting for this for a long time as this will be a great environmental benefit if this were taken commercial. The biggest issue will be educating the public that this is a better way to go. I am all for it”</li> </ul>

## Societal benefits

Perceived benefits to society (other than environmental and animal welfare benefits) were assessed in **three quantitative studies** conducted in the US – one **high quality** (Anderson and Bryant, 2018) and two **moderate quality** (Boykin, 2019; Bryant and Dillard, 2019) – two of which surveyed **representative samples** (Anderson and Bryant, 2018; Boykin, 2019). Similar findings were reported in two studies which assessed participants' agreement with the statement that CBM will have benefits for society, using a 5-point scale (Anderson and Bryant, 2018, Bryant and Dillard, 2019). In both studies average agreement levels fell between neutral ('neither agree nor disagree') and 'agree' ratings on the scale (mean scores 3.63-3.78 on the scale from 1-5); in the high-quality representative study, 65% of consumers agreed with the statement to some extent and 26% provided a neutral response ('neither agree nor disagree') (Anderson and Bryant, 2018). Notably, participants had similar perceptions regarding societal benefits of CBM, regardless of how information about CBM was framed (either emphasising the societal benefits of CBM, the similarity of CBM and traditional meat, or the technological aspects of CBM) (Bryant and Dillard, 2019). The third study assessed consumers' perceptions that CBM 'is good for future generations of people' and found that the average rating ( $3.74 \pm 1.84$  on a scale from 1=strongly disagree to 7=strongly agree) approximated 'neither agree nor disagree' (Boykin, 2019). However, views varied widely between consumers, with 68% of ratings between 'disagree' (1.9 on the scale) and 'agree' (5.6).

Other perceived societal benefits of CBM were raised in **two qualitative studies** conducted in NZ (moderate quality) (Hamlin et al., 2022) and the UK (low quality) (Verbeke et al., 2015). Participants in NZ (predominantly aged  $\leq 25$  years) were asked what came to mind when presented with the concept of CBM (in picture and written/spoken form), and approximately 5% mentioned a 'benefit to humanity', including: "One solution to famine", "human demand", "business opportunity", "future of food", "probably needed for future", "alternate solution", "future needs it", "future thinking" (Hamlin et al., 2022). However, these perceived benefits to humanity were not explored more deeply. Additionally, potential global societal benefits, including CBM playing a role in solving global food shortages and food insecurity, were acknowledged by focus group/online survey participants in the UK (Verbeke et al., 2015). However, these factors were only considered benefits in the absence of risks to human health (Verbeke et al., 2015). An example of a quote made by UK participants regarding potential societal benefits is shown in Table 5.

- Evidence from multiple studies (two of high quality but most of moderate or low quality; some of which surveyed representative samples), suggests consumers, on average, have neutral views towards the societal benefits of CBM, including benefits for the environment, animal welfare, and future populations/food security; however, views can vary widely between consumers.
- Qualitative findings provide insight on the factors underlying diversity of opinion about these benefits. For example, consumers' perceived benefits for animals were related to the treatment of animals and/or the absence of slaughtering; however, some consumers highlighted that the same outcomes could be achieved by reducing current levels of meat consumption. Further, global societal benefits were only perceived as benefits if there are no risks to human health.

**Table 5. Comments made by UK participants regarding perceived societal benefits of cell-based meat.**

Quality	Reference	CBM definition	Question	Results
Low	(Verbeke et al., 2015)	Yes(bias) refers to animal cruelty (uses emotive language when referring to animal impact).  YouTube video: 'Would you eat synthetic meat?', produced by the Royal Institution of Australia.	Participants were prompted to make comments and ask questions (in focus groups) or leave comments and questions (in the online survey) relating to the video.	Acknowledging potential societal benefits. Open to perceiving possible global societal benefits from a partial shift to cultured instead of traditional meat. <ul style="list-style-type: none"> <li>“But I mean, the...the third world and stuff, I mean, that sort of...that sort of research in...you know, if you think about the amount of people that are starving in poor places like Africa, if you could generate a food source that was sustainable, you know, it could change the world for millions of people, couldn't it? So, that's why I'm open to the concept of them trying to develop something like this.” (UK FG1, M, 40)</li> </ul>

### Personal benefits

Perceptions of personal benefits of CBM were assessed in **two quantitative studies** of moderate (Ruzgys and Pickering, 2020) and low quality (Boereboom et al., 2022), conducted in the UK and Canada. On average, both studies found **relatively neutral views regarding personal benefits** of CBM in their respective samples of young Canadians (Ruzgys and Pickering, 2020) and Muslim and non-Muslim participants in the UK (Boereboom et al., 2022). Specifically, for the statement, **‘I do not see any personal benefits to eating cultured meat’**, the average agreement level of Canadian participants fell between neutral (‘neither agree nor disagree’) and ‘moderately disagree’ on the rating scale (Ruzgys and Pickering, 2020). Notably, the mean score of  $3.47 \pm 1.30$  (on a scale from 1-5) shows that while consumers, on average, ‘neither agreed nor disagreed’ with the statement about personal benefits of eating CBM, around **68% of consumers** gave a rating between 2.17 and 4.77 (**between ‘moderately agree’ and ‘strongly disagree’**). Thus, views about personal benefits varied widely among young Canadians. For statements assessing **beliefs that CBM is tastier and cheaper than livestock meat**, significantly higher average agreement ratings were found among Muslims than non-Muslims in the UK, with ratings of Muslims closer to ‘neither agree nor disagree’ and ratings of non-Muslims closer to ‘moderately disagree’ (Boereboom et al., 2022). While it is not clear whether a description of CBM was provided to participants in the UK study, Canadian participants saw a description that highlighted, in a relatively objective manner, the comparability of CBM and traditional meat in terms of sensory characteristics. This would have reduced the likelihood of influencing Canadian consumers’ perceptions about personal benefits of CBM.

Perceived health benefits were discussed in **two qualitative studies** of moderate (Hamlin et al., 2022) and low quality (Verbeke et al., 2015) conducted in NZ and the UK (see Table 6) (Hamlin et al., 2022, Verbeke et al., 2015). In the NZ study of predominantly younger participants, approximately 6% of participants identified at least one personal benefit when presented with the concept of CBM and asked what came to mind (Hamlin et al., 2022). The following free text responses were coded as ‘personal benefit’: “healthy”, “safe”, “nutritious”, “quality”, “cheap”, “taste”, “naturalness”, “quality”, “healthfulness”, “vegan”, “vege”. However,

these perceived personal benefits of CBM were not explored more deeply. Further, most of the 60 UK consumers who participated in a focus group discussion or online survey, **perceived few personal benefits**, including benefits for their health or consumption practices, and this was mainly attributed to **uncertainty regarding the taste and price of CBM** (Verbeke et al. 2015). The CBM description provided to NZ participants highlighted that compared to traditional meat, CBM helps to prevent food-borne illnesses, enables the replacement of unhealthy saturated fat with healthier fat, and has equivalent taste/sensory characteristics. This information may have influenced consumers' perceptions of personal benefits of CBM. In contrast, it is not clear whether a description of CBM was provided to participants in the UK study, and how this might have influenced responses.

- The limited available evidence (all of moderate or low quality) suggests that **consumers, on average, are uncertain about the personal benefits of CBM**, which is not surprising given that consumers in these studies did not have market access to CBM (thus, had no personal experience with CBM products). Qualitative findings provide **insight into the range of personal benefits** that may be perceived by some consumers, which include benefits related to **health, safety, nutrition, quality, price, taste and naturalness**.

**Table 6. Quotes illustrating typical comments made by participants regarding perceived personal benefits of cell-based meat.**

Quality	Reference	CBM definition	Question	Results
Moderate	(Hamlin et al., 2022)	Yes (bias): Mentioned personal, ethical and environmental benefits	Write UP TO four words, phrases, feelings or thoughts that come to mind when you see this product.	Open responses coded as 'Personal benefit' "healthy", "safe", "nutritious", "quality", "cheap", "taste", "naturalness", "quality", "healthfulness", "vegan", "vege"
Low	(Verbeke et al., 2015)	Yes (bias). Refers to animal cruelty (uses emotive language)		Overall, the participants saw few direct personal benefits in cultured meat in terms of expected taste, improving their eating habits, or personal health. <ul style="list-style-type: none"> <li>• "If it's tasty and if it tastes the same and it's the same, then, yeah, why not?!" (UK FG5, M, 35)</li> </ul>

**Research Q4: What are consumers' perceived risks and/or downsides of cell-based meats (e.g. taste, texture, health, sustainability, safety, 'unnaturalness', manufacturing process, cost)?**

A total of 18 studies from 16 publications examined consumers' perceived risks or disadvantages of CBM, of which 13 were **quantitative studies** (Arango et al., 2023, Boykin, 2019, Hallman and Hallman, 2020, Jenkins et al., 2021, Juhasz et al., 2023, Krings et al., 2022, Malavalli et al., 2021, Malerich and Bryant, 2022, Wilks et al., 2021, Wilks and Phillips, 2017, Shaw and Mac Con Iomaire, 2019) and six were **qualitative studies** (Bogueva and Marinova, 2020, Hamlin et al., 2022, Laestadius and Caldwell, 2015, Verbeke et al., 2015, Shaw and Mac Con Iomaire, 2019, Ruzgys and Pickering, 2020). Two of the studies were counted in both quantitative and qualitative studies as they included **mixed methods** (Shaw and Mac Con Iomaire, 2019, Ruzgys and Pickering, 2020). Half of the studies were conducted in the US, including eight quantitative studies (Arango et al., 2023, Boykin, 2019, Hallman and Hallman, 2020, Jenkins et al., 2021, Malerich and Bryant, 2022, Wilks et al., 2021, Wilks and Phillips, 2017) and one qualitative study (Laestadius and Caldwell, 2015) with another conducted in the US, Europe and the UK (Krings et al., 2022). Two studies were conducted in NZ, one quantitative (Malavalli et al., 2021) and one qualitative (Hamlin et al., 2022); two in Canada (Juhasz et al., 2023, Ruzgys and Pickering, 2020); and one each in Australia (Bogueva and Marinova, 2020), the UK (Verbeke et al., 2015) and Ireland (Shaw and Mac Con Iomaire, 2019). Half of the studies were appraised as low quality and the other half were moderate quality (See Table 24 in the Conclusion). A largely representative sample was used in seven studies (Boykin et al., 2019, Hallman & Hallman 2020, Juhasz et al., 2023, Jenkins et al., 2021, Malerich and Bryant, 2022, Wilks et al., 2021, Wilks and Phillips).

### **Quantitative findings**

Most of the quantitative studies assessed perceived risks related to general risk and health or food safety concern about CBM products that are **not yet on the market** (see Table 7). Only one study (Arango et al., 2023) assessed perceived risks explicitly **in the context that 'if the CBM product was available now'**.

Three of the moderate quality studies asked participants how strongly they agreed with the statement that 'Cultured meat will have safety issues that we don't know about yet' (Wilks et al., 2021), or how likely that lab-grown meat 'poses a serious danger to future generations' or 'presents a serious health threat' or 'is harmful to my health' (Boykin, 2019), or 'do you think in-vitro meat has any health and safety concerns' (Malavalli et al., 2021). The average mean perceived risk score on a 5-point scale (1='risk is very unlikely' and 5='risk is very likely') was similar in all three studies [ $3.27 \pm 1.07$  (Wilks et al., 2021),  $3.29 \pm 1.14$  (Boykin, 2019), and  $3.27 \pm 0.94$  (Malavalli et al., 2021)], indicating a **moderate level** of perceived risk about CBM consumption. A similar level of perceived risk was reported in a NZ study regarding any health and safety concerns of in-vitro meat ( $3.27 \pm 0.94$ ), although the perceived risk regarding food safety was neutral ( $2.54 \pm 0.88$ ), on average (Malavalli et al., 2021). Further, when examining the proportion of consumers who selected each point on the rating scale, more than half (54.8%) of consumers were 'worried' or 'extremely worried' about potential risks of consuming CBM and more than one-third perceived that consumption of CBM was 'likely' or 'extremely likely' to seriously harm their health (Jenkins

et al. 2021). Additionally, unknown long-term health effects of consuming cultured meat were rated among the two greatest concerns for almost two-thirds of Irish consumers surveyed (66% urban and 58% rural) (Shaw and Mac Con Iomaire, 2019).

In another US study, where participants were randomly assigned to view an image of either beef, chicken or salmon labelled with one of the CBM names identified in recent FDA and USDA feedback requests and were asked to rate how safe it would be to eat the product (Malerich & Bryant, 2022), the mean perceived risk scores ranged from 3.39 for chicken to 4.31 for salmon on a 5-point scale where 1= 'very unsafe' and 5='very safe. Results from this study indicated a low level of safety concern for consuming the CBM product. It is worth noting that risk perception was evaluated in relation to different names and no description of CBM was provided.

Inconsistency in the perceived risks may partly be due to how the risks were framed in the studies, whether a CBM description was provided and if it was a neutral or biased description. Participants were also told that the product was not yet available commercially due to a high production cost in one study (Wilks et al., 2021), which may contribute to a higher level of perceived risks as consumers might view this to mean that the product has not been approved for sale.

Three studies from one publication (Arango et al., 2023) examined the impact of demand-based vs. supply-based scarcity appeals, strategies commonly used in advertising and marketing, on consumers' risk perception about a CBM product. Demand-based scarcity appeals promote popularity of a product (e.g., best-selling, high demand), whereas supply-based scarcity appeals highlight exclusivity (e.g., limited edition or number available). Participants were randomly assigned to either a demand-based scarcity or supply-based scarcity appeal or control, with or without providing information regarding the naturalness of the product. Participants were asked to rate their perceived risks if the product was available. Risk perceptions were measured using a 7-point scale. Results from the studies showed that risk perception was lower in demand-based scarcity appeal compared with supply-based scarcity appeal or control (no scarcity appeal) when the naturalness of the product was not mentioned (Arango et al., 2023). In contrast, risk perception did not differ between the demand-based, supply-based scarcity appeals or control when the product was described as naturally produced (Arango et al., 2023). This finding suggests that demand-based scarcity appeal may be a possible strategy to reduce consumers' perceptions of risk associated with CBM. One of the studies also briefly explored the impact of scarcity appeals on different dimensions of risk and found that their impact on perceived physical risk was similar to their impact on perceived general risk but had no significant impact on perceived psychological risk (e.g., discomfort associated with purchasing CBM) or social risks (e.g., how consumers of CBM would be perceived by others) (Arango et al., 2023).

- Overall, the evidence from the quantitative studies suggests, on average, low to moderate levels of perceived risks about consuming CBM. However, perceived risks were assessed mostly in the context of assuming the CBM products were not yet available for sale on the market. Only one study assessed perceived risk in the context 'if the product was available' to determine the impact of demand-based vs. supply-based scarcity appeals on consumers' perceived risks of CBM.

**Table 7. Consumers' perceived risks of cell-based meat (quantitative findings).**

Quality	Reference	Country	N	CBM Definition	Question	Response scale	Results							
							Demand-based	Mean±SD Supply-based	Control					
Low	Arango et al., 2023 Study 1	US	181	NR	Participants were provided with a statement: if the product was available now, then asked to rate whether a cultured chicken nugget product seemed "risky," "harmful," and "unsafe" with either a 'Demand-based scarcity' appeal ("Due to high demand, only 5 units of this products are available"), 'Supply-based scarcity' appeal ("Due to limited supply, only 5 units of this products are available") or 'No scarcity' appeal (Control)	1 = not at all, 7 = very much	2.50±1.21 <sup>a</sup>	3.14±1.70 <sup>b</sup>	3.30±1.68 <sup>b</sup>					
							Study 2	361	NR	Similar design as in Study 1 with some changes: 1) used a different product (burger patty), 2) used 'best seller' to indicate 'Demand-based scarcity' and 'limited edition' for 'Supply-based scarcity' and highlighted in Red fonts; 3) manipulated perceived naturalness as either 'Heightened naturalness' (the development of this product resembles how cells naturally grow within an animal, which is present in natural life) or 'Non-heightened naturalness' (no communication about naturalness) condition.	Heightened naturalness Non-heightened naturalness	2.50±1.21 <sup>a</sup>	3.14±1.70 <sup>b</sup>	3.30±1.68 <sup>b</sup>
												2.73±1.34 <sup>a</sup>	3.44±1.54 <sup>b</sup>	3.51±1.70 <sup>b</sup>
Study 3	594	NR	Used the same descriptions as in Study 1 for Demand-based and Supply-based scarcities and manipulated perceived naturalness as in Study 2. In addition, participants were informed at the beginning of the survey that the product is currently not available for the public and risk perceptions were explored with different dimensions including physical, phycological and social risks.	Heightened naturalness Non-heightened naturalness	<b>Physical risk</b>									
					3.33±1.74 <sup>a</sup>	3.08±1.37 <sup>a</sup>	3.32±1.52 <sup>a</sup>							
						Heightened naturalness & Non-heightened naturalness	<b>Psychological risk &amp; social risk</b>							
							No significant difference							
Moderate	Boykin et al., 2019	US	238	Yes (bias) framed to be supportive, against or neutral towards CBM	How likely that lab grown meat poses a serious danger to future generations How likely that lab grown meat presents a serious health threat How likely that lab grown meat is harmful to my health	1 = very unlikely, 5 = very likely	<b>Mean±SD</b>							
							3.33 ±1.24							
							3.30 ±1.22							
						3.25 ±1.22								
							<b>Mean±SD</b>							



Quality	Reference	Country	N	CBM Definition	Question	Response scale	Results					
							Pesticides	Other Contaminants	Unhealthy mercury			
Moderate	Hallman & Hallman, 2020	US	3186	NR (for perceived risk)	1. Compared to wild caught, does the product has more, less, or the same amount of pesticides (Scale: 1=Less, 2=same, 3=More) 2. Compared to wild caught, does the product has more, less, or the same amount of microplastics, mercury, antibiotics, bacteria, artificial colours, growth hormones other environmental contaminants. (Scale: 1=Less, 2=same, 3=More) 3. How likely that the product contains unhealthy amount of mercury (scale: 1=extremely unlikely, 7=extremely likely)	Cultured Cell-based Cell-cultured Cultivated Cultivated from the cells of Grown from the cells of Produced using cellular Ag Wild caught Farm raised Control	1.94±0.74 <sup>a</sup> 1.85±0.76 <sup>abc</sup> 1.80±0.75 <sup>abc</sup> 1.85±0.76 <sup>ab</sup> 1.74±0.75 <sup>bc</sup> 1.65±0.71 <sup>c</sup> 1.71±0.73 <sup>bc</sup> NA NA NA	No difference	3.60±1.58 <sup>cd</sup> 3.78±1.72 <sup>bcd</sup> 3.66±1.72 <sup>bcd</sup> 3.92±1.71 <sup>abc</sup> 3.47±1.75 <sup>d</sup> 3.61±1.77 <sup>cd</sup> 3.57±1.81 <sup>cd</sup> 4.14±1.66 <sup>a</sup> 3.47±1.80 <sup>d</sup> 4.08±1.61 <sup>ab</sup>			
Moderate	Jenkins et al., 2021	US	907	Yes (neutral)	How likely is it that your health will be damaged by consuming lab-grown meat How seriously do you think consuming lab-grown meat may harm your health How worried are you about potential risks associated with consumption of lab-grown meat? How risky do you consider consuming lab-grown meat to be?  How risky do you consider consuming lab-grown meat to be?	1=Not likely at all, 7=Extremely Likely 1=Not seriously at all, 7=Extremely seriously 1=Not worried at all, 7=Extremely worried  1=Not at all risky to consume, 7=Highly risky to consume	Scale 1- 2 (%) 12.0 Scale 3 (%) 12.0 Scale 4 (%) 35.6 Scale 5 (%) 22.1 Scale 6- 7 (%) 17.0	10.3 12.8	14.0 10.1	31.9 21.6	23.5 26.2	18.0 28.6
							<b>Mean±SD</b>					
							4.62±1.56					
Low	Juhasz et al., 2023	Canada	10,019	NR	Which, if any of these concerns would you most have about consuming cultured proteins? 1. Cost—it will be too expensive 2. Taste—it sounds gross/it won't be as good as real meat 3. Health—it is not as healthy as real meat 4. Safety—it is not safe to eat 5. Ethics—taking jobs away from farmers and ranchers 6. Identity—eating meat is part of my culture/identity 7. None of the above		Overall 41 NR NR NR NR NR NR NR	% 38 NR NR NR NR NR NR NR	Gen Z			
Low	Krings et al, 2022	EU, UK & USA	273 (Experiment 3)	Yes (neutral)	Perceived safety (exact question wasn't reported)	1=Seems extremely unsafe, 7=Seems extremely safe	5.37±1.06	5.17±1.07	0.001			
Moderate		NZ	206	Yes (bias, mentioned)	Do you think in-vitro meat (IVM) has any health and safety concerns?	1=Definitely not, 5=definitely yes	<b>Mean±SD</b> 3.27 ±0.94					



Quality	Reference	Country	N	CBM Definition	Question	Response scale	Results		
	Malavalli et al., 2021			environmental, ethical and health benefits)	Do you think in-vitro meat (IVM) is likely to cause any disease? Do you think in-vitro meat (IVM) is cancerous as it involves stem cells? Do you think in-vitro meat (IVM) will have any food safety risk?		2.47±1.01 2.86±0.89 2.54±0.88		
Moderate	Malerich & Bryant, 2022	US	2653	NR	Participants were randomly assigned to view an image of a product labelled with one of the 9 names identified in recent FDA and USDA feedback requests and consumer survey and one of the three products [beef (B), chicken (C) and salmon (S)]. They were then asked how safe it would be to eat the product for someone who was not allergic to the meat generally.	1=Very unsafe, 5=Very safe, or Don't know	<b>Mean±SD</b>		
							<b>Beef</b>	<b>Chicken</b>	<b>Salmon</b>
						Cell-cultivated	3.76	3.82	3.90
						Cultivated	4.03	4.04 <sup>b</sup>	4.08
						Cell-cultured	3.96	3.96 <sup>b</sup>	4.16 <sup>d</sup>
						Cultured	3.90	4.13 <sup>b</sup>	3.64 <sup>e</sup>
						Cell-based	3.92	3.87	3.68 <sup>e</sup>
						Novari	4.15 <sup>a</sup>	4.13 <sup>b</sup>	4.31
						Lab-grown	3.93	3.39 <sup>c</sup>	3.70 <sup>e</sup>
						Artificial	3.73	3.58	3.55 <sup>e</sup>
						Descriptive	4.05	3.78	4.01
Low	(Shaw and Mac Con lomaire, 2019)	Ireland	312	Yes (neutral)	Rate the following concerns from 1 to 5 in the order which you think are of greatest concern.	1=of greatest concern	<b>Among top-2 greatest concerns</b>		
					Nutritional value of cultured meat		<b>Urban</b>	<b>Rural</b>	<b>p-value</b>
					Unknown long-term health effects of consuming cultured meat		<b>NR</b>	<b>NR</b>	<b>NS</b>
					Damaging effect on agri-business and livelihood of farmers		<b>66%</b>	<b>58%</b>	<b>&lt;0.05</b>
					Damaging effect on Irish beef industry and Irish economy		<b>29%</b>	<b>44%</b>	<b>&lt;0.05</b>
					Lack of traceability of meat source		<b>NR</b>	<b>NR</b>	<b>NS</b>
Low	Wilks & Phillips 2017	US	673	Yes (mentioned animal welfare)	Participants were told that CBM isn't available commercially yet before answering the question: How much of a risk do you think there is for zoonosis for IVM compared to farmed meat?	1=much more, 5=much less	<b>Mean±SD</b>		
							3.95 ±1.02		
Moderate	Wilks et al., 2021	US	862	Yes (mentioned animal welfare)	Participants were told that CBM isn't available yet due to high production cost before rating the statement: Cultured meat will have safety issues that we don't know about yet	1=strongly disagree, 5=strongly agree	3.27 ±1.07		

**Note(s):** In each row, values followed by a different letter are significantly different while those with a same letter indicates no significant difference; NR = Not reported; NS = Not statistically significant.

## Qualitative findings

Six studies reported qualitative findings regarding consumers' perceived risks or disadvantages of CBM – three of **moderate quality** (Ruzgys and Pickering, 2020; Hamlin et al., 2022; Laestadius and Caldwell, 2015) and three **low quality** (Verbeke et al., 2015, Bogueva and Marinova, 2020; Shaw and Mac Con Lomaire, 2019). A **representative sample** was used in one study only (Bogueva and Marinova, 2020). Qualitative data was collected using focus group discussions, individual interviews and online surveys in Australia, NZ, Ireland, and the UK, with sample sizes ranging from 23 to 254. Additionally, one US study analysed online comments made on online US news articles which discussed the 2013 CBM hamburger event; this analysis considered 814 comments from 462 commenters of **unknown characteristics** (Laestadius and Caldwell, 2015). Overall, the perceived risks or disadvantages of CBM raised in these qualitative studies related to personal health and societal/ethical factors. Concerns about adverse societal consequences included concerns about risks to the environment; risks to the economy and farmers; and other concerns related to unethical practices and changes to society (including anticipated loss of human cultural practices and traditions that centre on meat; and betrayal of their meat-producing country).

The reported findings represent **consumers' responses to open-ended questions**, rather than closed questions (e.g., asking consumers to rate or rank predetermined statements or to select from predetermined options). The information about CBM provided prior to asking open questions varied across studies. Notably, only one of the six studies presented a **neutral description of CBM** to participants (Shaw and Mac Con Lomaire, 2019). The remaining studies either presented a biased description or the level of bias could not be determined. Specifically, one study (of young NZ consumers) mentioned personal, ethical and environmental benefits in the CBM description (Hamlin et al. 2022) and another study (of young Canadian consumers) used emotive language when describing impact on animals (i.e., referred to animals not being 'harmed' or 'killed') (Ruzgys and Pickering, 2020).

### Risks to personal health

In **all** six qualitative studies, participants raised concerns about personal health risks associated with CBM (see Table 8). Participants in these studies expressed a belief that **CBM will be unhealthy/have poor nutritional value** and/or that CBM will **pose a food safety risk**. The concern that CBM will be unhealthy or will have poor nutritional value was expressed in three studies conducted in Australia, NZ, and the UK (Bogueva and Marinova, 2020, Hamlin et al., 2022, Verbeke et al., 2015). Specifically, 32% of young Australians surveyed believed CBM was not healthy or nutritious, which was commonly related to **perceptions of the production process**, with CBM being described as "far too chemically processed" and associated with "engineering and modifications" (Bogueva and Marinova, 2020). Similarly, UK participants' fear that consumption of CBM would lead to nutritional deficiencies stemmed from **perceiving CBM as unnatural** and **being uncertain about its health effects** (Verbeke et al., 2015). Additionally, participants interviewed in NZ described CBM as "fatty" when asked what came to mind when presented with the CBM concept; however, this perception was not explored more deeply. Further, this perception of CBM being 'fatty', was expressed despite participants being shown a description of CBM that stated that '...healthier fat can be added to muscle cells in replacement of unhealthy saturated fat in traditional products'(Hamlin et al., 2022).

In all studies, some participants expressed concern that CBM **will pose a food safety risk or could potentially in the future**. Perceptions of CBM as “harmful” or a food safety risk were expressed by participants in NZ and the US (Laestadius and Caldwell, 2015, Hamlin et al., 2022). Concerns about the **possible unknown adverse health effects** (“side effects”), including long-term consequences, of consuming CBM were raised by participants in Australia, Ireland and the UK (Verbeke et al., 2015, Shaw and Mac Con Iomaire, 2019, Bogueva and Marinova, 2020). The **novelty of CBM and its production process, contributed to these concerns**, and in the UK study, CBM was likened to other substances such as asbestos that initially were considered safe but later were shown to be unsafe (Verbeke et al., 2015). Further, UK participants expressed doubt regarding the safe and practical implementation of the science behind the production of CBM (Verbeke et al., 2015). They highlighted several concerns, including the **potential occurrence of “mutations” during the production process** and the **risk of bacterial contamination** in entire production batches. Overall, they found it challenging to comprehend the feasibility of scaling up CBM production from a single cell and were curious about the criteria for selecting healthy animals for initial cell harvesting. Participants **raised numerous questions** regarding the laboratory-based production of CBM as they sought to understand the scientific processes involved in CBM.

Potential unknown adverse health effects were a major worry of participants in studies in Australia and the UK (Bogueva & Marinova 2020; Verbeke 2015). While young Australian participants **expressed relief that CBM is not yet on the market** (Bogueva and Marinova, 2020), participants in the UK study highlighted a need for **strict health and safety controls and regulations** to allow consumers to make safe and informed food purchase decisions (Verbeke et al., 2015). Similarly, 8% of young Canadians, expressed a need for **more information to help alleviate concerns about short- and long-term health risks** of CBM, when asked about their opinion about the consumption of CBM (Ruzgys and Pickering, 2020)

Overall, participants **expressed health concerns about CBM primarily due to two factors**: the perception that CBM is **unnatural or manufactured**, and their **uncertainty regarding the current scientific understanding** of CBM. These concerns contributed to worries about **potential unknown short- and long-term health effects**. Comments also suggest a **concern about or perceived need for trustworthy health and safety information, and regulations regarding CBM**. Examples of quotes illustrating the types of comments made by study participants who perceived health risks of CBM are provided in Table 8.

**Table 8. Quotes illustrating typical comments made by study participants regarding perceived health risks of cell-based meat.**

Quality	Reference	Design/sample	CBM defined	Results
Low	(Verbeke et al., 2015)	60 UK consumers participated in a focus group or completed an online survey	Yes (bias)	<p>A number of concerns expressed about potential negative long-term effects of CBM on human health, largely centred on potential unknown risks. Participants' main concerns about CBM related to expected poor nutritional value and unknown negative health impacts, underpinned by perceptions (un)naturalness and the view that what is not natural is likely to have negative health effects. Consequently, the participants insisted that convincing health and safety checks and quality controls would have to be carried out on cultured meat before it is marketed.</p> <ul style="list-style-type: none"> <li>• “How do we know that many years down the line they will not decide that synthetic meat harms you in some way? After all, after generations of eating red meat it is only in the last few years that we have heard so much about how detrimental to our health red meat is.” (UK Online488, F, 41–50)</li> <li>• “Unfortunately, I was unable to keep watching the video. However, as a consumer I would be concerned about the use of in-vitro meat, just as I am about the use of genetically modified crops. I would want to be certain that this sector was very tightly regulated and that if/once this is released for sale, I would wish to ensure that it was very clearly labeled and adequate information provided to consumers about this product and any way in which it had been modified.” (UK Online494, M, 31–35)</li> </ul>
Low	(Shaw and Mac Con lomaire, 2019)	Focus groups with 23 Irish participants in urban (U) and rural (R) areas	Yes (neutral)	<p>Concern about the safety of cultured meat:</p> <ul style="list-style-type: none"> <li>• “I’d wonder that if years down the line it would come out that oh actually that process we were doing causes cancer” (G1M, R)</li> <li>• “We don’t know the long-term effects on us” (G3F, U)</li> <li>• “The uncertainty and the side effects of eating something manufactured like that” (G4F, U)</li> <li>• “There’s too much unknown about it” (G2M, R)</li> </ul> <p>Distrust in food companies and labelling</p> <ul style="list-style-type: none"> <li>• “They could throw anything into it after a while” (G4F, U)</li> <li>• “Who’s to say that they’ve picked a good cut...and haven’t thrown something else into the mix along the way” (G3F, U)</li> <li>• “It will start off being handled well, but then people will abuse it” (G4M, U)</li> <li>• “Was it produced in Ireland or was it packaged in Ireland? I only heard something from the weekend about [companies] putting the Irish flag on things and it’s not Irish at all” (G4F, U)</li> <li>• “There was this meat packaging place I think it was down in Cork that was saying “oh yeah 100% Irish beef” but the stuff was being imported from Argentina but because they were packaging it in Cork they were allowed to call it 100% Irish beef” (G1M, R)</li> <li>• “A way for them to charge you more money” (G2F, R)</li> <li>• “Sure you never know for sure [if the meat is truly organic]” (G1M, R)</li> <li>• “I’ve heard so many conflicting stories that “oh this is organic” but then you hear it’s not organic at all...I wouldn’t really trust it” (G1M, R).</li> <li>• “I wouldn’t definitely believe that everything [that is labelled organic] is pure organic” (G2M, R)</li> </ul>

Quality	Reference	Design/sample	CBM defined	Results
Moderate	(Laestadius and Caldwell, 2015)	Content analysis of comments made on online US news articles which discussed the 2013 IVM hamburger event.	Yes (framing and likely bias/ but news articles not available for evaluation)	IVM will pose food safety risk (2%); IVM will result in unknown or unanticipated negative risks to humans and/or the environment (5%). <ul style="list-style-type: none"> <li>• 'I would like to know the exact nutritional components of lab created food. I'll bet there aren't many. You cannot fool Mother Nature—only stupid humans'.</li> </ul> 'I'm also a cell biologist. The thought of consuming this "product" bathed in growth factors, steroids, fetal bovine serum, and who knows what else makes me ill. But the point about viruses and other contaminants is one I had had not considered—cells grown in the lab, removed from the cow or whatever host animal, will not have the benefit of an immune system to prevent the proliferation of all sorts of human pathogens. This stuff will make factory farm cattle, raised in the worst possible manner, seem like free range beef by comparison'
<b>Predominantly younger consumers (all or majority aged 18-25 years)</b>				
Low	(Bogueva and Marinova, 2020)	Online survey with 226 young Australians (18-24y)	Not reported	Not convinced that cultured meat will be safe for consumers. A major worry is the possible unknown "adverse," "negative," "hidden side effects" of cultured meat. <ul style="list-style-type: none"> <li>• "If we think about the future food security of the planet, we have to be ready to accept anything. But I believe engineered and chemically processed food are not good for human to consume. I even think these will counteract in the opposite direction and contribute to human non-communicable diseases." (occasional meat eater, nurse, age group 21–24 years)</li> <li>• "Maybe there are more health benefits to not eat meat than eating cultured meat. They could be some future side effects to human from eating it. It's good that it is not mass market produced yet." (non-meat eater, solicitor, age group 21–24 years).</li> <li>• "Artificial growth cells and hormones to make it edible in vitro meat thanks god that is still an underdeveloped technology. No one knows what this meat will be lacking and what will be the side effects for us." (daily meat eater, high school sports aid, age group 18–20 years)</li> <li>• "Not normal, maybe the good thing about it is that humans created some emerging modern technology but multiplying cells to grow meat for human is wrong. It's against the nature and if we consume it, we will pay sooner or later for this." (daily meat eater, university student, age group 18–20 years)</li> <li>• "Scientists created in vitro meat cultivation because of their interests to advance in technologies, but this doesn't mean what they created is good for human consumption without any future negative effects." (daily meat eater, trading operations analyst, age group 21–24 years)</li> <li>• "Need scientifically proven information about cells-made meat before trying it. It could have some unhealthy side effects." (occasional meat eater, graphic designer, age group 21–24 years)</li> <li>• "We don't know yet if we are going to eat cultured meat. It's still in early stage of its development and far away from the natural meat appearance. It can't be possible to not have some future negative effects on human." (daily meat eater, physiotherapist, age group 21–24 years)</li> </ul>
Moderate	(Hamlin et al., 2022)	Individual interviews with n=542 NZ participants (72% aged 18-24y)	Yes (bias). Mentioned personal, ethical and environmental benefits	Open response question: 'Write UP TO four words, phrases, feelings or thoughts that come to mind when you see this product' Responses coded as 'Personal risk': <ul style="list-style-type: none"> <li>• Unsavoury, unorganic, fatty, potentially expensive, harmful, concern of quality, disease, protein will be harmful, not hygienic, reinforces misconception</li> </ul>
Moderate	(Ruzgys and Pickering, 2020)	Online survey of 200 Canadian university students (18-30y)	Yes (bias). Referred to animals not being 'harmed' or 'killed'	Open response question: "What is your opinion about the consumption of cultured meat?" Want more information: n=16 (8%) <ul style="list-style-type: none"> <li>• "I think it sounds like a good idea, but further research on the effects of it on human health, short term and long term need to be studied"</li> <li>• "Would prefer to know long-term effects of consuming GMO's like this before turning to it as my only meat source"</li> </ul>

## Risks to the environment

In four studies (two moderate quality and two low quality; none using representative samples), participants raised concerns regarding the environmental impact of CBM (Bogueva and Marinova, 2020, Hamlin et al., 2022, Laestadius and Caldwell, 2015, Verbeke et al., 2015). In three studies conducted in Australia, NZ, the UK, participants' concerns about the environmental impact of CBM related to the **demand placed on natural resources** and/or the **inefficient use of resources** (Bogueva and Marinova, 2020, Hamlin et al., 2022, Verbeke et al., 2015). Young Australians and UK consumers also expressed the view that CBM **does not address the root cause of the environmental issues** related to meat consumption – which is the **overconsumption of meat** (Bogueva and Marinova, 2020, Verbeke et al., 2015). The issue of **unknown or unexpected negative risks to the environment** was raised by commenters (of unknown characteristics) on online US news articles but was not explored more deeply (5% were concerned about risks for humans and/or the environment) (Laestadius and Caldwell, 2015). Further, **concerns about the preservation of livestock, open space and biodiversity** were expressed by consumers in the UK who voiced worries about what a world without farm animals and their respective ecosystems will look like (Verbeke et al., 2015). Examples of quotes from study participants who discussed perceived environmental risks of CBM are provided in Table 9.

## Risks to the economy and farmers

In three studies, participants in NZ, the UK and Ireland believed CBM could pose risks to the **economy and livelihoods of farmers** (Hamlin et al., 2022, Shaw and Mac Con Iomaire, 2019, Verbeke et al., 2015). Specifically, while participants in the UK and Ireland raised concerns about the **loss of agricultural jobs** and the **Irish economy**, respectively, participants in NZ raised concerns about “**spending taxpayers' money**”. Concern about the impact of CBM on livelihoods of local farmers was expressed by participants in all three studies, with **loss of farming traditions** also highlighted as a concern among UK participants. Notably, while these perceived risks were raised in response to open-questions, **only one of the three studies** presented participants with a **neutral** description of CBM (Shaw and Mac Con Iomaire, 2019), with the other studies presenting either a description that mentioned personal, ethical and environmental benefits (Hamlin et al., 2022) or a YouTube video that used emotive language when referring to animal impact (Verbeke et al., 2015).

**Examples of quotes illustrating typical comments made by study participants regarding perceived risks of CBM to the economy and farmers are provided in**

Table 10.

**Table 9. Quotes illustrating comments made by study participants regarding perceived environmental risks of cell-based meat.**

Quality	Reference	Design/ sample	CBM defined	Results
Low	(Verbeke et al., 2015)	60 UK consumers (focus group or online survey)	Yes (unclear if bias)	Participants worried about the preservation of livestock and struggled to imagine a world where farm animals and the ecosystem they belong to do not exist. <ul style="list-style-type: none"> <li>“All the fields of the cows will have been built upon, won’t they?! Industry, housing developments and ...” (UK, FG1, M, 40), and “.... Car parks, probably!” (UK FG1, M, 34)</li> </ul>
Moderate	(Laestadius and Caldwell, 2015)	Content analysis of comments on online US news articles discussing 2013 IVM hamburger event.	Yes (framing and likely bias but news articles not available for evaluation)	5% expressed concern that IVM will be less sustainable than conventional meat production. <ul style="list-style-type: none"> <li>‘This experiment is not a zero-sum activity. The necessary nutrients, the workers, the laboratory etc. all require much more energy than the product. There will be no benefit to the earth when the method is commercialized. A cow is a very efficient machine. A group of humans have historically been shown to be inefficient and enormous polluters’</li> </ul>
<b>Predominantly younger consumers (all or majority aged 18-25 years)</b>				
Low	(Bogueva and Marinova, 2020)	Online survey with 226 young Australians (18-24y)	Not reported	Mixed views regarding environmental benefits. Perceived by some but others were unsure or believed cultured meat was not better for environment. <ul style="list-style-type: none"> <li>“Livestock producers must make sure that livestock is environmentally sustainable. Ideas like growing meat on a plate under shelter is quite unsustainable.” (a few times per week meat eater, business owner, age group 21–24 years)</li> <li>“With the projected rapid decline in meat availability because of climate change, it’s important to be substituted with some meat alternatives but not cultured meat. You can’t ensure livestock and environmental sustainability with producing extra meat which is the cause of the problem.” (a few times per week meat eater, bartender, age group 21–24 years)</li> <li>“Lab meat could minimize the associations with the environmental impacts and ethical issues, but it is still resource consuming. Think about how much energy is put into it being under constant light and in a special environment. It’s not a sustainable option.” (a few times per week meat eater, remedial massage therapist, age group 18–20 years)</li> </ul>
Moderate	(Hamlin et al., 2022)	Individual interviews with 542 NZ participants (72% aged 18-24y)	Yes (bias). Personal, ethical and environmental benefits	Open response question: ‘Write UP TO four words, phrases, feelings or thoughts that come to mind when you see this product’) Responses coded as ‘Risks to the environment’: <ul style="list-style-type: none"> <li>Inefficient</li> </ul>

**Table 10. Quotes illustrating typical comments made by study participants regarding perceived risks of cell-based meat to the economy and farmers.**

Quality	Reference	Design/ sample	CBM defined	Results
Moderate	(Hamlin et al., 2022)	Individual interviews with n=542, NZ participants (72% aged 18-24y)	Yes (bias). Mentioned personal, ethical and environmental benefits	Open response question: 'Write UP TO four words, phrases, feelings or thoughts that come to mind when you see this product') Responses coded as 'Risks to humanity' "may affect our farming", "spending taxpayers' money", "poor farmers"
Low	(Verbeke et al., 2015)	60 UK consumers participated in a focus group or completed an online survey	Yes (used emotive language when referring to animal impact)	Participants were shown seven stimuli/content testers regarding various possible risks and benefits of red meat. One of these content testers was a two-minute YouTube video on CBM. Focus group: participants encouraged to raise comments and queries in relation to the video, but were advised that questions would not be answered during the discussion. Online: participants prompted to leave comments and questions on the content tester page related to the video.  Expressed concerns about the loss of farming traditions and agricultural jobs, and viewed cultured meat as "the end of a system", which was not really wanted.
Low	(Shaw and Mac Con lomaire, 2019)	Focus groups with 23 Irish participants in urban (U) and rural (R) areas	Yes (neutral)	Questions were asked to determine what participants viewed as the possible advantages and disadvantages of CBM and if they would be willing to try it. Concern for the Impact on Irish farmers and Irish economy: <ul style="list-style-type: none"> <li>• "I don't know if I would want to be a consistent buyer of it, because you feel like you wouldn't be supporting the Irish farmers" (G3F, U)</li> <li>• "My heart would hate to see it taking off" (G2F, R)</li> <li>• "What about our exports? A lot of people value Irish beef products" (G1F, R)</li> <li>• "[cultured meat would] kill the agribusiness" (G2F, R)</li> <li>• "The collapse of our... dairy and meat industry" (G4F, U)</li> <li>• "What are they [farmers] going to do for a living now?" (G3F, U)</li> <li>• "Where does the poor farmer come at the end of it?" (G1M, R)</li> </ul>

## Other concerns related to ethics and society

Other ethical concerns related to CBM were voiced in three qualitative studies conducted in Australia, NZ, and the US (Bogueva and Marinova, 2020, Hamlin et al., 2022, Laestadius and Caldwell, 2015). Ethical concerns related to the **use of animals** (two studies); **suspecting hidden agendas/potential for a lack of transparency** (three studies); and **moral issues and/or genetic alteration** (two studies).

Concerns about **animal ethics** were raised by 11% of young Australians surveyed (Bogueva and Marinova, 2020); specifically, growing meat from the cells of an animal was viewed as having **"no respect for the animal dignity", being done "without consent", and being "really unethical and painful"** (Bogueva and Marinova, 2020). Concerns about the **fate of animals if they are no longer needed for food** were also raised by 2% of commenters on the seven online US news articles discussing the 2013 CBM hamburger event analysed by Laestadius and Caldwell (2015).



Concerns about **hidden agendas and/or the potential for a lack of transparency in the marketing/selling of CBM** were raised by Australian, US and Irish consumers (Bogueva and Marinova, 2020, Laestadius and Caldwell, 2015, Shaw and Mac Con Iomaire, 2019). **Conspiracy** concerns were voiced by young Australians, with the surveyed consumers questioning the **motivations behind the development of CBM** and suspecting that CBM production was **profit driven** with funders seeking a return on their investment (Bogueva and Marinova, 2020). Similar concerns were expressed by commenters on online US news articles (Laestadius and Caldwell, 2015). Further, when Irish consumers were asked what would instil their trust in CBM, their comments revealed **distrust in food companies and labelling** – they believed that food companies could manipulate labelling information without consumers' knowledge (Shaw and Mac Con Iomaire, 2019).

Additionally, concerns about **moral issues** were raised among US and NZ consumers (Laestadius and Caldwell, 2015, Hamlin et al., 2022). Specifically, concerns about CBM being tied to cannibalism and fear of forced CBM consumption were expressed by 10% and 3% of online commenters (Laestadius and Caldwell, 2015). Participants in NZ also reported that “moral issues” and “genetic alter(ation)” came to mind when presented with the CBM concept, but these perceptions were not explored more deeply (Hamlin et al., 2022).

Other societal consequences of CBM were raised in two studies, conducted in the UK and Australia (Bogueva and Marinova, 2020, Verbeke et al., 2015). Concerns related to the **(anticipated) loss of human cultural practices and culinary traditions that centre around traditional meat (e.g., barbeques and Sunday roasts)** were raised by participants in the UK (Verbeke et al., 2015). Similarly, 13% of young Australians surveyed discussed **Australian pride** and viewed CBM as a **disloyalty to perceived high-quality Australian meat** and **betrayal of their country** (Bogueva and Marinova, 2020).

**Overall**, a range of concerns regarding potential risks associated with consumption of CBM were expressed by consumers in qualitative studies of moderate and low quality. Perceived risks mainly related to food safety, personal health, environmental and societal risks. The two main factors underlying health concerns were perceived unnaturalness/high level of processing of CBM and uncertainty regarding the current scientific understanding of CBM. Hidden agendas and/or the potential for a lack of transparency in the marketing/selling CBM, motivation behind the development of CBM, loss of cultural practices and culinary traditions that centre around traditional meat were some of the other concerns raised by Australian consumers.

## Summary of perceived **benefits and risks** examined in quantitative and qualitative studies

In many instances, the same type of impact was seen as both a benefit and a risk; this tended to vary among consumers.

### Personal impact

Perceived personal **benefits and risks** of CBM were assessed using **both quantitative and qualitative approaches**.

#### ***Perceived personal benefits:***

- Quantitative findings suggest that consumers, **on average, are uncertain about the personal benefits** of CBM (particularly price and taste). However, there was some variability among consumers.
- Qualitative findings provide further insight into the range of personal benefits that may be perceived by some consumers, including **benefits related to health, safety, nutrition, quality, price, taste and naturalness**.

#### ***Perceived personal risks:***

- Quantitative findings suggest that, on average, **consumers perceive low to moderate risks** related to CBM with respect to general risk and health or food safety concerns.
- Qualitative findings further revealed that participants expressed **health concerns** about CBM primarily due to two factors: the **perception that CBM is unnatural or manufactured**, and their **uncertainty regarding the current scientific understanding of CBM**. These concerns contributed to worries about **potential unknown short- and long-term health effects**. Comments also suggest a concern about or perceived need for **trustworthy health and safety information, and regulations regarding CBM**.

### Animal impact

Perceived animal welfare **benefits** of CBM were assessed using **both quantitative and qualitative approaches**, but perceived animal welfare **risks** were assessed using **qualitative approaches only**.

#### ***Perceived animal welfare benefits:***

- Limited quantitative data (from one study) suggests **consumers have varied views regarding animal welfare benefits of CBM**, with most responses ranging between agree and disagree.
- Likewise, qualitative findings indicate that a range of views exist among consumers who **may have been primed** by information provided by researchers. Perceived benefits mainly related to the **overall reduction in animals slaughtered** for meat and the **treatment/welfare of the animals** used for meat production.

#### ***Perceived animal welfare risks:***

- Perceived risks to animals were discussed in fewer studies than perceived benefits, and mainly related to **perceived unethical treatment of animals, a lack of respect for animal dignity and consent, and concerns about the fate of animals when no longer needed for food**. However, **generalisable data is lacking** from samples

that are sufficiently large, nationally representative, and not primed and potentially influenced by information about CBM provided by researchers.

### *Environmental impact*

- Perceived environmental **benefits** of CBM were assessed using **both quantitative and qualitative** approaches, but perceived environmental **risks** were assessed using **qualitative approaches only**. Quantitative data suggests **consumers have varied views regarding environmental benefits of CBM**, with most responses ranging between agree and disagree. Likewise, **qualitative** findings suggest that some consumers associate CBM with benefits to the environment, while others perceive risks to the environment (related to use of natural resources and imagining a world without livestock). While existing evidence indicates that a **range of views exists among consumers about environmental benefits of CBM, generalisable data is lacking** from samples that are both representative and unprimed.

### *Other societal impacts*

Other perceived societal **risks and benefits** of CBM were assessed using **both quantitative and qualitative approaches**.

#### ***Perceived societal benefits:***

- **Quantitative** findings regarding perceptions of other societal benefits of CBM suggests consumers, on average, have **neutral views** towards the societal benefits related to **future populations** and **food security**. This was also discussed in **qualitative** studies; however, it was noted that **global societal benefits are only considered benefits if there are no risks to human health**.

#### ***Perceived societal risks:***

- Quantitative findings regarding perceptions of other societal **risks** of CBM were limited (reported in two studies only), and suggest that consumers, on average, perceive a **lower risk for zoonosis for CBM compared to farmed meat**; and some identify risks to **agri-business and livelihood of farmers** among their top concerns (29-44% of Irish consumers).
- A **wider range** of 'other societal risks' were discussed **qualitatively**, including **risks to the economy and farmers**; concerns related to **unethical practices**, including **moral issues, genetic alteration, and suspecting hidden agendas/potential for a lack of transparency**; and **changes to society**, including **anticipated loss of human cultural practices and traditions that centre on meat, and betrayal of the domestic meat industry**.

**Research Q5: Do consumers perceive cell-based meats as the same or different to their traditional counterparts? Are they perceived as being as healthy as, and/or nutritionally equivalent (e.g., levels of protein/fat) to, their traditional counterparts?**

Consumers' perception regarding the healthiness and nutritional quality of CBM compared to their traditional counterparts was assessed in nine studies, including seven quantitative studies (Hallman and Hallman, 2020, Juhasz et al., 2023, Wilks and Phillips, 2017, Wilks et al., 2021, Giezenaar et al., 2023, Shaw and Mac Con Iomaire, 2019, Vural et al., 2023) and two qualitative studies (Bogueva and Marinova, 2020, Laestadius and Caldwell, 2015). Four of the studies were conducted in the US and one each in Australia (Bogueva & Marinova, 2020), NZ (Giezenaar et al., 2023), Canada (Juhasz et al., 2023), Ireland (Shaw and Mac Con Iomaire, 2019) and the UK (Vural et al., 2023).

Five studies, four quantitative online surveys (Giezenaar et al., 2023, Hallman & Hallman 2020, Wilks et al., 2021, Vural et al., 2023) and one qualitative study (Laestadius and Caldwell, 2015), were appraised as of moderate quality, with sample sizes ranging from 195 (Vural et al., 2023) to 3186 (Hallman & Hallman 2020). Overall, there were mixed perceptions about the healthiness/nutritional quality of CBM relative to conventional meat. Results of the quantitative studies are summarised in Table 11.

### **Quantitative findings**

Among the three studies appraised as low quality, approximately one-third (36%) of participants in the Canadian national survey (n=10,019) believed that 'cultured proteins' are equally as nutritious as conventional meat, but the percentage was slightly higher (43%) in Gen-Z (aged between 16 and 24 years old approximately) (Juhasz et al., 2023). On average, the US consumers viewed in-vitro meat (IVM) slightly less healthy than farmed meat as reflected with a mean score of 3.08 on a scale of 1 (much more) to 5 (much less) (Wilks and Phillips, 2017). Similarly, Irish consumers in both rural and urban areas believed that CBM would be 'a little less' to 'much less' healthy compared with conventional meat, with mean scores of 1.28 and 1.53, respectively, on the scale from 1 (much less) to 5 (much more). Only one of the three studies provided a neutral description of CBM (Shaw & Mac Con Iomaire 2019); one did not provide any description of CBM (Juhasz et al., 2023); and one mentioned animal welfare in the description (Wilks et al., 2021).

Results from the moderate quality studies (Giezenaar et al., 2023, Hallman & Hallman 2020, Wilks et al., 2021, Vural et al., 2023), suggested that consumers perceived CBM to be either similar or slightly healthier/nutritious compared with their traditional counterparts. It should be noted that consumers were primed with positive information about CBM in some studies (Giezenaar et al., 2023 & Wilks et al., 2021). The amount of healthy omega-3 fats, protein and general nutrition of cell-based seafood, labelled with one of the common and usual names identified in responses to the FDA's call for feedback, was perceived by US consumers as similar to their wild caught counterparts (Hallman and Hallman, 2020), but consumers were less certain if 'cultured meat' is molecularly the same as conventional meat (Wilks et al., 2021). In a NZ survey, 'cultivated meat' was viewed as slightly healthier and safer (Giezenaar et al., 2023), when participants were provided with a CBM description mentioning the nutritional benefits of CBM 'are expected to be equal or better than animal

meat'. Only the Hallman and Hallman (2020) study provided a neutral description of CBM, with the other study mentioning animal welfare in the description (Wilks et al., 2021).

Consistent with the quantitative studies described above, the findings from the qualitative studies are mixed. The studies collected online survey data from 227 young Australians (all aged 18-24 years) (Bogueva and Marinova, 2020) or analysed comments made on seven online news articles (814 comments from 462 commenters) (Laestadius and Caldwell, 2015). In the Australian study, where participants were asked to share their opinions about cultured meat, 32% believed cultured meat is not healthy or nutritious; while others believed cultured meat had the potential to be healthy and nutritious or admitted they had no idea (Bogueva and Marinova, 2020). Only a small proportion of the commenters in the US study discussed nutritional equivalence, noting that comments were made in relation to the news articles all of which focused on the 2013 CBM hamburger event, and commenters had unknown characteristics. Overall, 3% of commenters believed CBM will be less nutritious than conventional meat, 2% believed it will be healthier/more nutritious, and 2% believed it will have less fat (Laestadius and Caldwell, 2015). Quotes illustrating comments made by study participants regarding the healthiness/nutritional equivalence of CBM and conventional meat are shown in Table 12.

- Overall, both quantitative and qualitative studies suggest mixed perceptions regarding the healthiness and nutritional quality of CBM relative to conventional meat. Evidence from moderate quality studies suggests CBM is perceived as equivalent to conventional meat in terms of healthiness and nutritional quality whereas lower quality studies tend to suggest that CBM is perceived as less healthy or nutritious. Gen Z is more likely to view CBM as comparable to conventional meat. Concerns regarding overall healthiness and nutritional quality of CBM exist based on the limited evidence available. More research is needed to further examine the interaction between consumers' knowledge and awareness of the nature and manufacturing process of CBM, dietary preferences and their perceptions regarding the healthiness and nutritional quality of CBM.

**Table 11. Perceived healthiness and nutritional quality of cell-based proteins compared to their traditional counterparts (quantitative findings).**

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results		
							Mean±SD Cultivated meat vs. Conventional Meat	p-value	
Moderate	Giezenaar et al., 2023	NZ	592	Yes (mentions nutritional benefits)	Compared to conventional meat, I think cultivated meat would be: Healthier  Safer	1 = strongly disagree to 7 = strongly agree	4.3±0.06 4.3±0.06	0.94 0.057	
Moderate	(Hallman and Hallman, 2020)	US	3186	Yes (neutral)	Compared to wild caught, does the product 1. has more, less, or the same amount of "heart-healthy omega 3s," protein & environmental contaminants (Scale: 1= Less, 2=same, 3=More) 2. Is better, the same, or worse with respect to nutrition.	Cultured Cell-based Cell-cultured Cultivated Cultivated from the cells of... Grown from the cells of... Produced using cellular agriculture Wild-caught Farm-raised Control	No significant difference	No significant difference	Actual data not reported
Low	(Juhasz et al., 2023)	Canada	10,019	NR	"Cultured proteins (e.g., meat/poultry/dairy/seafood alternatives) will be able to provide an equally nutritious food."	1=strongly agree to 5=strongly disagree.	<b>%</b> Strongly agree 10 18	Agree 26 25	Sample Overall Gen Z
Low	(Shaw and Mac Con lomaire, 2019)	Ireland	312	Yes (neutral)	In comparison with conventional meat: How healthy do you think cultured meat would be?	1=much less, 5= much more	<b>Mean±SD</b> Rural 1.28±1.19	Urban 1.53±1.12	
Low	(Wilks and Phillips, 2017)	UA	673	Yes (mentioned animal welfare)	How healthy do you think invitro-meat (IVM) is compared to farmed meat?	1=much more to 5=much less	3.08±0.95		
Moderate	(Wilks et al., 2021)	US	862	Yes (mentioned animal welfare)	cultured meat is molecularly the same as real meat	1=strongly disagree to 5=strongly agree	2.77±1.12		

							Main effect of label (cultured or conventional)	Main effect of diet (meat eaters or non-meat eaters)	Comment
Moderate	Virual et al., 2023)	UK	195	Yes (neutral)	A 100-point visual analogous scale (from Not at all to Extremely)	Beef	0.17 (p=0.684)	17.29 (p<0.001)	Cultured beef burger rated lower by meat eaters compared to non-meat eaters
					Participants were randomly allocated to evaluate one of the two CBM products (either a cultured beef burger or cultured chicken nuggets), which was compared to a conventional counterpart, and were asked 'how healthy is this food?'	Chicken	16.50 (p<0.001)	5.73 (p=0.19)	cultured chicken nuggets rated higher by both meat eaters & non-meat eaters

**Table 12. Quotes illustrating typical comments made by study participants regarding perceived similarities/differences between CBM and conventional meat (qualitative findings).**

Quality	Reference	Design/sample	Results
Moderate	(Laestadius and Caldwell, 2015)	Content analysis of comments made on online US news articles which discussed the 2013 IVM hamburger event.	<p>N=12 (3%) IVM will be less nutritious than conventional meat            N=11 (2%) IVM will have less fat than conventional meat            N=9 (2%) IVM will be healthier/more nutritious than conventional meat</p> <ul style="list-style-type: none"> <li>• 'I would like to know the exact nutritional components of lab created food. I'll bet there aren't many. You cannot fool Mother Nature—only stupid humans'</li> <li>• 'I'm also a cell biologist. The thought of consuming this "product" bathed in growth factors, steroids, fetal bovine serum, and who knows what else makes me ill. But the point about viruses and other contaminants is one I had had not considered—cells grown in the lab, removed from the cow or whatever host animal, will not have the benefit of an immune system to prevent the proliferation of all sorts of human pathogens. This stuff will make factory farm cattle, raised in the worst possible manner, seem like free range beef by comparison'</li> </ul>
Low	(Bogueva and Marinova, 2020)	Online survey with 226 young Australians (18-24y)	<p>Not convinced that cultured meat will be safe for consumers. A major worry is the possible unknown "adverse," "negative," "hidden side effects" of cultured meat.</p> <ul style="list-style-type: none"> <li>• "If we think about the future food security of the planet, we have to be ready to accept anything. But I believe engineered and chemically processed food are not good for human to consume. I even think these will counteract in the opposite direction and contribute to human non-communicable diseases." (occasional meat eater, nurse, age group 21–24 years)</li> <li>• "Maybe there are more health benefits to not eat meat than eating cultured meat. They could be some future side effects to human from eating it. It's good that it is not mass market produced yet." (non-meat eater, solicitor, age group 21–24 years).</li> <li>• "Artificial growth cells and hormones to make it edible in vitro meat thanks god that is still an underdeveloped technology. No one knows what this meat will be lacking and what will be the side effects for us." (daily meat eater, high school sports aid, age group 18–20 years)</li> <li>• "Not normal, maybe the good thing about it is that humans created some emerging modern technology but multiplying cells to grow meat for human is wrong. It's against the nature and if we consume it, we will pay sooner or later for this." (daily meat eater, university student, age group 18–20 years)</li> <li>• "Scientists created in vitro meat cultivation because of their interests to advance in technologies, but this doesn't mean what they created is good for human consumption without any future negative effects." (daily meat eater, trading operations analyst, age group 21–24 years)</li> <li>• "Need scientifically proven information about cells-made meat before trying it. It could have some unhealthy side effects." (occasional meat eater, graphic designer, age group 21–24 years)</li> <li>• "We don't know yet if we are going to eat cultured meat. It's still in early stage of its development and far away from the natural meat appearance. It can't be possible to not have some future negative effects on human." (daily meat eater, physiotherapist, age group 21–24 years)</li> </ul>



## Consumers' information preferences

Research Q6: Do consumers want a specific term to differentiate between cell-based meat and traditional counterparts, and what terminologies are best for consumer understanding?

Ten studies, including nine quantitative studies (DeMuth et al., 2023, Hallman and Hallman, 2020, Hallman and Hallman, 2021, Hubbard, 2022, Malerich and Bryant, 2022, Szejda et al., 2021, Van Loo et al., 2020, Asioli et al., 2022, Anderson and Bryant, 2018) and one qualitative study (Dillard and Szejda, 2019), examined consumers' views and preferences regarding terminologies used to differentiate cell-based from traditional meat. Nine of the 11 studies were conducted in the US, one study included consumers from both the US and UK (Szejda et al., 2021). One study was appraised as **high quality** (Anderson and Bryant 2018), five were **moderate quality** (Asioli et al., 2022, Hallman and Hallman, 2020, Hallman and Hallman, 2021, Malerich and Bryant, 2022, Van Loo et al., 2020) and four were **low quality** (De Muth et al., 2023, Dillard & Szejda 2019, Hubbard et al., 2022, Szejda et al., 2021). Study samples were largely **representative** except in two studies (Dillard & Szejda 2019; Hubbard et al., 2022). Results of these studies are summarised in Table 13. The qualitative study was conducted with 27 young US consumers (most aged 18-21 years) who participated in focus group discussions where they provided their views on a narrative explaining CBM, a corresponding visual analogy, and potential names for CBM (see Table 14) (Dillard and Szejda, 2019).

The names tested in most of the studies included "cell-based", "cell-cultured", "cultivated", "cultured", and 'lab-grown', which were also suggested as appropriate names for labelling CBM by at least two contributors to the FDA and USDA's call for feedback (Malerich and Bryant, 2022). Additionally, commonly tested phrases included, "produced using cellular aquaculture," "cultivated from the cells of \_\_\_\_\_," and "grown directly from the cells of \_\_\_\_\_," where the blanks are filled by the name of the seafood or meat. Four experimental studies of moderate quality, with sample sizes ranging from 625 to 3186 (Malerich and Bryant, 2022, Hallman and Hallman, 2021, Hallman and Hallman, 2020, Asioli et al., 2022) assessed which of the common or preferred names and phrases for describing CBM (identified in the responses to the FDA and USDA's request for feedback) are best understood by consumers in terms of their ability to differentiate CBM from traditional meat and fish. Of the four studies, two focused on seafood (Hallman and Hallman, 2021, Hallman and Hallman, 2020); one examined beef, chicken and salmon (Malerich and Bryant, 2022); and the remaining study focused on chicken (specifically, fresh skinless boneless chicken breast products), and included the name 'artificial' in addition to 'cultured' and 'lab-grown' (Asioli et al., 2022). Three of the studies (Malerich and Bryant, 2022; Hallman and Hallman, 2021; Hallman and Hallman, 2020) also assessed the ability of various names to signal allergenicity of a CBM product.

There were some differences in participants' understanding of the nature of the product according to the different names. In three studies, participants were randomly assigned to view an image of a realistic package of a seafood (either salmon, tuna, or shrimp), chicken or beef **labelled with one of the common names** (identified in the FDA's and USDA's call for feedback) and were **asked which of the names best described the product as wild-caught, farm raised, neither wild-caught nor farm raised** (Hallman and Hallman, 2020,

Hallman & Hallman 2021) or **whether the product was hunted/fished in the wild, farm raised, produced by animal cells in a food facility, or was plant-based** (Malerich and Bryant, 2022).

**Without providing any additional description of CBM**, the percentage of participants who correctly identified that the CBM product was neither wild caught nor farm raised, ranged from 53.7% for the phrase 'Grown directly from the cells of \_' (Hallman and Hallman, 2020) to 83.8%, 93.7% and 94.7% for the name 'Cell-cultivated' for beef, chicken and salmon, respectively (Malerich and Bryant, 2022). Compared with phrases/names without the word 'cell', those containing the word 'cell' ('Cultivated from the cells of \_', 'Grown directly from the cells of \_', 'Cell-based' or 'Cell-cultured') or the name 'lab-grown', performed better in terms of their ability to signal that the CBM product differed from the conventional farm raised or wild caught meat and fish. However, these phrases/names had lower consumer appeal (Hallman & Hallman 2020, Malerich and Bryant, 2022). 'Lab-grown' CBM had a lower level of perceived safety and CBM labelled with the name 'artificial' was more likely to be incorrectly viewed as a plant-based alternative compared to other names tested (Malerich and Bryant, 2022).

Interestingly, **names containing the word "cell"** were perceived as more likely to be **genetically modified** and **made from plants** than those without it [as indicated by higher mean scores ranging from 4.94 to 5.62 vs. 2.95 to 4.60 on a 7-point scale (1=extremely unlikely, 7=extremely likely)] (Hallman & Hallman 2020), and **'cell-cultured salmon'** was seen as **more likely to be genetically modified** than **'cell-based salmon'**. However, consumers' **familiarity with the concept of CBM did not differ** significantly between the names and these names were seen as **slightly appropriate** to describe the new way of producing CBM with a mean score of  $4.97 \pm 1.81$  on a 7-point scale (1=extremely inappropriate, 7=extremely appropriate) (Hallman and Hallman, 2020, Hallman and Hallman, 2021)..

The ability of the names to signal allergenicity of CBM was assessed by asking participants whether it is safe for an individual with allergy to fish, beef or chicken to consume their CBM counterparts. On average, participants believed that individuals who were allergic to fish should not consume the CBM counterpart and responses did not differ significantly across the names tested (Hallman & Hallman 2020, Hallman & Hallman 2021). Another study with a similar design but including beef and chicken (Malerich and Bryant, 2022), found that the percentage of participants indicating that the CBM products were unsafe for allergy sufferers was consistently higher across different CBM products for names containing 'cultivated' [41.8-51.4% (beef), 61.5%-66.3% (chicken), 62.1-80.2% (salmon)], 'cultured' [51.0-54.5% (beef), 62.1-64.9% (chicken), 63.0-74.7% (salmon)] and the phrase 'grown from [animal] cells, not farmed [or fished]' [65.2% (beef), 63.4% (chicken), 61.2% (salmon)] compared with 'lab-grown' [43.7% (beef), 52.5% (Chicken), 57.4% (salmon)] and 'artificial' [15.7% (beef), 29.4% (chicken), 24.5% (salmon)]. These findings suggest that consumers are either unable to differentiate CBM products labelled with the terms 'cultured' and 'cultivated' from their traditional counterparts or that consumers believe CBM products have a similar allergenicity to their traditional counterparts. Overall, the percentage of participants who indicated that the CBM products were unsafe for allergy sufferers was lower for beef compared with chicken and salmon.

**After reading a description of CBM**, participants indicated that the name ‘cell-cultured’ was slightly clearer than ‘cell-based’ in communicating that the salmon tested in the experiment was not caught in the ocean or farm-raised (Hallman & Hallman 2021). However, ‘cell-cultured’ was perceived as less positive and nutritious compared to traditional counterparts, with smaller differences in these perceptions found for the other names tested.

Consumers’ **understanding of the composition of a CBM product** (without being given a description) was **improved** when the product was **labelled as a ‘protein’** rather than ‘meat’ (DeMuth et al., 2023). Substituting the word ‘Meat’ with ‘Protein’ in the label of a CBM burger, from ‘JUST Meat’ to ‘JUST Protein’, reduced the percentage of respondents who incorrectly identified ground beef as an ingredient in the burger from 80.6% to 63.1% (DeMuth et al., 2023). Whether labelling the product with the common names tested in other studies would further improve the understanding of the composition is unknown.

Consumers were found to prefer and be averse to specific CBM terms. For example, 70% (n=1830) of the participants surveyed in the US reported that ‘lab-grown meat’ should not be allowed to be labelled as ‘beef’; however, whether this finding can be applied to labelling of other types of meat (e.g., chicken, fish, etc) or to other common names identified in the responses to the FDA’s and USDA’s call for feedback was not assessed (Van Loo et al., 2020). One study specifically asked participants to suggest ‘better’ names that reflect the nature of CBM and are more relatable and friendly (Hubbard, 2022). The suggestions included ‘Cultivated Meat, Cultured Meat, Cell-Based Meat, Lab-Created Meat’, which are consistent with the common and usual names identified in the responses to the FDA’s and USDA’s call for feedback. Additionally, consumers who were asked to make hypothetical purchase decisions between conventional chicken and cell-based chicken (where the specific CBM term varied between respondents), preferred ‘cultured’ chicken over the terms ‘artificial’ and ‘lab-grown’, and preferred ‘artificial’ to ‘lab-grown’ (Asioli et al., 2022); however, consumer understanding of the CBM terms was not examined in this study.

As part of a focus group, young US consumers evaluated five potential names for CBM based on the ability of the names to help consumers understand what they are buying, differentiate CBM from other types of meat (not conventional meat or plant-based meat), and the name’s overall appeal (see results in Table 14) (Dillard and Szejda, 2019). Overall, ‘cultivated’ was the most preferred term and was generally perceived positively (though some consumers noted the term was ‘less accurate’ or ‘not straightforward’); ‘Cultured’ and ‘Cell-based’ elicited more mixed perceptions, including being perceived as too scientific and unappetising (Dillard and Szejda, 2019); and ‘Cell-cultured’ and ‘Propagated’ elicited either neutral or negative perceptions, including being perceived as ‘unnatural’, ‘creepy’, ‘propaganda’, ‘weird’, and ‘not-meatish’.

Two studies also examined consumers’ view on whether cell-based salmon should be sold in the same section of the supermarket as wild-caught and farm-raised fish (Hallman and Hallman, 2020, Hallman and Hallman, 2021) using a 7-point scale (1=strongly disagree & 7=strongly agree). The mean score of 4.47 (Hallman and Hallman, 2020) and 4.31 (Hallman and Hallman, 2021) suggested that on average consumers are unsure or don’t have a strong view on this issue. Whether this finding can be generalised to other CBM meat is unknown.

- Overall, there are some differences in the ability of the common and usual names or descriptive phrases (identified in the FDA’s and USDA’s call for feedback) to differentiate CBM products from conventional meat and fish. Phrases and names that

contain the word 'cell' (e.g., 'Cultivated from the cells of\_', 'Grown directly from the cells of\_', 'Cell-based' or 'Cell-cultured'), the name 'lab-grown', and descriptive phrases (e.g., 'grown from [animal] cells', 'not farmed [or fished]') appear to be better understood by consumers (enabling consumers to correctly identify the true nature of the CBM product) compared to names without the word 'cell' (e.g., 'cultured', 'cultivated' and 'artificial' meat and fish). However, these phrases/names may decrease consumer appeal compared to 'cultured'/'cultivated'.

- Despite most of the common names identified in the responses to the FDA's and USDA's call for feedback being considered slightly appropriate for describing CBM production, confusion about the nature of CBM products exists. Overall, none of the names tested alone achieved 100% correct identification that the CBM product is neither wild caught nor farm-raised..
- Consumers are unsure or do not have a strong view about whether cell-based seafood products should be allowed to be sold in the same section as their traditional counterparts.
- The suitability and clarity of the best names including short descriptions identified from the review could be further tested in the Australian and NZ context

**Table 13.** Results summarising consumers perceptions regarding terminology/labelling applied to cell-based proteins.

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results		
							Mean willingness to pay (\$/lb) (SE)		
							'Cultured'	'Artificial'	'Lab-grown'
Moderate	(Asioli et al., 2022),	US	625	Yes (neutral)	<p>Imagine you are in a store and you would like to purchase a package of fresh skinless boneless chicken breast product. Would you choose option A, option B or option C?</p> <ul style="list-style-type: none"> <li>12 choice sets presented to each participant. Each choice set showed two chicken products (one conventional and one CBM) and an opt-out option (choose none). Products varied in four attributes: production method (conventional or CBM), Carbon Trust Label (label or no label), antibiotic use ('no antibiotics ever' or information), and price (four levels).</li> <li>Participants randomised to see one of three names for CBM: 'cultured', 'artificial', 'lab-grown'.</li> </ul>	Choice of one of three options (two product options and one 'no choice'/opt-out option)	-2.60 (0.41) <sup>a</sup>	-7.49 (0.61) <sup>b</sup>	-8.69 (0.80) <sup>c</sup>
							<b>JUST Meat (%)</b>	<b>JUST Protein (%)</b>	
Low	(DeMuth et al., 2023)	US	1504	NR	<p>What do you think are the ingredients in this product? Choices of ingredients included ground beef, natural and artificial flavours, onions, soy, sesame oil, corn, wheat, beets, and peas.</p>	Selected ground beef as an ingredient	80.6	63.1	

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results									
							Q1 (%)	Q2 (Mean score)		Q3 (Mean±SD)	Q4 (Mean±SD)					
						NWCFR (%)	FR (%)	WC (%)	NFR	NCO						
Moderate	(Hallman and Hallman, 2020) <sup>1</sup>	US	3186	Yes (neutral) for Q2, 5 & 6 only	Participants were randomly assigned to one of 30 packages (10 terms & 3 seafood products)											
							1.	"Which of the following best describes this product is 'Neither wild caught nor farm raised' (NWCFR); Product is 'Farm Raised' (FR); Product is 'Wild caught' (WC)].	<b>Name tested</b>							
								Cultivated from the cells of_	60.9 <sup>a</sup>	22.1 <sup>a,b</sup>	16.9 <sup>a</sup>	5.1 <sup>a,b</sup>	5.25 <sup>a,b</sup>	5.62±1.63 <sup>a</sup>	3.04±1.88 <sup>bc</sup>	
								Cultured	40.8 <sup>b,c</sup>	41.1 <sup>c,d</sup>	18.1 <sup>a</sup>	4.06 <sup>d</sup>	4.21 <sup>d</sup>	4.60±1.68 <sup>de</sup>	2.71±1.83 <sup>cd</sup>	
								Cell-based	58.4 <sup>a</sup>	21.9 <sup>a,b</sup>	19.7 <sup>a</sup>	4.49 <sup>c,d</sup>	4.46 <sup>c,d</sup>	4.94±1.75 <sup>cd</sup>	3.73±1.95 <sup>a</sup>	
								Cell-cultured	55 <sup>a</sup>	29.1 <sup>b,c</sup>	16.0 <sup>a</sup>	4.80 <sup>b,c</sup>	4.89 <sup>b,c</sup>	5.18±1.64 <sup>bc</sup>	3.39±1.91 <sup>ab</sup>	
								Cultivated	29.9 <sup>c</sup>	53.8 <sup>d</sup>	16.4 <sup>a</sup>	4.18 <sup>d</sup>	4.59 <sup>c,d</sup>	4.49±1.77 <sup>e</sup>	4.49±1.77 <sup>cd</sup>	
								Farm raised	4.7 <sup>d</sup>	89.4 <sup>f</sup>	5.9 <sup>d</sup>	NA	NA	4.24±1.85 <sup>ef</sup>	2.14±1.77 <sup>c</sup>	
								Grown directly from the cells of_	53.7 <sup>a</sup>	29.0 <sup>b,c</sup>	17.4 <sup>a</sup>	5.30 <sup>a</sup>	5.5 <sup>a</sup>	5.48±1.69 <sup>ab</sup>	2.98±1.97 <sup>bc</sup>	
								Produced using cellular aquac...	40.3 <sup>b,c</sup>	39.3 <sup>c</sup>	20.4 <sup>a,b</sup>	4.46 <sup>c,d</sup>	4.54 <sup>c,d</sup>	4.94±1.71 <sup>cd</sup>	3.06±1.92 <sup>bc</sup>	
								Wild caught	4.6 <sup>d</sup>	2.8 <sup>e</sup>	92.6 <sup>c</sup>	NA	NA	2.95±1.93 <sup>g</sup>	2.03±1.74 <sup>c</sup>	
								Control	52.8 <sup>a,b</sup>	15.5 <sup>a</sup>	31.6 <sup>b</sup>	NA	NA	4.03±1.66 <sup>f</sup>	2.44±1.81 <sup>de</sup>	
								2.	Rate the clarity of each name in communicating that the product was Not Caught in the Ocean" (NCO) or was Not Farm Raised (NFR). (Scale: 1 = <i>extremely unclear</i> to 7= <i>extremely clear</i> )							
	3.	How likely that the seafood is genetically modified (Scale: 1= <i>extremely unlikely</i> , 7= <i>extremely likely</i> )														
	4.	How likely that the seafood is made from plants (Scale: 1= <i>extremely unlikely</i> , 7= <i>extremely likely</i> )														
	5.	Whether the product should be sold in the same section of the supermarket as wild-caught and farm-raised fish	1= <i>strongly disagree</i> to 7= <i>strongly agree</i>	4.47±1.83	No difference between the different names											
	6.	How appropriate the name they viewed is "for describing this new way of producing just the parts of salmon/tuna/shrimp that	1= <i>extremely inappropriate</i> to 7= <i>extremely appropriate</i>	4.97±1.81	No difference between the different names											

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results												
					people eat, instead of catching or raising them whole.”					<b>Cell-based (%)</b>			<b>Cell-cultured (%)</b>			<b>Total (%)</b>			
Moderate	(Hallman and Hallman, 2021),	US	1200	Yes (neutral) for Q3-5 only	Participants were randomly assigned to one of two names ('Cell-based' and 'Cell-cultured')	Q1 Wild-Caught (WC) Farm-Raised (FR) Neither WC nor FR	15.0			11.1			13.0			27.6			59.5
					1. Which of the following best describes this salmon?	Q2 Made from the Cells of Salmon <sup>3</sup> Made from the Cells of Plants <sup>3</sup>	40.8			43.9			42.4			11.7			
					2: Those that answered Neither WC nor FR to Q1 were ask Which of the following best describes this salmon?	Made from Neither Salmon nor Plants <sup>3</sup>	8.0			2.9			5.4						
							<b>Mean ±SD</b>			<b>Mean ±SD</b>			<b>p-value</b>						
					3. How clearly the name communicates that the salmon was 'not caught in the ocean' or 'not farm raised'	Not caught in the ocean Not farm raised	4.12±2.18			4.52±2.07			0.001						
					4. How appropriate the name they viewed is "for describing this new way of producing just the parts of salmon/tuna/shrimp that People eat, instead of catching or raising them whole."	1= extremely inappropriate to 7=extremely appropriate	4.97±1.81			4.97±1.81			0						
					5. Whether the product should be sold in the same section of the supermarket as wild-caught and farm-raised fish	1=strongly disagree to 7=strongly agree	4.31±1.90			4.31±1.90			0						
Moderate	(Malerich and Bryant, 2022),	US	2653	NR	Participants were randomly assigned to a product labelled with one of the 9 names identified in recent FDA and USDA feedback requests and consumer surveys and	<b>Name tested</b>	<b>Correct (%)</b>			<b>Incorrect (%)</b>			<b>Don't know (%)</b>						
						Cell-cultivated	B	C	S	B	C	S	B	C	S				
						Cultivated	83.8	93.7	94.7	8.6	3.2	3.2	7.6	3.2	2.1				
						Cell-cultured	46.2	42.2	35.4	25.3	28.4	45.8	28.6	29.4	18.8				
						Cultured	84.4	89.5	90.0	2.1	1.1	2.0	13.5	9.5	8.0				
						Cell-based	61.6	54.6	53.5	13.1	20.6	19.2	25.3	24.7	27.3				
						Novari	82.3	81.7	81.3	8.0	3.8	3.8	9.7	14.4	15.0				
						Lab-grown	3.1	3.0	0.0	24.7	18.8	18.1	72.2	78.2	81.9				
							82.8	96.0	94.3	9.2	1.0	2.8	8.0	3.0	2.8				

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results								
					one of three products [beef (B), chicken (C) and salmon (S)]. They were asked to identify what the product was - whether it was hunted/fished in the wild, farm raised, produced by animal cells in a food facility, or was plant-based.	Artificial Descriptive	33.3 96.7	52.9 98.0	42.5 98.1	40.2 2.2	20.7 0	25.5 1.9	26.5 1.1	26.4 2.0	32.1 0.0
Low	(Hubbard, 2022)	US	153	NR	If you could give cell-based meat a better name or term that makes it more relatable and friendly to you, what would you call it		<b>Names suggested</b>								
							<ul style="list-style-type: none"> <li>Related to animal welfare and the environment: Monk meat, Humane Certified Meat, Ethical/Ethically grown Meat, Clean Meat, Humane Meat, Cruelty-free Meat, No-kill Farming, Animal friendly Meat, Environmentally Friendly Meat, Next-Gen Meat, Animal-free Meat, Neat Meat, The Better Alternative</li> <li>Related to the nature/science of CBM: Cultivated Meat, Cell-conscious Meat, Cultured Meat, Cell-Based Meat 'Metaphoric names': Fake Meat, A Science Project, Maybe Meat, Lab Created Meat</li> </ul>								
High	(Anderson and Bryant, 2018) <sup>2</sup>	US	338	Yes (mentioned nutritional, health, animal welfare & environmental benefits)	To what extent does the name [NAME/LABEL] ACCURATELY DESCRIBE this type of meat?	1= Not at all descriptive, 2 = Somewhat descriptive, 3 = Moderately descriptive, 4 = Very descriptive, 5 = Extremely descriptive	<b>Clean</b>	<b>Cultured</b>	<b>Cell-based</b>	<b>Craft</b>	<b>Slaughter -free</b>				
							<b>Phase 3</b>								
							2.73±1.28 <sup>a</sup>	3.33± 1.19 <sup>b</sup>	3.57 ±1.05 <sup>b</sup>	2.82 ±1.19 <sup>a</sup>	3.41± 1.20 <sup>b</sup>				
							<b>Phase 4</b>								
							3.19±1.34 <sup>a</sup>	3.39±1.19 <sup>a,b</sup>	3.56±1.19 <sup>b,c</sup>	3.24±1.33 <sup>a</sup>	3.70±1.16 <sup>c</sup>				
					To what extent would the term "[NAME/LABEL]" HELP YOU TELL THE DIFFERENCE between this type of meat and conventional meat?	1=not at all, to, 5=a great deal	<b>Phase 3</b>								
							3.03±1.29 <sup>a</sup>	3.45±1.19 <sup>a,b</sup>	3.70±1.19 <sup>b</sup>	3.15±1.33 <sup>a</sup>	3.29±1.25 <sup>a,b</sup>				
							<b>Phase 4</b>								
							3.28±1.35 <sup>a</sup>	3.43±1.31 <sup>a</sup>	3.81±1.19 <sup>b</sup>	3.37±1.34 <sup>a</sup>	3.74±1.23 <sup>b</sup>				
Low	(Szejda et al., 2021),	US & UK	4050	Yes (mentioned nutritional, health, animal welfare & environmental benefits)	Which name would you prefer to see on a PACKAGE LABEL, for example when you are buying a product at the grocery store?	Order of preference: 1 to 4 (1= most preferred)	<b>Cultivated</b>	<b>Cultured</b>	<b>Cell-based</b>	<b>Cell-cultured</b>	Estimated from Figure 8				
							2	2	3	3					
		US	2018		To what extent does each of the following names	1=not at all descriptive, to, 5=extremely descriptive	General	2.83	2.84	3.40	3.44				
							Early adopter	3.04	3.03	3.69	3.60				



Quality	Reference	Country	N	CBM definition	Question	Response scale				Results
		UK	2034		help you tell the difference between this type of meat and conventional meat?	General	2.61	2.58	3.20	3.20
						Early adopter	2.86	2.83	3.60	3.60
							<b>Yes</b>	<b>No</b>		
Moderate	(Van Loo et al., 2020)	US	1830	NR	Should the following 'lab-grown meat' be allowed to be labelled as 'beef'?	1="yes, it should be allowed to be labelled as 'beef'", 2="No the USDA and FDA should prohibit the use of the word 'beef' on the labels for these products".	29.8%	70.2%		
					Should 'plant-based meat using pea protein' be allowed to be labelled as 'beef'?		23.9%	76.1%		
					Should 'plant-based meat using animal-like proteins produced by yeast' be allowed to be labelled as 'beef'?		24.2%	75.8%		

NR = Not reported; NS = Not statistically significant.

<sup>1</sup>In each column, values followed by a different letter are significantly different while those with a same letter indicates no significant difference;

<sup>2</sup>In each row, values followed by a different letter are significantly different while those with a same letter indicates no significant difference;

<sup>3</sup>Those answered 'Neither WC nor FR' were given the subsequent questions

**Table 14. Summary of qualitative study exploring consumers perceptions and evaluation of cell-based meat descriptions and terminology (Dillard and Szejda, 2019).**

Quality	Reference	Country	CBM definition	N	Question/response options	Results												
Low	(Dillard and Szejda, 2019)	US	Yes (mentioned health, animal welfare, social, environmental, and economic benefits)	27	<p>After listening to the <b>narrative description</b>:</p> <p>[Written activity] Please write down the first thoughts that come to mind in response to this concept. Please write down any questions that come to mind. Please indicate aspects (including specific words and phrases) you like by circling them and aspects that you don't like/are confused by underlining them.</p> <p>[Discussion] Please briefly share your first thoughts with the group. Please share your most important question with the group. (probe) Does the narrative help you understand that the product will be real meat, not a plant-based alternative?</p> <p>After viewing the <b>visual analogy to plant propagation</b> [Written activity] Please write down the first thoughts that come to mind in response to this analogy. Please write down any questions that come to mind. Please indicate aspects you like by a check mark and aspects that you don't like/are confused by an X.</p> <p>[Discussion] Please briefly offer your general response to this analogy. (Probe) Does describing meat like this make sense?</p> <p><b>Evaluation of potential names</b> Participants evaluated five potential names – first by ranking them 1–5 given the below considerations and then by discussing their rankings. Participants were asked to bear in mind the following criteria when considering a name:</p> <ol style="list-style-type: none"> <li>1. Helps consumers understand what they are buying (real meat but produced in a new way)</li> <li>2. Differentiates from other types of meat (not conventional meat or plant-based meat)</li> <li>3. Has overall appeal (sounds appetising)</li> </ol> <p>Ranking from 1-5 (1= the most appealing, and 5= the least appealing)</p>	<ul style="list-style-type: none"> <li>• Participants generally had a positive reaction to the narrative, finding it clear and concise. Some participants showed scepticism, noting that the narrative seemed both oversimplified and too narrowly focused on benefits (without evidence).</li> <li>• Readily understood that this new type of meat was not plant-based; instead, derived from animal cells. Some participants indicated that because this production method was a new concept, messaging that helped them categorise it was useful in building understanding.</li> <li>• Could readily distinguish this new category after reading the narrative, but also expressed a desire for more-specific information.</li> <li>• Questions arose around cost, health risks and benefits, sensory characteristics (taste, appearance), environmental impact, specifics of the production method, and overall appeal concerns.</li> <li>• Notable reactions to the visual elements of the second graphic included dislike of the syringe pictured; confusion over the cultivator image (both the construction of the apparatus itself and the image of the meat produced); and questions about specific production aspects, such as the number of cells needed to create a specific quantity of meat.</li> <li>• Another notable reaction was a desire for consistent imagery at the conclusions of the processes depicted (a plate of food for both).</li> </ul>												
						<table border="1"> <thead> <tr> <th></th> <th>Most preferred term</th> <th>Second-most preferred term</th> <th></th> </tr> </thead> <tbody> <tr> <td><b>Cultivated</b></td> <td>40.7% (n=11/27)</td> <td>37.0% (n=10/27)</td> <td>Reactions during discussion were overall quite positive. Examples of positive comments: “sounds most natural,” “makes me think of growing,” “implies that it’s cared for,” and “associated with farming.” However, in written comments, n=2 noted that they perceived the term as “less accurate,” “not straightforward.”</td> </tr> <tr> <td><b>Cultured</b></td> <td>29.6% (n=8/27)</td> <td>18.5% (n=5/27)</td> <td>Mixed reactions during discussion. Examples of positive comments are “culture has a double meaning—we all want to be cultured,” “sounds new, innovative,” and “suave.” Examples of negative comments are “cultured sounds too lab-like, hospital-like,” and “cultured doesn’t sound right—it’s almost like it sounds aged or old.”</td> </tr> </tbody> </table>		Most preferred term	Second-most preferred term		<b>Cultivated</b>	40.7% (n=11/27)	37.0% (n=10/27)	Reactions during discussion were overall quite positive. Examples of positive comments: “sounds most natural,” “makes me think of growing,” “implies that it’s cared for,” and “associated with farming.” However, in written comments, n=2 noted that they perceived the term as “less accurate,” “not straightforward.”	<b>Cultured</b>	29.6% (n=8/27)	18.5% (n=5/27)	Mixed reactions during discussion. Examples of positive comments are “culture has a double meaning—we all want to be cultured,” “sounds new, innovative,” and “suave.” Examples of negative comments are “cultured sounds too lab-like, hospital-like,” and “cultured doesn’t sound right—it’s almost like it sounds aged or old.”
	Most preferred term	Second-most preferred term																
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Quality	Reference	Country	CBM definition	N	Question/response options	Results		
					<b>Cell-based</b>	25.9 (n=7/27)	14.8 (n=4/27)	Mixed reactions during discussion. Examples of positive comments: "Simple," "the most accurate," "the most straightforward," and "points toward science" are some of the positive comments. Examples of negative comments: "Cell ... not appetizing," "I don't want to eat a science project," and "people will be turned off".
					<b>Cell-cultured</b>	3.7% (n=1/27)	14.8 (n=4/27)	Primarily neutral or negative reactions during discussion. An example of a neutral comment is "differentiates it from regular meat." Examples of negative comments are "sounds lab-based and unnatural," "sounds a bit creepy—body snatchers," and "too long."
					<b>Propagated</b>	0% n=0/27	14.8 (n=4/27)	Primarily neutral or negative reactions during discussion. One neutral comment is "most people won't know what this word means." Examples of negative comments are "sounds weird and not meat-ish," "sounds like 'propaganda,'" and "off-putting."

Research Q7: Do consumers expect this information (i.e., that it is cell-based meat) to be available when food is not required to bear a label (e.g., food sold for immediate consumption in a restaurant)?

Only one study (appraised as low-quality) assessed whether consumers expect to see labelling information that identifies CBM products (Juhasz et al., 2023). In a Canadian national survey, participants were asked whether they agree with the statement 'I believe processed foods (e.g., burgers, beverages, snacks) that contain cultured protein should be required to provide detailed labelling and information for consumers'. More than 70% of participants agreed (42% strongly agreed and 34% agreed) that processed foods containing cultured protein should be required to provide detailed labelling information for consumers (Juhasz et al., 2023), though the labelling requirement investigated in the study was in a general context and not specifically related to the requirements for foods that are not required to bear a label.

Further research examining consumer preferences regarding labelling of CBM products is warranted, particularly in Australia and NZ.

## Consumer behaviour and motivations

Research Q8: Are consumers willing to consume cell-based meats? If so, how are cell-based meats likely to be incorporated into the diet (frequency, substitute or consume in addition to regular counterpart)?

Overall, 16 studies assessed participants' **willingness to 'eat', 'taste' or 'try' CBM**, and 12 examined **how** consumers are likely/willing to **incorporate CBM into their diet**. The findings from each set of studies are reviewed under their respective subheadings below.

Notably, in both cases, **direct comparison of study findings was limited by several factors:**

- Most studies assessed levels of willingness using either 5-point or 7-point rating scales, with the **difference in the number of scale points** limiting direct comparison of results to studies that used the same number of scale points.
- **Different labels/descriptors for the points** on the rating scale were also used in studies, thus changing the meaning of the ratings, and further limiting direct comparison of results.
- Additionally, while willingness scores in most studies were based on responses to a single question/item, three studies assessed willingness using an aggregate score of items that assessed willingness to try CBM in addition to factors such as how CBM would be incorporated into the diet, willingness to recommend CBM to others, and/or willingness to support policy that enables sale of CBM (Bryant and Barnett, 2019, Leong, 2022; Boykin, 2019). This **variation in single item scores vs. aggregate scores** further limits the reliability of direct comparisons with other studies.

## Are consumers willing to consume ('eat', 'taste' or 'try') cell-based proteins?

Of the 16 studies that assessed participants' willingness to 'eat', 'taste' or 'try' CBM (see Table 15) - two studies were appraised as **high quality** (Anderson and Bryant, 2018; Bryant et al., 2019b), 11 **moderate quality** (Bryant and Dillard, 2019; Bryant et al., 2019a; Bryant and Barnett, 2019; Boykin, 2019; de Oliveira Padilha et al., 2022; Giezenaar et al., 2023; Leong, 2022; Leung et al., 2023; Ruzgys and Pickering, 2020; Wilks et al., 2019; Hallman and Hallman, 2020), and three **low quality** (Szejda et al., 2021; Verbeke et al., 2015; Wilks and Phillips, 2017).

**Representative samples** were used in most studies except the following five: (Verbeke et al., 2015; Bryant and Dillard, 2019; Ruzgys and Pickering, 2020; Giezenaar et al., 2023; Bryant and Barnett, 2019). Fifteen studies reported **quantitative** findings from online surveys conducted in Australia, NZ, the UK, the US, Canada, and Singapore with sample size ranging from 185 to 2034. **Qualitative** findings were reported in a single study, which collected data from 60 participants in the UK using focus groups or an online survey (Verbeke et al., 2015).

**Most** studies that assessed participants' willingness to 'eat', 'taste' or 'try' CBM examined **CBM in general**, but two studies examined **specific types** of CBM (chicken and beef) (de Oliveira Padilha et al., 2022) or CB seafood (Atlantic salmon) (Hallman and Hallman, 2020). **Different names for CBM** used in studies include 'clean meat', 'cultivated meat', 'cultured meat', 'cell-based meat', 'in vitro meat', 'animal-free meat', and 'lab grown meat'. Overall, one study presented a **neutral description of CBM** (Hallman and Hallman, 2021); 13 presented **biased and/or framed descriptions**; and the remaining study did not report if a description was provided (Leong, 2022).

Overall, findings from studies that report the proportion of participants who selected each rating on the 5-point or 7-point rating scale, show that 33-66% of consumers would be willing to try CBM (representing a rating on the positive end of the scale), 12-22% would not try it (a rating on the negative end of the scale), and 12-22% are unsure (midpoint rating) (Szejda et al., 2021, Anderson and Bryant, 2018, Bryant and Dillard, 2019, Bryant et al., 2019a, Giezenaar et al., 2023, Wilks and Phillips, 2017). Relatively higher uncertainty and lower aversion were reported in the 'high-quality' study of US consumers, with 21% unsure, and 12% reporting they would not try CBM (Anderson and Bryant, 2018). Differences in proportions were observed across rating scales with different descriptors/labelling, with 65-67% (in the US and NZ) willing to try CBM when assessed with rating scales from 'definitely no' to 'definitely yes' or 'strongly disagree' to 'strongly agree' (Anderson and Bryant, 2018, Bryant and Dillard, 2019, Giezenaar et al., 2023, Wilks and Phillips, 2017), reducing to 33-40% (in the US and UK) when assessed with 'Not at all likely' to 'Extremely likely' (Bryant et al., 2019a, Szejda et al., 2021). However, it is also possible that these differences reflect variation across studies in the framing of questions; the CBM terminology used; the prior information given about the product, with none of the studies providing a neutral description of CBM; and/or other differences between samples and countries.

Notably, the proportion of consumers willing to eat CBM was found to be lower when asking about eating specific types of CBM, with 27% of Australians surveyed willing to eat CB chicken and slightly fewer willing to eat CB beef (24%) (de Oliveira Padilha et al., 2022). However, this difference in the proportion of consumers willing to eat CBM (33-66%) vs. specific types of CBM (24-27%, investigated in one study), could also be due to differences

in the framing of questions or other difference between samples and countries, among other factors.

Average scores for willingness to try/eat CBM provide a different perspective. In studies that used 5-point rating scales, average willingness scores ranged from just below to just above the midpoint of the scale (mean score 2.58-3.35 on the scale from 1-5) (Anderson and Bryant, 2018, Bryant and Dillard, 2019, Bryant and Barnett, 2019, Wilks et al., 2019, Hallman and Hallman, 2021). Similarly, in studies that used 7-point rating scales, average willingness to try scores fell between the midpoint ('unsure'/'neither agree nor disagree'/'neither willing nor unwilling'/'neither likely nor unlikely' rating) and the one point above the midpoint ('maybe yes'/'somewhat agree'/'somewhat willing'/'somewhat likely' rating) on the scale (mean scores of 4.3-5.3 on the scale from 1-7) (Leung, 2023; Giezenaar, 2023; Leung, 2022; Ruzgys, 2020).

Overall, the highest mean willingness ratings were observed among NZ consumers who reported prior awareness of CBM (mean 5.3 out of 7) (Giezenaar et al., 2023) and US consumers asked about their willingness to try 'clean' meat (mean 3.8 out of 5) or presented with information emphasising the societal benefits of CBM or the similarities between CBM and conventional meat (mean 3.8-3.9 out of 5) (Anderson and Bryant, 2018, Bryant and Dillard, 2019). The lowest mean willingness ratings were found among consumers who were asked about their interest in trying CB seafood (Hallman and Hallman, 2021) or their willingness to try 'lab-grown' meat (Bryant and Barnett, 2019, Boykin, 2019).

### **Impact of naming (CBM term used)**

Two studies (both moderate quality and conducted in the US) investigated the impact of **different names** on willingness to try CBM (Bryant and Barnett, 2019), one of which focused on CB seafood (Hallman and Hallman, 2021). In both studies, the **names used for CBM** impacted average willingness to try. In one study, consumers were randomly allocated to one of four names for CBM ('cultured meat', 'clean meat', 'lab-grown meat', and 'animal-free meat') and were shown the same description of CBM, with the only difference being the name used for CBM (their allocated name). Notably, this description used emotive language (i.e., referred to animals not being 'killed'), which may have influenced consumer's willingness ratings, but any influence would likely have been similar across groups due to all group seeing the same description. On average, willingness to try CBM was **higher** among participants who saw the name **'clean meat' than those who saw the name 'lab grown meat'** (mean score 3.35 vs. 2.58 on the scale from 1=Strongly disagree, to 5=Strongly agree) (Bryant & Barnett, 2019), with no other statistically significant differences found between other pairs of names tested (all combinations were tested) (Bryant and Barnett, 2019). The study that focused on CB seafood, examined consumers' interest in tasting 'Cell-based' or 'Cell-cultured' Atlantic Salmon, with each participant assessing and viewing a description of only one of the two names. Overall, **willingness to taste cell-based salmon was significantly higher than cell-cultured salmon**, and this was found both before and after participants read a description explaining the meaning of their assigned term (Hallman and Hallman, 2021).

## Impact of information framing

Three studies investigated the **impact of different descriptions/framing of CBM** (Anderson and Bryant, 2018, Bryant and Dillard, 2019, Leung et al., 2023) on willingness to consume CBM. The provided **information about CBM** was found to **influence willingness to consume** the products in **some studies** (Bryant and Dillard, 2019, Hallman and Hallman, 2021, Ruzgys and Pickering, 2020; Boykin, 2019) **but not others** (Anderson and Bryant, 2018, Leung et al., 2023). **Framing** of information about CBM was found to have an impact on willingness to try CBM among US consumers, such that those who saw **framing that emphasised the technological aspects of CBM** ('high tech' framing) were, on average, significantly **less willing to try CBM** than those who saw framing that **emphasised the societal benefits of CBM** ('societal benefits') **or the similarity of CBM and traditional meat** ('same meat') (Bryant and Dillard, 2019). The average level of willingness was closer to 'unsure' for the 'high tech' group and closer to 'probably yes' for the 'same meat' and 'societal benefits' groups. Another US study found that, on average, willingness to consume CBM was **higher** among consumers shown a blog post framed to be either **supportive of CBM or neutral**, relatively those who saw a blog post framed to be **against CBM**; notably, the compared mean scores were aggregate scores that considered behaviours beyond trying CBM, including consuming CBM regularly and as a replacement for conventional meat (Boykin, 2019). Additionally, average willingness to try CBM significantly **increased** among young Canadian participants, after being shown a **message about the general benefits of CBM** and **increased further** after being shown a **message framing CBM as natural** (Ruzgys and Pickering, 2020). In contrast, a higher average willingness to taste 'Cell-based' and 'Cell-cultured' Atlantic Salmon was found among US consumers **before** they read a description of the meaning of the term, suggesting that their initial perceptions of the product were more favourable than the neutrally framed information presented to them (Hallman and Hallman, 2021).

Notably, other studies that experimentally manipulated the framing of information about CBM, found **no significant difference** in mean willingness scores between treatment groups (Anderson and Bryant, 2018, Leung et al., 2023). These studies were conducted in the US and Singapore, and **both study samples were relatively large and representative**. This is similar to one of the studies that found significant framing effects (Hallman and Hallman, 2021), but different to the other two studies, which surveyed samples that were relatively small and skewed towards younger age groups (Bryant and Dillard, 2019; Ruzgys and Pickering, 2020). Also same as Hallman and Hallman (2021), both studies **randomly assigned consumers to information treatments**. The US consumers were shown one of three messages about naturalness or a control message about the health/animal/environmental benefits of CBM (Anderson and Bryant, 2018), while Singaporean consumers were shown one of five framed messages highlighting benefits of CBM (Leung et al., 2023). Notably, manipulation checks in the US study showed that two of the three framed messages were **not successful at convincing consumers of the intended message** (i.e., perceptions of the intended message in these groups were no different to the control group). Similarly, framing had no significant effect on reasons for consuming CBM among Singaporean consumers, which may suggest that the framed messages were also not persuasive (but could also be due to the benefits highlighted in the messages not being important enough to influence behaviour). Additionally, Singapore is currently the **only country where consumers can purchase CBM**. It is possible that consumers' perceptions of CBM might be stronger and less amenable to change (e.g., via framed messages), when CBM exists on the market/is no longer a hypothetical product.

Other differences between samples and study design could also be contributing to discrepancies in findings regarding framing effects. Overall, **findings are mixed regarding the influence of message framing on willingness to consume CBM.**

**Conclusion:**

- Overall, multiple studies (most of moderate quality and most using representative samples) indicate that, **on average, consumers are either unsure about eating CBM or are somewhat willing or somewhat unwilling to eat it**; and show that **33-66%** of consumers would be **willing to try CBM**, **12-27%** are **unsure**, and **12-22%** **would not try it**. The varied results across studies may be explained by the different samples, framing of questions and/or the type of information provided to participants about CBM.
- **The name used for CB proteins can influence consumers' willingness to consume the products.** The limited included studies suggest **'clean' meat** is associated with greater willingness to consume CBM than is **'lab-grown' meat**, and **'cell-based' seafood** is preferred to **'cell-cultured' seafood**.
- The **framing of information** regarding CBM had **variable influence** on willingness to consume the products, with studies reporting mixed findings.



**Table 15. Summary of results for studies assessing consumers' willingness to consume cell-based meat**

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results					
High	(Anderson and Bryant, 2018)	US	1185	Yes (bias and framing)	Would you be willing to try clean meat?	1= 'Definitely no' to 5='Definitely yes'	<b>Definitely no</b>	<b>Probably no</b>	<b>I am unsure</b>	<b>Probably yes</b>	<b>Definitely yes</b>	
					Total sample		6.0%	6.1%	21.6%	32.6%	33.8%	
					Total sample		<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
					Total sample		12.1%	21.6%	66.4%			
					3 Information treatment groups and 1 control. No significant difference in mean scores between experimental vs. control groups.		<b>Total sample</b>	<b>'Clean meat is natural'</b>	<b>'Conventional meat is unnatural'</b>	<b>'Challenging appeal to nature'</b>	<b>Control</b>	
					Mean		3.88	3.8	4.0	3.8	3.9	
High	(Bryant et al., 2019b)		1185	Yes (bias and framing)	Willingness to try clean meat	1= 'Definitely no' to 5='Definitely yes'	<b>Total</b>	<b>Clean meat is natural</b>	<b>Conventional meat is unnatural</b>	<b>Challenging appeal to nature</b>	<b>Control</b>	<b>p-value</b>
					Mean		3.88	3.81	3.98	3.81	3.91	0.13
Moderate	(Bryant and Dillard, 2019)	US	480	Yes (framing)	Willingness to try cultured meat	1= 'Definitely no' to 5='Definitely yes'	<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
					3 Information treatment groups and no control. Significant difference in mean scores between experimental groups.		18.4%	16.9%	64.6%			
					Total sample		<b>'Societal benefits' group</b>	<b>'High tech' group</b>	<b>'Same meat' group</b>			
					Mean±SD		3.79±1.10 <sup>a</sup>	3.30±1.55 <sup>b</sup>	3.85±1.62 <sup>a</sup>	P<0.001		
Low	(Wilks and Phillips, 2017)	US	673	Yes (bias)	Would you be willing to try IVM?		<b>Definitely no</b>	<b>Probably no</b>	<b>Unsure</b>	<b>Probably yes</b>	<b>Definitely yes</b>	
							8.6%	12.6%	11.9%	34.8%	31.6%	
							<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
							21.2%	11.9%	66.4%			

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results					
Moderate	(Bryant et al., 2019a)	US	987	Yes (bias)	How likely are you to try clean meat?	1=Not at all likely, 2=Somewhat likely, 3=Moderately likely, 4=Very likely, 5=Extremely likely	<b>Not at all likely</b>	<b>Somewhat likely</b>	<b>Moderately likely</b>	<b>Very likely</b>	<b>Extremely likely</b>	
							24.5%	22.9%	19.8%	15.9%	16.9%	
Low	(Szejda et al., 2021)	Multiple - US and UK	2018 (US); 2034 (UK)	Yes (bias)	Once cultivated meat has become widely available, how likely are you to try cultivated meat?	1 = Not at all likely; 2 = Somewhat likely; 3 = Moderately likely; 4 = Very likely; 5 = Extremely likely	<b>'Not at all likely' or 'Somewhat likely'</b>					
					US		21%	40%	40%			
					UK		22%	39%	40%			
Moderate	(de Oliveira Padilha et al., 2022)	Australia	1060	Yes (bias)	Willingness to eat...		<b>Probably or definitely no</b>		<b>Unsure</b>	<b>Probably or definitely yes</b>		
					Lab-grown chicken		49%	23%	27%			
					Lab-grown beef		49%	27%	24%			
Moderate	(Bryant and Barnett, 2019)	US	185	Yes (bias)	Aggregate score for the items: I would be willing to try [X], I would eat [X] instead of conventional meat, I would rather eat [X] than soy-based meat substitutes or Quorn. Mean±SD	1=Strongly disagree, to, 5=Strongly agree	<b>'Animal free meat'</b>	<b>'Clean meat'</b>	<b>'Cultured meat'</b>	<b>'Lab grown meat'</b>		
							3.08±1.05 <sup>a,b</sup>	3.35±0.98 <sup>a</sup>	3.17±1.00 <sup>a,b</sup>	2.58±1.35 <sup>b</sup>	P<0.05	
Moderate	(Hallman and Hallman, 2021)	US	1200	Yes (neutral)	Interest in tasting 'Cell-based' or 'Cell-cultured' Atlantic Salmon Mean±SD	1=not at all interested, 2=slightly interested, 3=moderately interested, 4=very interested, 5=extremely interested	<b>'Cell-based' Atlantic salmon (n=519)</b>	<b>'Cell-cultured' Atlantic salmon (n=609)</b>				
					Before reading the description of the meaning of the term		3.12±1.49	2.94±1.52	P=0.034			
					After reading the description of the meaning of the term		2.83±1.47	2.65±1.51	P=0.036			
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias)	If readily available, how likely is it that you would try cultured meat?	1=Extremely unlikely, to, 7=Extremely likely	<b>Before reading CBM statements (no messaging)</b>	<b>After reading CBM statements (general educational messaging)</b>	<b>After reading CBM statements (naturalness messaging)</b>			
					Mean		4.3 <sup>a</sup>	4.5 <sup>b</sup>	4.7 <sup>c</sup>		P<0.05	

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results				
Moderate	(Giezenaar et al., 2023)	NZ	572	Yes (bias)	I would be willing to taste cultivated meat	1=Strongly disagree; 2=disagree; 3=somewhat disagree; 4=neither agree nor disagree; 5=somewhat agree; 6=agree; 7=Strongly agree	<b>Total sample</b>	<b>Aware of CBM</b>	<b>Not aware of CBM</b>		
					Mean±SD % 'somewhat agreed' 'agreed', or 'strongly agreed'		4.9±0.06 67%	5.3±0.06 <sup>a</sup>	4.5±0.06 <sup>b</sup>	P<0.001	
						1=strongly disagree, to 7=strongly agree	<b>Total sample</b>	<b>Mean±SD</b>			
								<b>Message against lab grown meat</b>	<b>Message supporting lab grown meat</b>	<b>Neutral message</b>	
Moderate	(Boykin, 2019)	US	238	Yes (framing)	How likely are you to try lab grown meat at least once? Aggregate score of three items: How likely are you to try lab grown meat at least once?, How likely are you to eat lab grown meat as a replacement for conventional meat?, How likely are you to purchase lab grown meat regularly?		2.66±1.48	2.03±1.21 <sup>a</sup>	2.64±1.27 <sup>b</sup>	2.55±1.41 <sup>b</sup>	
							<b>Mean±SD</b>				
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	Willingness to eat cultivated meat	1= 'Definitely no' to 7='Definitely yes'	4.68±1.47				
Moderate	(Leong, 2022)	US	326	Not reported	Results are an aggregate score of four questions: 1) Willingness to try cultured meat, 2) Willingness to buy cultured meat regularly, 3) Willingness to recommend cultured meat to my family and friends, 4) Willingness to support policy to sell cultured meat in stores. Mean±SD	1 = Very unwilling to 7 = Very willing	4.37±1.87				

Quality	Reference	Country	N	CBM definition	Question	Response scale	Results
Moderate	(Wilks et al., 2019)	US	1193	Yes (bias)	Would you be willing to try cultured meat? Mean±SD (no response n=79) Aggregate score of two items: Would you be willing to try cultured meat?" and "Would you be willing to eat cultured meat regularly".	1=Definitely no, to, 5=Definitely yes	2.91±1.24
Low	(Verbeke et al., 2015)	UK	60	Unclear	A few people expressed willingness to try cultured meat (if not more expensive and mostly out of ethical considerations), but most were against the idea and did not imagine consuming it if it ever became commercially available.		

**Note(s):** In each row, values followed by different letters are significantly different

## How are cell-based meats likely to be incorporated into the diet?

In addition to examining willingness to eat, taste or try CBM, which could be once-off behaviours, most studies also examined how consumers are likely/willing to incorporate CBM into their diet. This next section reviews findings from **12 studies that investigated the different ways that consumers are willing to incorporate CBM into their diet**. The most assessed CBM 'incorporation' behaviours in these studies were willingness to eat CBM **regularly** (eleven studies), willingness to eat CBM as a **replacement for conventional meat** (ten studies); and willingness to eat CBM meat **instead of plant-based meat substitutes** (five studies). Additionally, the following were each assessed in a single study: willingness to eat CBM as a supplement to conventionally produced meat (Leung et al., 2023); the proportion of CBM and conventional meat that participants expect to consume in an imagined future where both CBM conventional meat are available (Szejda et al., 2021); and likely frequency of consuming CB meat and CB fish (Giacalone and Jaeger, 2023). Only one of the 12 studies investigated cell-based seafood (Giacalone and Jaeger, 2023).

Of the 12 studies, two were appraised as **high quality** (Anderson and Bryant, 2018; Bryant et al., 2019b), nine as **moderate quality** (Bryant and Dillard, 2019; Bryant et al., 2019a; Malavalli et al., 2021; Ruzgys and Pickering, 2020; Giezenaar et al., 2023; Leung et al., 2023; Boykin, 2019; Garcez de Oliveira Padilha et al., 2021; Giacalone and Jaeger, 2023), and one as **low quality** (Wilks and Phillips, 2017). **Representative samples** were used in most studies except the following four: (Bryant and Dillard, 2019; Malavalli et al., 2021; Ruzgys and Pickering, 2020; Giezenaar et al., 2023).

### ***Willingness to consume cell-based meat regularly***

Willingness to eat (or buy) CBM regularly was assessed in 11 studies conducted in Australia, NZ, Singapore, the US and Canada (see Table 16). Different names for CBM used in studies include 'clean meat' in three studies (Anderson and Bryant, 2018; Bryant et al., 2019b; Bryant et al., 2019a); 'cultivated meat' in two studies (Giezenaar et al., 2023; Leung et al., 2023); 'cultured meat' in three studies (Giacalone and Jaeger, 2023; Ruzgys and Pickering, 2020; Bryant and Dillard, 2019); 'in vitro meat' in two studies (Malavalli et al., 2021; Wilks and Phillips, 2017); and 'lab grown meat' in two studies (Boykin, 2019; Garcez de Oliveira Padilha et al., 2021). All studies presented biased and/or framed descriptions of CBM.

Consumers' willingness to eat CBM **regularly**, was generally **lower** than their willingness to **try/eat** CBM, based on the **eight studies** that assessed both behaviours (Anderson and Bryant, 2018; Bryant et al., 2019b; Bryant and Dillard, 2019; Wilks and Phillips, 2017; Bryant et al., 2019a; Ruzgys and Pickering, 2020; Giezenaar et al., 2023; Leung et al., 2023). All studies presented **biased and/or framed** descriptions of CBM.

Overall, based on studies that report the proportion of participants who selected each rating on a 5-point scale (all four surveys of US consumers and one of NZ consumers) or 7-point scale (one NZ survey), **33-49% of US consumers would be willing to consume CBM regularly** ('probably yes' or 'definitely' yes'; score  $\geq 4$  on 5-point scale; or 'somewhat agreed', 'agreed', or 'strongly agreed', score of  $\geq 5$  on 7-point scale), **15-32% would not be willing to consume CBM regularly** ('probably' or 'definitely' no; score  $\leq 2$  on 5-point rating scale), and **26-38% were unsure** (midpoint of the rating scale) (Anderson and Bryant, 2018, Bryant and Dillard, 2019, Wilks and Phillips, 2017, Bryant et al., 2019a, Malavalli et al., 2021; Giezenaar et al., 2023).

**Average rating scores for willingness to eat CBM regularly, provide a different perspective.** In studies that used 5-point rating scales, average willingness scores generally fell between the 'unsure' and the 'probably yes' ratings on the response scale (mean score 3.03 – 3.80 on the scale from 1-5) (Anderson and Bryant, 2018, Bryant and Dillard, 2019), but were lower among Australian consumers, with mean scores near the 'somewhat unwilling' rating (2.23) (Garcez de Oliveira Padilha et al., 2021). A larger range of mean ratings was observed in studies that used 7-point rating scales, with average scores for 'willingness to eat regularly' falling between a score of 2.2 and 4.6 on the scale from 1-7, which would be between 'disagree' and 'somewhat agree' on a scale from 'strongly disagree' to 'strongly agree' (Boykin, 2019, Giezenaar et al., 2023, Leung et al., 2023, Ruzgys and Pickering, 2020). Across all studies, the highest mean willingness ratings were observed among NZ consumers who reported prior awareness of CBM (mean 4.6 out of 7) (Giezenaar et al., 2023) and the two lowest scores were both in the only studies that used the term 'lab-grown meat', both of which also provided biased or framed descriptions of CBM to consumers (as did most other studies) (Boykin, 2019, Garcez de Oliveira Padilha et al., 2021).

Further, findings of a **segmentation study of Australian consumers** suggest just 11.5% of Australian adults are willing to eat CBM regularly. Using a representative sample, this study identified six distinct groups (segments) of consumers based on their responses to questions assessing their willingness to eat lab-grown meat 'occasionally' and 'regularly', and the relative importance of various food choice factors when grocery shopping. Overall, average ratings for willingness to eat lab-grown meat regularly were on the positive side of the scale's mid-point in the smallest segment only. With other studies showing that 'lab-grown meat' is associated with lower willingness ratings than some other names/descriptors (Bryant and Barnett, 2019), it is possible that these findings underrepresent willingness among Australian consumers.

**Mixed findings were reported regarding the impact of information framing on willingness to consume CBM regularly (this is similar to the findings regarding willingness to eat/taste/try CBM).** Despite average willingness ratings for regular consumption being somewhat lower than willingness ratings for eating/tasting/trying CBM, the same trends were observed such that consumers exposed to 'high tech' framing of CBM were, on average, significantly less willing to consume CBM regularly than those who saw the 'same meat' or 'societal benefits' framing (Bryant and Dillard, 2019); and young Canadian participants were significantly more willing to consume CBM regularly after seeing a message about the general benefits of CBM, with willingness increasing further after seeing a message framing CBM as natural (Ruzgys and Pickering, 2020). As was the case for willingness to eat/try/buy CBM, two studies found that framing did not significantly influence willingness to consume CBM regularly (Leung et al., 2023; Bryant et al., 2019b).

**Anticipated frequency of consuming CB meat and CB fish** was assessed in one study that surveyed consumers in Australia, the US, and Singapore (Giacalone and Jaeger, 2023). On average, participants in Australia and the US anticipated consuming both CB products 'never or less than once yearly'. Slightly more frequent consumption of '2-3 times per year', on average, was anticipated by consumers in Singapore, which is currently the only country with market access to CBM. Thus, slightly higher but still overall low average consumption frequency was anticipated among consumers who currently have the option of purchasing CBM. However, in all three countries, large standard deviations indicate there is

**considerable variation in anticipated consumption frequency within the study samples.**

- The overall evidence based on multiple studies (**most of moderate quality and most using representative samples**) suggests that consumers' **willingness to eat CBM regularly**, is generally **lower** than their willingness to **eat/taste/try** CBM. Overall, **33-49%** of consumers would be **willing** to consume CBM regularly, **26-38% are unsure**, and **16-32%** are **unwilling**. Consumers may be less willing to regularly consume CBM when it is **described as 'lab grown meat'**. On average, consumers **anticipated a relatively low consumption frequency** of CBM and CB fish (two to three times per year or less).

**Table 16. Summary of results for studies assessing consumers' willingness to consume cell-based meat regularly.**

Quality	Reference	Country	N	CBM defined	Question	Response scale	Results					
High	(Anderson and Bryant, 2018)	US	1185	Yes (bias and framing)	Would you be willing to buy clean meat regularly?	1= 'Definitely no' to 5='Definitely yes'	<b>Definitely no</b>	<b>Probably no</b>	<b>I am unsure</b>	<b>Probably yes</b>	<b>Definitely yes</b>	
					Total sample		7.5%	8.9%	37.7%	28.4%	17.5%	
					Total sample		<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
					3 Information treatment groups and 1 control. No significant difference in mean scores between experimental vs. control groups. Mean±SD		16.4%	37.7%	45.9%			
							<b>Total sample</b>	<b>'Clean meat is natural'</b>	<b>'Conventional meat is unnatural'</b>	<b>'Challenging appeal to nature'</b>	<b>Control</b>	
							NR	3.5	3.6	3.4	3.5	
High	(Bryant et al., 2019b)	US	1185	Yes (bias and framing)	Willingness to buy clean meat regularly	1= 'Definitely no' to 5='Definitely yes'	<b>Total</b>	<b>Clean meat is natural</b>	<b>Conventional meat is unnatural</b>	<b>Challenging appeal to nature</b>	<b>Control</b>	<b>p-value</b>
					Mean		3.47	3.45	3.57	3.38	3.49	0.13
Moderate	(Bryant and Dillard, 2019)	US	480	Yes (framing)	Willingness to eat cultured meat regularly.	1= 'Definitely no' to 5='Definitely yes'	<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
					Total sample		24.5%	26.4%	49.1%			
					3 Information treatment groups and no control. Significant difference in mean scores between experimental groups. Mean±SD		<b>'Societal benefits' group</b>	<b>'High tech' group</b>	<b>'Same meat group'</b>			
							3.50±1.10 <sup>a</sup>	3.03±1.33 <sup>b</sup>	3.48±1.21 <sup>a</sup>		P=0.001	
Low	(Wilks and Phillips, 2017)	US	673	Yes (bias)	Would you be willing to eat IVM regularly?	1=Definitely yes, 2=Probably yes, 3=Unsure, 4=Probably No, 5=Definitely No	<b>Definitely no</b>	<b>Probably no</b>	<b>Unsure</b>	<b>Probably yes</b>	<b>Definitely yes</b>	
							7.5%	18.9%	30.8%	26.2%	6.4%	
							<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
							26.4%	30.8%	32.6%			



Quality	Reference	Country	N	CBM defined	Question	Response scale	Results				
Moderate	(Bryant et al., 2019a)	US	987	Yes (bias)	How likely are you to purchase clean meat regularly?	1=Not at all likely, 2= Somewhat likely, 3=Moderately likely, 4=Very likely, 5=Extremely likely	<b>Not at all likely</b>	<b>Somewhat likely</b>	<b>Moderately likely</b>	<b>Very likely</b>	<b>Extremely likely</b>
							23.6%	23.7%	22.9%	16.2%	13.6%
Moderate	(Malavalli et al., 2021)	NZ	206	Yes (bias)	Do you think you would buy in-vitro meat (IVM) regularly	1= 'Definitely no' to 5= 'Definitely yes'	<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>	<b>Mean±SD</b>	
							32%	35%	33%	2.97±1.04	
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias)	If readily available, how likely is it that you would incorporate cultured meat into your regular diet?	1=Extremely unlikely, to, 7=Extremely likely	<b>Before reading CBM statements (no messaging)</b>	<b>After reading CBM statements (general educational messaging)</b>	<b>After reading CBM statements (naturalness messaging)</b>	<b>P-value</b>	
					Mean		3.3 <sup>a</sup>	3.8 <sup>b</sup>	4.4 <sup>c</sup>	<0.05	
Moderate	(Giezenaar et al., 2023)	NZ	572	Yes (bias)	I would be willing to eat cultivated meat regularly	1=Strongly disagree; 2= disagree; 3=somewhat disagree; 4=neither agree nor disagree; 5=somewhat agree; 6=agree; 7=Strongly agree	<b>Total sample</b>	<b>Aware of CBM</b>	<b>Not aware of CBM</b>	<b>P-value</b>	
					Mean±SD		4.3±0.07	4.6 ± 0.06 <sup>a</sup>	4.0 ± 0.06 <sup>b</sup>	<0.001	
					% 'somewhat agreed' 'agreed', or 'strongly agreed'		47%				
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	Willingness to eat cultivated meat regularly	1='Definitely no' to 7='Definitely yes'	<b>Mean±SD</b>				
							4.09±1.53				
Moderate	(Boykin, 2019)	US	238	Yes (framing)	How likely are you to purchase lab grown meat regularly?	1=strongly disagree, to 7=strongly agree					
							2.30±1.37				

Quality	Reference	Country	N	CBM defined	Question	Response scale	Results						
Moderate	(Garcez de Oliveira Padilha et al., 2021)	Australia	1078	Yes (bias)	Willingness to eat LGM	1= Not at all willing to do this, 2= somewhat unwilling, 3=neither willing nor unwilling, 4= somewhat willing, 5= Very willing to do this	<b>Cluster 1 (21.9%)</b>	<b>Cluster 2 (14.4%)</b>	<b>Cluster 3 (14.9%)</b>	<b>Cluster 4 (21.3%)</b>	<b>Cluster 5 (16.0%)</b>	<b>Cluster 6 (11.5%)</b>	<b>Total</b>
					Occasionally		1.09 <sup>a</sup>	1.14 <sup>a</sup>	2.16 <sup>b</sup>	3.41 <sup>d</sup>	3.23 <sup>c</sup>	4.44 <sup>e</sup>	2.48
					Regularly		1.00 <sup>a</sup>	1.00 <sup>a</sup>	1.81 <sup>b</sup>	2.92 <sup>c</sup>	2.94 <sup>c</sup>	4.37 <sup>d</sup>	2.23
Moderate	(Giacalone and Jaeger, 2023)	Multiple-Australia, Singapore, US	623 (Australia), 623 (Singapore); 629 (US)	Yes (bias)		1=Never or less than once yearly'; 2='2-3 times a year'; 3= 'Every 2-3 months'; 4= 'Once every month'; 5= '1-3 times per month'; 6='Once every week'; 7= '2-4 times per week'; 8= '5-6 times per week'; 9='Once daily or more often'	<b>Australia</b>	<b>Singapore</b>	<b>US</b>				
					How often would you consume cell-cultured meat?		1±3	2±4	1±4				
					How often would you consume cell-cultured fish?		1±2	2±4	1±3				

**Note(s):** In each row, values followed by different letters are significantly different.

## **Willingness to consume cell-based meat as a replacement for conventional meat**

**Twelve studies** assessed willingness to eat CBM as a replacement for conventional meat – **two** appraised as **high quality** (Anderson and Bryant, 2018; Bryant et al., 2019b), eight moderate quality (Bryant and Dillard, 2019; Malavalli et al., 2021; Bryant et al., 2019a; Garcez de Oliveira Padilha et al., 2021; Boykin, 2019; Ruzgys and Pickering, 2020; Giezenaar et al., 2023; Leung et al., 2023), and **two low quality** (Szejda et al., 2021; Wilks and Phillips, 2017) (see Table 17). **Representative samples** were used in most studies except the following four: (Bryant and Dillard, 2019; Malavalli et al., 2021; Ruzgys and Pickering, 2020; Giezenaar et al., 2023).

Different names for CBM used in studies include 'clean meat' (three studies: Anderson and Bryant, 2018; Bryant et al., 2019b; Bryant et al., 2019a), 'cultivated meat' (three studies: Szejda et al., 2021; Giezenaar et al., 2023; Leung et al., 2023), 'cultured meat' (two studies: (Ruzgys and Pickering, 2020; Bryant and Dillard, 2019)), 'cell-based meat', 'in vitro meat' (two studies: (Malavalli et al., 2021; Wilks and Phillips, 2017)), and 'lab grown meat' (two studies: (Boykin, 2019; Garcez de Oliveira Padilha et al., 2021)). All studies presented **biased and/or framed** descriptions of CBM.

Findings indicate that between **29 - 53% of US consumers are willing to eat CBM as a replacement for conventional meat** (score  $\geq 4$  on 5-point rating scale); **17-49% are unwilling** (score  $\leq 2$  on 5-point rating scale); and **22-44% are unsure** (midpoint of rating scale).

Most studies that assessed willingness to eat CBM as a replacement for conventional meat also assessed willingness to consume CBM regularly. Typically, **similar proportions** of consumers were **willing to both eat CBM regularly and eat it in place of conventional meat** (Bryant and Dillard, 2019, Wilks and Phillips, 2017, Leung et al., 2023, Bryant et al., 2019a, Boykin, 2019). However, one study (high quality and using a representative sample) found a higher proportion of consumers was willing to eat CBM in place of conventional meat than was willing to eat CBM regularly (Anderson and Bryant, 2018); and three studies (all moderate quality, and one using a representative sample) found the opposite. Notably all three studies assessed willingness to replace all conventional meat with CBM (extent of replacement was not specified in other studies), and found a higher proportion was willing to eat CBM regularly than was willing to eat it in place of conventional meat (Garcez de Oliveira Padilha et al., 2021, Giezenaar et al., 2023, Ruzgys and Pickering, 2020). There were no notable differences in the terms or information used to describe CBM in these three studies compared to others, with most studies presenting biased or framed descriptions of CBM and a range of CBM terms (e.g., the CBM terms used in the three studies were 'lab grown meat', 'cultured meat' and 'cultivated meat', which were also used in some of the other studies). The three studies were conducted in Australia, NZ and Canada, while the others were mostly in the US and one in Singapore. Therefore, differences between countries could be contributing to the discrepancy in findings.

Findings from studies that specified the extent of replacement when assessing willingness to eat CBM in place of conventional meat suggest a **preference among consumers to retain some conventional meat in their diet** (Garcez de Oliveira Padilha et al., 2021, Giezenaar et al., 2023, Ruzgys and Pickering, 2020). For example, only 30% of NZ participants were willing to regularly, often, or always purchase CBM instead of conventional meat (Giezenaar et al., 2023). Likewise Australian participants were, on average, 'somewhat unwilling' to

replace either all or some of the conventional meat in their diet with CBM, but average willingness level increased by 32% (from a mean score of 2.08 to 2.45, on a 5-point scale from 1-5) when asked about willingness to replace some of the conventional meat (vs. all of it) (Garcez de Oliveira Padilha et al., 2021). Overall, this is consistent with findings from the US and UK, showing that consumers anticipate that CBM will partially (rather than fully) replace conventional meat in their diet, with **participants expecting CBM to account for 37-42% of their total meat consumption** (Szejda et al., 2021).

- The overall evidence based on multiple studies (**most of moderate quality and using representative samples**) suggests that **29-53% of consumers are willing to eat CBM as a replacement for conventional meat**, 22-44% are unsure, and 17-49% are unwilling.
- Generally, similar proportions of consumers are willing to both eat CBM regularly and eat it in place of conventional meat, but **there is a preference to retain some conventional meat in the diet.**

**Table 17. Summary of results for studies assessing consumers' willingness to consume cell-based meat in place of conventional meat.**

Quality	Reference	Country	N	CBM defined	Question	Response scale	Results					
High	(Anderson and Bryant, 2018)	US	1185	Yes (bias and framing)	Would you be willing to eat clean meat as a replacement for conventionally-produced meat? <sup>1</sup>	1= 'Definitely no' to 5='Definitely yes'	<b>Definitely no</b>	<b>Probably no</b>	<b>I am unsure</b>	<b>Probably yes</b>	<b>Definitely yes</b>	
							7.5%	9.4%	30.4%	35.0%	17.8%	
							<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
							16.9%	30.4%	52.8%			
					3 Information treatment groups and 1 control. No significant difference in mean scores between experimental vs. control groups. Mean	<b>Total sample</b>	<b>'Clean meat is natural'</b>	<b>'Conventional I meat is unnatural'</b>	<b>'Challenging appeal to nature'</b>	<b>Control</b>		
						NR	3.5	3.7	3.5	3.6		
High	(Bryant et al., 2019b)	US	1185	Yes (bias and framing)	Willingness to eat clean meat as a replacement for conventional meat	1= 'Definitely no' to 5='Definitely yes'	<b>Total</b>	<b>Clean meat is natural</b>	<b>Conventional meat is unnatural</b>	<b>Challenging appeal to nature</b>	<b>Control</b>	p-value
							3.54	3.48	3.65	3.45	3.57	0.06
Moderate	(Bryant and Dillard, 2019)	US	480	Yes (framing)	Willingness to replace conventional meat with cultured meat	1= 'Definitely no' to 5='Definitely yes'	<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
							26.6%	24.9%	48.5%			
							<b>'Societal benefits' group</b>	<b>'High tech' group</b>	<b>'Same meat group'</b>			
					Mean±SD	3.37±1.16 <sup>a</sup>	3.03±1.36 <sup>b</sup>	3.49±1.24 <sup>a</sup>	P=0.004			
Low	(Wilks and Phillips, 2017)	US	673	Yes (bias)	Would you be willing to eat IVM as a replacement for farmed meat? (1.9% 'not applicable- I do not eat farmed meat')	1=Definitely yes, 2=Probably yes, 3=Unsure, 4=Probably No, 5=Definitely No	<b>Definitely no</b>	<b>Probably no</b>	<b>Unsure</b>	<b>Probably yes</b>	<b>Definitely yes</b>	
							9.1%	21.1%	26.3%	24.3%	7.2%	
							<b>Probably or definitely no</b>	<b>Unsure</b>	<b>Probably or definitely yes</b>			
						30.2%	26.3%	31.5%				

Quality	Reference	Country	N	CBM defined	Question	Response scale	Results				
							Probably or definitely no	Unsure	Probably or definitely yes	Mean±SD	
Moderate	(Malavalli et al., 2021)	NZ	206	Yes (bias)	Do you think you will try it (in-vitro meat) over traditional meat?	1= 'Definitely no' to 5='Definitely yes'	15%	44%	41%	2.32±1.42	
					Do you think you would buy in-vitro meat (IVM) over traditional meat?		19%	32%	50%	3.35±0.98	
Moderate	(Bryant et al., 2019a)	US	987	Yes (bias)	How likely are you to eat clean meat as a replacement for conventional meat?	1=Not at all likely, 2= Somewhat likely, 3=Moderately likely, 4=Very likely, 5=Extremely likely	<b>Not at all likely</b>	<b>Somewhat likely</b>	<b>Moderately likely</b>	<b>Very likely</b>	<b>Extremely likely</b>
							28.2%	20.6%	22.1%	16.2%	13.0%
Low	(Szejda et al., 2021)	Multiple - US and UK	2018 (US); 2034 (UK)	Yes (bias)	Once cultivated meat has become widely available, how likely are you to eat cultivated meat as a replacement for conventional meat?	1 = Not at all likely; 2 = Somewhat likely; 3 = Moderately likely; 4 = Very likely; 5 = Extremely likely	<b>'Not at all likely' or 'Somewhat likely'</b>	<b>'Moderately likely'</b>	<b>'Very likely' or 'Extremely likely'</b>		
					US		28%	42%	29%		
					UK		29%	44%	27%		
					Proportion of cultivated and conventional meat that participants expect to consume in an imagined future where both cultivated and conventional meat are available.	Average expected percentage of meat from each production method.	<b>Cultivated meat</b>	<b>Conventional meat</b>			
					US		37%	63%			
UK		42%	59%								
Moderate	(Garcez de Oliveira Padilha et al., 2021)	Australia	1078	Yes (bias)	Please indicate your willingness to do the following in the future, when lab-grown meat is available:	1= not at all willing to do this, 2= somewhat unwilling, 3=neither willing nor unwilling, 4= somewhat willing, 5= very willing to do this	<b>Mean±SD</b>				
					<b>Replace some</b> of the farmed meat in my diet with lab-grown meat		2.45				
					<b>Replace all</b> of the farmed meat in my diet with lab-grown meat		2.08				
Moderate	(Boykin, 2019)	US	238	Yes (framing)	How likely are you to eat lab grown meat as a replacement for conventional meat?	1=strongly disagree, to 7=strongly agree	2.32±1.42				

Quality	Reference	Country	N	CBM defined	Question	Response scale	Results			
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias)	If readily available, how likely is it that you would completely replace farmed/alternative meat with cultured meat in your regular diet?	1=Extremely unlikely, to, 7=Extremely likely	<b>Before reading CBM statements (no messaging)</b>	<b>After reading CBM statements (general educational messaging)</b>	<b>After reading CBM statements (naturalness messaging)</b>	<b>P-value</b>
					Mean score		2.8 <sup>a</sup>	3.3 <sup>b</sup>	3.7 <sup>c</sup>	<0.001
Moderate	(Giezenaar et al., 2023)	NZ	572	Yes (bias)	Willing to regularly, often, or always purchase cultivated meat instead of conventional meat % 'somewhat agreed' 'agreed', or 'strongly agreed'	1=Strongly disagree; 2= disagree; 3=somewhat disagree; 4=neither agree nor disagree; 5=somewhat agree; 6=agree; 7=Strongly agree	30%			
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	Willingness to eat cultivated meat as a replacement for conventionally produced meat, Mean±SD	1= 'Definitely no' to 7='Definitely yes'	4.10±1.58			

**Note(s):** In each row, values followed by different letters are significantly different.

## **Willingness to consume cell-based meat compared to plant-based meat substitutes**

Consumers' willingness to eat CBM compared to plant-based meat substitutes was assessed in **six studies** - four in the US (Bryant et al., 2019b; Anderson and Bryant, 2018; Bryant and Dillard, 2019; Wilks and Phillips, 2017) and one each in Canada (Ruzgys and Pickering, 2020) and Singapore (Leung et al., 2023) (see Table 18). **Two** studies were appraised as **high quality** (Bryant et al., 2019b; Anderson and Bryant, 2018) and **four moderate quality**; and four studies used representative samples (Bryant et al., 2019b; Anderson and Bryant, 2018; Wilks and Phillips, 2017; Leung et al., 2023).

Different names for CBM used in these studies include 'clean meat' in two studies (Anderson and Bryant, 2018; Bryant et al., 2019b); 'cultured meat' in two studies (Ruzgys and Pickering, 2020; Bryant and Dillard, 2019); 'cultivated meat' in one study (Leung et al., 2023); and 'in vitro meat' in one study (Wilks and Phillips, 2017). Further, while four studies used the term 'plant-based meat substitutes', enabling more reliable comparison of findings, the other two studies either used the term 'soy substitutes' (Wilks and Phillips, 2017) or referred to both 'farmed/alternative meat' (Ruzgys and Pickering, 2020), which limits comparison with findings from other studies. Notably, all studies presented consumers with a biased or framed description of CBM.

Overall, results shown that between 48-63% of US consumers would be 'somewhat more' or 'much more' willing to eat CBM compared to plant-based meat substitutes; 10-26% would be 'somewhat less' or 'much less' willing; and 22-29% would be 'neither more nor less willing' (Bryant et al., 2019b, Anderson and Bryant, 2018, Bryant and Dillard, 2019, Wilks and Phillips, 2017). The two studies that assessed willingness separately for consumers and non-consumers of plant-based meat substitutes, generally found that those **not-currently consuming plant-based meat substitutes**, reported a **greater willingness** to eat CBM compared to plant-based meat substitutes (Bryant et al., 2019b, Anderson and Bryant, 2018, Bryant and Dillard, 2019). Findings for **non-consumers of plant-based meat substitutes**, show that average willingness approximated the 'probably yes' rating on the scale (3.67 on the scale from 1-5) Bryant et al., 2019b; and **63%** would be '**somewhat more**' or '**much more**' willing to eat CBM compared to plant-based substitutes, **10%** would be '**somewhat less**' or '**much less**' willing, and **27%** would be '**neither more nor less**' willing (Anderson and Bryant, 2018).

On average, the consumers surveyed in Canada and Singapore and Canada were **unsure** about their willingness to eat CBM in place of plant-based meat alternatives, with average willingness/likelihood ratings near the midpoint of the scale in both studies (Leung et al., 2023, Ruzgys and Pickering, 2020). However, some key **differences in study design** could be contributing to the discrepancy in findings between these two studies and the US studies that reported somewhat higher willingness. In particular, the findings reported in the Canadian study, combine the responses of non-meat eaters who were asked about their likelihood of replacing 'meat alternatives with cultured meat' with the responses of meat eaters who were asked about their likelihood of replacing 'farmed meat with cultured meat' (Ruzgys and Pickering, 2020). Therefore, it is not clear whether the reported finding applies equally to farmed meat and alternative meat. Thus, it is possible that responses could be driven more by consumers' (un)willingness to replace farmed meat. Additionally, the Singaporean study was the only study where consumers had market access to CBM, which



could influence consumers' reported willingness to eat CBM instead of plant-based meat substitutes (Leung et al., 2023). Further, in contrast to the other studies that used the term 'plant-based meat substitutes', this study only reported an aggregate finding for the total sample, whereas the others reported findings separately for *current consumers* and *non-consumers* of plant-based meat substitutes and showed differences between the two samples (although statistical significance of the differences was not reported); and this study also used a 7-point rating scale while the others used a 5-point scale.

- The overall evidence based on multiple studies (most of moderate quality and using representative samples) suggests that 48-63% of US consumers would be 'somewhat more' or 'much more' willing to eat CBM compared to plant-based meat substitutes; 22-29% would be 'neither more nor less willing'; and 10-26% would be 'somewhat less' or 'much less' willing. Generally, greater willingness to eat CBM compared to plant-based meat substitutes was found among consumers who are not-currently eating plant-based meat substitutes.

**Table 18.** Summary of quantitative results for studies assessing consumers' willingness to consume cell-based meat compared to plant-based meat substitutes.

Quality	Referenc	Country	N	CBM defined	Question	Response scale	Results					
High	(Anderson and Bryant, 2018)	US	1185	Yes (bias and framing)	How willing would you be to eat clean meat compared to plant-based substitutes (e.g., soy)?	1=Much less, 2=Somewhat less, 3= Neither more nor less, 4= Somewhat more; 5=Much more	<b>Much less</b>	<b>Somewhat less</b>	<b>Neither more nor less</b>	<b>Somewhat more</b>	<b>Much more</b>	
							6%	8.4%	28.9%	32.3%	24.4%	
							Current eaters of plant-based substitutes (n=381)	6%	8.4%	28.9%	32.3%	24.4%
							Non-consumers of plant-based substitutes (n=804)	5.8%	4.4%	27.1%	34.5%	28.2%
								<b>Somewhat or much less</b>	<b>Neither more nor less</b>	<b>Somewhat or much more</b>		
	Current eaters of plant-based substitutes (n=381)	14.4%	28.9%	56.7%								
	Non-consumers of plant-based substitutes (n=804)	10.2%	27.1%	62.7%								
High	(Bryant et al., 2019b)	US	1185	Yes (bias and framing)	Willingness to eat clean meat compared to plant-based substitutes. Mean	1= 'Definitely no' to 5= 'Definitely yes'	<b>Total</b>	<b>Clean meat is natural</b>	<b>Conventional meat is unnatural</b>	<b>Challenging appeal to nature</b>	<b>Control</b>	p-value
							3.67	3.66	3.77	3.48	3.74	0.216
							3.81	3.76	3.91	3.77	3.79	0.350
Moderate	(Bryant and Dillard, 2019)	US	480	Yes (framing)	Willingness to eat cultured meat compared to plant-based meat substitutes 3 Information treatment groups and no control. Significant difference in mean scores between experimental groups.	1=Much less, 2= Somewhat less, 3= Neither more nor less, 4= Somewhat more; 5=Much more	<b>Somewhat or much less</b>	<b>Neither more nor less</b>	<b>Somewhat or much more</b>			
							25.5%	24.7%	49.8%			
							<b>'Societal benefits' group</b>	<b>'High tech' group</b>	<b>'Same meat group</b>			
							3.42±1.20 <sup>a,b</sup>	3.10±1.27 <sup>b</sup>	3.51±1.23 <sup>a</sup>	P=0.008		
Low	(Wilks and Phillips, 2017)	US	673	Yes (bias)	How willing would you be to eat IVM compared to soy substitutes?	1=much more, 2=somewhat more, 3=neither more nor less, 4=somewhat less, 5=much less.	<b>Much more</b>	<b>Somewhat more</b>	<b>Neither more nor less</b>	<b>Somewhat less</b>	<b>Much less</b>	
							19.3%	28.4%	22.1%	14.8%	5.3%	
							<b>Somewhat or much less</b>	<b>Neither more nor less</b>	<b>Somewhat or much more</b>			
	20.1%	22.1%	47.7%									

Quality	Referenc	Country	N	CBM defined	Question	Response scale	Results			P-value
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias)	If readily available, how likely is it that you would completely replace farmed/alternative meat with cultured meat in your regular diet?	1=Extremely unlikely, to, 7=Extremely likely	<b>Before reading CBM statements (no messaging)</b>	<b>After reading CBM statements (general educational messaging)</b>	<b>After reading CBM statements (naturalness messaging)</b>	
					Mean score		2.8 <sup>a</sup>	3.3 <sup>b</sup>	3.7 <sup>c</sup>	<0.001
							<b>Meant±SD</b>			
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	Willingness to eat cultivated meat instead of plant-based meat substitutes	1= 'Definitely no' to 7='Definitely yes'	4.40±1.55			

**Note(s):** In each row, values followed by different letters are significantly different.

Research Q9: What are consumers' key motivations for consuming or not consuming cell-based proteins (e.g., taste, health, sustainability, aversion to manufacturing process, cost etc.)?

This research question addresses consumers' key motivations (or reasons) for consuming or not consuming CBM. This differs to RQ3 and RQ4 which assessed consumers' perceived benefits and risks/disadvantages of CBM, respectively. While consumers may consider a factor to be a benefit or risk associated with CBM, this perceived benefit or risk may not necessarily influence their consumption behaviour towards CBM (i.e., something could be perceived as a benefit of CBM but may not be reason for consuming CBM). The following section reviews findings from studies that examined the factors motivating consumption of CBM and highlights whether motivating factors were also perceived as benefits or risks in studies reviewed under RQ3 and RQ4.

### Consumers' key motivations for consuming cell-based meat

Seven studies (representing nine survey cohorts) reported consumers' motivations for consuming CBM, including one study that investigated CB **seafood** (Liu, 2022). Four studies were appraised as **moderate quality** (Giacalone and Jaeger, 2023; Leung et al., 2023; Malavalli et al., 2021; Ruzgys and Pickering, 2020) and three **low quality** (Bogueva and Marinova, 2020; Szejda et al., 2021; Liu, 2022). **Representative samples** were used in four of the studies/seven cohorts (Giacalone and Jaeger, 2023; Leung et al., 2023; Szejda et al., 2021; Bogueva and Marinova, 2020).

When assessing motivations, studies asked about the reasons for consuming or purchasing CBM **in general** (five studies) or for **consuming CBM in place of traditional meat** [two studies (Liu, 2022, Szejda et al., 2021)]. Six of the seven studies reported **quantitative** findings from online surveys conducted in Australia, the US, UK, Canada, Singapore with sample size ranging from 200 to 1305. In two of the studies, the same questionnaire was used to collect data in multiple countries (i.e., data was collected from **multiple cohorts**) (Giacalone and Jaeger, 2023, Szejda et al., 2021). Survey questions typically assessed reasons for consuming or buying CBM by asking respondents to select reasons/factors from a list of predetermined options or to rate the likelihood or importance of various predetermined reasons/factors using a 5-point or 7-point rating scale. All studies assessed **both** personal factors (including **health, taste/liking/pleasure, price, convenience, guilt, religion, and/or trends**) and societal factors (including **environmental impact, sustainability, animal welfare, food security, population growth, and/or farmers' livelihoods**). One study reported qualitative findings from an online survey of 200 Canadian university students (Ruzgys and Pickering, 2020); in this study, motivations for consuming CBM were discussed in response to an open question asking participants for their opinion about the consumption of CBM.

Only one of the seven studies presented a **neutral** description of CBM to participants (Liu, 2022); one study **did not report** whether a description was provided (Bogueva and Marinova, 2020); and five studies provided descriptions that **highlighted benefits** (health, nutrition, animal welfare and/or environmental) of CBM or used emotive language when referring to animal impact, and, therefore, may have biased consumers' responses (Giacalone and Jaeger, 2023; Malavalli et al., 2021; Leung et al., 2023; Szejda et al., 2021; Ruzgys and Pickering, 2020). Study results are summarised in Table 19.

## Societal factors as motivations

**Environmental benefits** of CBM were assessed as motivational factors in six studies (three moderate quality and two low quality) representing nine survey cohorts across Australia, the UK, US, Canada, and Singapore (see Table 19) (Liu, 2022, Bogueva and Marinova, 2020, Giacalone and Jaeger, 2023, Leung et al., 2023, Ruzgys and Pickering, 2020, Szejda et al., 2021). Environmental benefits were commonly identified as **important or moderately important** factors that would motivate CBM consumption. In studies where consumers selected motivations for CBM consumption from a **predetermined list of options**, environmental reasons were **among the top motivators**. Specifically, **sustainability concerns** (59%), followed by **resource depletion** (44%) were the dominant reasons for embracing meat alternatives (including CBM) among young Australians (Bogueva and Marinova, 2020); and 30-40% of consumers across Australia, Singapore, and the US, indicated that **adopting a more sustainable diet** would motivate them to eat CBM (Giacalone and Jaeger, 2023). Notably, environmental impact/sustainability was the **second most common motivation** after novelty (36-41%) **across all three countries** in one of the multi-country studies (Giacalone and Jaeger, 2023); and was the dominant motivation among young Australians surveyed by Bogueva and Marinova (2020), only 22% of whom selected 'fashion trend' (comparable to novelty) as a reason for embracing meat alternatives. While it is not clear whether a description of CBM was shown in the survey of young Australians, consumers participating in the multi-country survey were shown a description that highlighted environmental benefits of CBM. Thus, in both studies, consumers' selection of environment-related motivations for consuming/embracing CBM **may potentially have been influenced** by the description of CBM provided.

Additionally, in studies that used **rating scales** to assess the motivational role of various predetermined factors, environmental reasons were found to be of **moderate to high importance**. **Similar** findings were reported regardless of whether participants were shown descriptions of CBM that were **neutral** (Liu, 2022) or **highlighted its environmental benefits** (Szejda et al., 2021; Leung et al., 2023); or whether CBM was **available on the market** (Leung et al., 2023). On average, CBM being 'better for the environment' was rated as a 'moderately important' to 'very important' reason for replacing conventional meat with CBM in a multi-country survey of consumers in the US and UK (Szejda et al., 2021). Likewise, among Singaporean consumers asked whether they would eat CBM because it is environmentally friendly, this reason was moderately applicable, on average (Leung et al., 2023); and when investigating motivations for cell-based seafood, 'biodiversity' and 'environment' were each rated as moderately to highly important factors in the decision to choose CB seafood over wild-caught or farm-raised seafood (Liu, 2022).

**Table 19. Summary of results for studies assessing environmental benefits as a motivation for consuming cell-based meat or seafood.**

Quality	Reference	Country	N	CBM definition	Question	Response options	Results		
Low	(Bogueva and Marinova, 2020)	Australia	226	Not reported	Multiple-choice question asking what would make participants accept alternatives to traditional animal meat.	Broader sustainability concerns, including environmental impacts and contribution to climate change Resource depletion	59%		
							44%		
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	I eat cultivated meat because it is ... "environmentally friendly"	1 = not at all applies to me, to 7 = very much applies to me	<b>Mean</b>	<b>SD</b>	
							4.83	1.59	
Low	(Liu, 2022)	US		Yes (neutral)	<b>Cell-based seafood</b> How important would each of the following *factors be in your decision to eat alternative seafood over wild-caught or farm-raised seafood? Biodiversity (aggregate score of items: "Reducing overfishing", "Reducing by-catch (when other marine life like dolphins or turtles are caught while fishing for a different species)", "Saving ocean habitats", and "Reducing harm towards marine animals") Environment (aggregate score of items: "Reducing the impact of fishing and fish farms on the climate", "Reducing the environmental pollution from fish farms", "Reducing plastic waste in the ocean from fishing", "Reducing waste along the seafood supply chain ", and "Reducing my carbon footprint")	1= 'least important' to 5 = 'most important'.	<b>Mean</b>	<b>SD</b>	
							3.85	1.00	
							3.76	1.01	
Low	(Szejda et al., 2021)	Multiple - US and UK	2018 (US) 2034 (UK)	Yes (bias). Human health/animal/enviro benefits.	How important to you are each of the following reasons to replace conventional meat with cultivated meat?  "Cultivated meat is better for the environment".	1 = Not at all important; 2 = Somewhat important; 3 = Moderately important; 4 = Very important; 5 = Extremely important	<b>US (mean)</b>	<b>UK (mean)</b>	
							3.47	3.68	
Moderate	(Giacalone and Jaeger, 2023)	Multiple- Australia, Singapore, US	623 (Australia), 623 (Singapore), 629 (US)	Yes (bias). Environmental benefits.	Participants were instructed to select all statements (describing motivations for use of foods) that, in their mind, were relevant for describing 'meat from cell cultures grown in a laboratory.  To move my diet in a more sustainable direction		<b>Australia (%)</b>	<b>Singapore (%)</b>	<b>US (%)</b>
							37.2	39.6	29.5
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias). Emotive language for animal impact.	Key themes from the open response question "What is your opinion about the consumption of cultured meat?"	Environment n=33 (17%) • "I would 100% try it, I believe it will be very beneficial to the environment and the future of the earth"			

**Animal welfare** was discussed as a motivational factor in five studies (representing six survey cohorts) in Australia, Singapore, the UK and US (see Table 20) (Bogueva and Marinova, 2020; Leung et al., 2023; Malavalli et al., 2021; Szejda et al., 2021; Liu, 2022). One study provided a neutral description of CBM to consumers (Liu, 2022), three mentioned animal welfare benefits in the description of CBM (Leung et al., 2023; Malavalli et al., 2021; Szejda et al. 2021); and one study did not specify whether a description was provided (Bogueva and Marinova, 2020).

Findings were generally consistent between studies, showing animal welfare to be a **moderately important** motivator of CBM consumption. In surveys that used rating scales to assess motivations, similar average rating scores were reported for animal welfare items, ranging between the midpoint and one point above the midpoint towards the positive end of the scale (in both 5-point and 7-point scales). However, the meaning of the scale points differed in each study. For example, animal welfare benefits, on average: were of moderate to high importance in the decision to choose CBM over conventional meat for consumers in the US and UK (Szejda et al., 2021), or to eat alternative seafood over wild-caught or farm-raised seafood in the US (Liu, 2022); were a probable reason for purchasing CBM among young NZ consumers (Malavalli et al., 2021); and applied moderately to Singaporean consumers as a reason for consuming CBM (Leung et al., 2023). Further, 24% of young Australians surveyed selected animal welfare as a factor that would make them accept CBM (Bogueva and Marinova, 2020) and 58% of young NZ consumers reported they would 'probably' or 'definitely' buy CBM if it was labelled as 'guilt-free meat' (Malavalli et al., 2021). However, in the latter (NZ) study, it was not clear whether the guilt-free label was in reference to the impact on animals, the environment, or other factors.

**Other societal issues** that were reported as motivating factors in single studies only, include population growth (Bogueva and Marinova, 2020); and global food security, and supporting small-scale farmers (Szejda et al., 2021) (see Table 20). Overall, 40% of young Australians surveyed selected population growth as a factor that would make them accept CBM (Bogueva and Marinova, 2020). Statements referring to CBM contributing to global food security and acting as 'a complementary agricultural system that can help small family farmers continue their way of life', were each, on average, of moderate to high importance in the decision to choose CBM over traditional meat for participants in the US and UK (Szejda et al., 2021). Additionally, consuming CBM because it 'has benefits for society' applied moderately (on average) to participants in Singapore, where CBM is available on the market (Leung et al., 2023)

- The overall evidence, based on multiple studies (all moderate or low quality, including two moderate quality studies with representative samples) suggests that environmental benefits and animal welfare are, on average, of moderate to high importance in motivating consumption of CBM.
- Limited evidence from single studies of low quality suggests reasons related to population growth, global food security, and supporting small-scale farmers may also be important in motivating consumption of CBM among some consumers.

**Table 20. Summary of results for studies assessing animal welfare and other societal benefits as a motivation for consuming cell-based meat or seafood.**

Quality	Reference	Country	N	CBM definition	Question	Response options	Results				
							Mean	SD	Distribution: Score 1–2	Distribution: Score 3	Distribution: Score 4–5
Moderate	(Malavalli et al., 2021)	NZ	206	Yes (bias)	Do you think you would buy in-vitro meat (IVM) if it is labelled as guilt-free meat	1=Definitely not, to, 5=definitely yes	3.64	1.20	12%	30%	58%
Low	(Bogueva and Marinova, 2020)	Australia	226	Not reported	Multiple-choice question asking what would make participants accept alternatives to traditional animal meat.	Population growth Animal welfare	%				
							40	24			
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	I eat cultivated meat because it is ... "animal friendly" I eat cultivated meat because it is ... "has benefits for society"	1 = not at all applies to me, to 7 = very much applies to me	Mean	SD			
							4.85	1.60			
Low	(Liu, 2022)	US		Yes (neutral)	<b>Cell-based seafood</b> How important would each of the following *factors be in your decision to eat alternative seafood over wild-caught or farm-raised seafood? Biodiversity (aggregate score of items: "Reducing overfishing", "Reducing by-catch (when other marine life like dolphins or turtles are caught while fishing for a different species)", "Saving ocean habitats", and "Reducing harm towards marine animals")	1= 'least important' to 5 = 'most important'.	Mean	SD			
							3.85	1.00			
Low	(Szejda et al., 2021)	Multiple - US and UK	2018 (US) 2034 (UK)	Yes (bias). Human health/animal/enviro benefits.	How important to you are each of the following reasons to replace conventional meat with cultivated meat?  "Cultivated meat contributes to global food security" "Cultivated meat is a complementary agricultural system that can help small family farmers continue their way of life" "Cultivated meat is better for animals"	1 = Not at all important; 2=Somewhat important; 3 = Moderately important; 4 = Very important; 5 = Extremely important	US (mean)	UK (mean)			
							3.59	3.65			
							3.50	3.50			
							3.41	3.58			



### **Personal factors as motivations**

A range of personal benefits were examined as motivations for consuming CBM in six studies - four studies were appraised as **moderate quality** (Giacalone and Jaeger, 2023; Leung et al., 2023; Malavalli et al., 2021) and three **low quality** (Bogueva and Marinova, 2020; Szejda et al., 2021; Liu, 2022). **Representative samples** were used in four of the studies (Giacalone and Jaeger, 2023; Leung et al., 2023; Szejda et al., 2021; Bogueva and Marinova, 2020). All studies reported quantitative findings for various predetermined factors. Four of the studies assessed motivations using rating scales and two used multiple-choice questions. Further, only one of the six studies presented a **neutral description** of CBM to participants (Liu, 2022); one study **did not report** whether a description was provided (Bogueva and Marinova, 2020); and four studies provided descriptions that **highlighted benefits** (Giacalone and Jaeger, 2023; Leung et al., 2023; Szejda et al., 2021; Malavalli et al., 2021), three of which presented **health benefits**. Health benefits mentioned were that CBM production 'reduces antibiotic resistance and foodborne illnesses' (Szejda et al., 2021); that 'IVM is high in protein, low in unhealthy fats' (Malavalli et al., 2021); and that 'Cultivated meat enables consumers to avoid undesirable elements that are found in some food products (e.g., foodborne diseases, growth hormones or GMOs)' or 'Cultivated meat enables the nutritional value of meat to be enhanced' (Leung et al., 2023). Notably, in one of these studies, the authors highlighted that message framing had no significant influence on variables measured (Leung et al., 2023). A summary of these results is provided in Table 21.

**Health in general** was examined as a motivation for consuming CBM in four studies (two moderate quality and two low quality), representing seven survey cohorts (Bogueva and Marinova, 2020, Giacalone and Jaeger, 2023, Leung et al., 2023, Szejda et al., 2021). Overall, **43%** of young Australians surveyed identified health concerns as a factor that would make them accept alternatives (including CBM) to traditional animal meat. Another survey of Australian, Singaporean and US consumers, revealed that **19-28%** would consume CBM when they 'want something healthy' (Giacalone and Jaeger, 2023). The remaining studies used rating scales for assessment but reported similar findings in terms of the healthiness of CBM being of **moderate importance** in decisions to consume CBM either in general (Singaporean participants) or as a substitute for conventional meat (US and UK participants) (Leung et al., 2023, Szejda et al., 2021).

- Thus, multiple studies (of moderate and low quality, and all using representative samples) indicate that, **on average, general health considerations play a moderately important role** in motivating individuals to consume CBM.

**Safety in general** was discussed in one study only (moderate quality and representative sample), which found that, on average, consuming CBM because it is "as safe as real meat" applied only moderately to participants in Singapore (Leung et al., 2023). Specific factors related to **health and safety**, including **toxicity, pathogens, foodborne diseases, growth hormones and antibiotics** were examined in three studies (one moderate quality and two low quality, with two using representative samples), which surveyed participants in Singapore, the UK and the US (Leung et al., 2023, Liu, 2022, Szejda et al., 2021). Overall, 'no toxicity' for CB seafood and 'no antibiotics' and 'no pathogens' for CBM were, on average, found to be 'moderately important' to 'very important' in the decision to choose the CB option over traditional options for participants in the US and UK (Liu, 2022, Szejda et al., 2021). Differences in rating scales used in surveys (including a different number of scale

points and use of different labels/descriptors for the scale points) limit direct comparison of these results with that of Leung et al. (2023), who surveyed consumers in Singapore which is currently the only country where consumers can purchase CBM. Nonetheless, similar findings were reported such that consuming CBM because it is 'free of undesirable elements such as foodborne diseases and growth hormones', on average, applied only moderately to participants in Singapore (Leung et al., 2023).

- Thus, **specific health and safety factors were generally found to be of moderate to high importance** in decisions to consume CBM in the limited available studies of moderate or low quality, two of which used representative samples.

**Nutrition** as a motivational factor was specifically referred to in three studies (two moderate quality and one low quality, with one moderate quality study using a representative sample) conducted in NZ, Singapore, and the US (Leung et al., 2023, Liu, 2022, Malavalli et al., 2021). It was generally found to be a **less important** motivator than factors related to **health and safety**. On average, consuming CBM because it is 'healthy and nutritious' applied only **moderately** to participants in Singapore who had market access to CBM (average rating of 4.42 near the midpoint on the scale from 1-7) (Leung et al., 2023). For participants surveyed in NZ, the average rating was also near the midpoint (3.42 on the scale from 1-5), when asked if they think they would try CBM for its nutritional profile, but in this case the midpoint rating represents **uncertainty** (Malavalli et al., 2021). Additionally, when investigating motivations for CB seafood consumption among US consumers, the 'nutrition' of CB **seafood** was, on average, of **moderate to high importance** in the decisions to choose CB seafood over wild-caught or farm-raised seafood (mean score of 3.94 on the scale from 1-5) (Liu, 2022). Notably, different to the other studies which assessed nutrition using a single item, Liu's (2022) 'nutrition' score represented an aggregate rating of items considering content of omega-3's, fibre, protein and micronutrients. These items could have implied to consumers that the product has these nutritional qualities. This could have contributed to the higher average ratings, along with other factors including the focus on CB seafood rather than meat.

- Overall, multiple studies (of moderate and low quality, and one using a representative sample) indicate that, on average, nutrition is of **moderate or uncertain importance** in motivating consumption of CBM and of somewhat higher importance in motivating consumption of CB seafood (though this higher importance could potentially be attributed to the survey question implying specific nutritional benefits).

**Sensory characteristics/eating experience** were considered as motivations for consuming CBM or CB seafood in three studies (two moderate quality and representative, and one low quality) representing five survey cohorts across Australia, Singapore and the US (Giacalone and Jaeger, 2023, Leung et al., 2023, Liu, 2022). The motivational importance of sensory characteristics varied across the studies (see Table 21). Findings indicate that, across Australia, Singapore and the US, only 13-18% of participants would consume CBM when 'I want something I like'; while this might suggest that these consumers anticipate that CBM will provide a positive eating experience, the meaning of 'like' was not specified in the question and, therefore, responses may not reflect liking of sensory characteristics (Giacalone and Jaeger, 2023). A survey conducted in Singapore found that, on average, consuming CBM because it is 'has the same sensory quality as real meat' applied moderately to participants (Leung et al., 2023). Sensory characteristics were found to be

particularly important in motivating consumption of CB seafood among US consumers (Liu, 2022). 'Sensory attributes' (which was an aggregate score of items: 'Has a desirable texture' and 'Tastes good') were, on average, rated as being of high importance in decisions to choose CB seafood over wild-caught or farm-raised seafood. Notably, this item had the highest mean rating of the items assessed, which included a range of personal and societal benefits (Liu, 2022). Several factors could be contributing to the variation in findings, including differences in assessment methods. For example, while Giacalone and Jaeger (2023) used a multiple-choice question, the other studies used rating-scales that differed in the number of scale points and the labels applied to the scale points (see Table 21). Further, in studies where it was clear the question was referring to sensory characteristics (i.e., not just referring to 'liking' the product), the focus was on the importance of sensory characteristics of CBM being either positive in general (Liu, 2022) or equivalent to traditional meat (Leung et al., 2023).

- Overall, multiple studies (of moderate quality and representative, and of low quality) indicate that sensory characteristics are of **moderate importance** in motivating consumption of CBM (specifically, consuming CBM because it will provide a good eating experience or because it will provide the same eating experience as traditional meat), and of **high importance** in motivating consumption of CB **seafood**.

**Price** of CBM was discussed as a motivating factor in two studies (one moderate quality and one low quality, neither using representative samples) conducted in the US and NZ (Liu, 2022, Malavalli et al., 2021). Overall, price was found to be of high or moderate-high importance in consumption decisions. The US study focused on CB seafood and found that the price of CB seafood was, on average, rated as being of high importance in decisions to choose CB seafood over wild-caught or farm-raised seafood (Liu, 2022). In contrast, the NZ study assessed motivation to consume CBM under different price conditions (Malavalli et al., 2021). Findings showed that, on average, NZ consumers had moderately to highly positive intentions for purchasing CBM if it was 'affordable' or if it was 'cheaper than conventional meat'.

- **Thus, price was generally found to be of moderate to high importance in decisions to consume cell-based proteins in the limited available studies of low or moderate quality in unrepresentative samples.**

**A range of factors related to personal benefits were uniquely explored** as motivations in **one moderate-quality and representative study** which surveyed consumers in Australia, Singapore and the US (Giacalone and Jaeger, 2023). Across countries, novelty was found to be the most selected motivator, with 36-41% of participants indicating they would consume CBM 'when I feel like trying something new'. Other personal benefits motivating CBM consumption that were explored exclusively in this study were: 'convenience' (17-21%), 'setting a good example for others' (13-17%), 'as part of meals posted on social media' (5.0-10.5%).

Religious motivations were also explored in one moderate-quality study, which surveyed a relatively small sample (n=206) of NZ consumers who were predominantly young (74% aged 18-25 yrs), and well-educated (47% completed tertiary education); and around half were religious (44%) or preferred not to say (10%) (Malavalli et al., 2021). Findings indicate that, on average, religious factors were 'probably not' likely to motivate consumption of CBM

among the NZ consumers surveyed, and religious factors were less likely motivators than factors relating to price and guilt-free labelling/animal welfare.

### **Insight on the most important motivating factors**

Identifying the most important motivating factors based on the six reviewed studies that examined multiple motivational factors is difficult due to variation in both the assessment methods used and the motivational factors evaluated within and across studies. Additionally, in studies that used rating scales, several items often had similar mean ratings and it was not reported whether differences in mean ratings were statistically significant. With these considerations in mind, **some insight can be provided by examining the top motivations identified in each study:**

- In **four studies (five survey cohorts)** the **top motivation** represented a **societal benefit** ('broader sustainability concerns', if 'labelled as guilt-free', 'animal friendly' and 'global food security') (Bogueva and Marinova 2020; Leung et al., 2023; Szejda et al., 2021; Malavalli et al., 2021) and in the remaining two studies (four survey cohorts) the top motivation represented a **personal benefit** (novelty and sensory) (Giacalone and Jaeger, 2023; Liu, 2022).
- **Overall, the available evidence suggests that both personal and societal factors may play a role in motivating consumption of CBM.**

**Table 21. Summary of results for studies assessing personal benefits as a motivation for consuming cell-based meat or seafood.**

Quality	Reference	Country	N	CBM definition	Question	Response options	Results				
							Mean	SD	Score 1-2	Score 3	Score 4-5
Moderate	(Malavalli et al., 2021)	NZ	206	Yes (bias)	Do you think you would try in-vitro meat (IVM) for its nutritional profile?	1=Definitely not, to, 5=definitely yes	3.42	±1.05	13%	39%	48%
					Do you think you would buy in-vitro meat (IVM) if...						
					it is labelled as guilt-free meat		3.64	±1.20	12%	30%	58%
					it is affordable		3.53	±1.08	13%	31%	56%
					it would be cheaper than conventional meat		3.40	±0.97	17%	34%	49%
					your religious beliefs permitted		2.40	±1.09	44%	38%	18%
					the religious leaders informed you?		2.16	±1.08	25%	54%	21%
there will be halal or kosher options available?		1.89	±1.05	18%	53%	28%					
Low	(Bogueva and Marinova, 2020)	Australia	226	Not reported	Multiple-choice question asking what would make participants accept alternatives to traditional animal meat.		%				
						Health concerns	43				
						Fashion trend	22				
Moderate	(Leung et al., 2023)	Singapore	948	Yes (framing)	I eat cultivated meat because it is ... "free of undesirable elements, such as foodborne diseases and growth hormones"	1 = not at all applies to me, to 7 = very much applies to me	4.65	1.54			
					I eat cultivated meat because it is ... "as safe as real meat"		4.57	1.57			
					I eat cultivated meat because it is ... "has the same sensory quality as real meat"		4.45	1.57			
					I eat cultivated meat because it is ... "healthy and nutritious"		4.42	1.54			
Low	(Liu, 2022)	US		Yes (neutral)	<b>Cell-based seafood</b>	1= 'least important' to 5 = 'most important'.	<b>Mean</b>	<b>SD</b>			
					How important would each of the following *factors be in your decision to eat alternative seafood over wild-caught or farm-raised seafood?						
					Sensory Attributes (aggregate score of items: "Has a desirable texture" and "Tastes good")		4.25	0.76			
					Price		4.08	0.97			
					No toxicity (aggregate score of items: "Does not contain any mercury" and "No microplastic")		3.94	1.03			
Nutrition (aggregate score of items: "Rich in Omega-3's", "High in fiber", "High in protein", and "Micronutrient content (e.g., iron, zinc, calcium)".		3.78	0.95								

Quality	Reference	Country	N	CBM definition	Question	Response options	Results		
Low	(Szejda et al., 2021)	Multiple - US and UK	2018 (US) 2034 (UK)	Yes (bias) Health, animal, environment benefits.	How important to you are each of the following reasons to replace conventional meat with cultivated meat?  "Cultivated meat contains no antibiotics" "Cultivated meat contains no pathogens" "Cultivated meat is better for my health"	1 = Not at all important; 2 = Somewhat important; 3 = Moderately important; 4 = Very important; 5 = Extremely important	<b>US (mean)</b>	<b>UK (mean)</b>	
							3.57	3.65	
							3.52	3.54	
							3.27	3.22	
Moderate	(Giacalone and Jaeger, 2023)	Multiple- Australia, Singapore, US	623 (Australia), 623 (Singapore); 629 (US)	Yes (bias). Environmental benefits.	Participants were instructed to select all statements (describing motivations for use of foods) that, in their mind, were relevant for describing 'meat from cell cultures grown in a laboratory'.  When I feel like trying something new When I want something healthy As part of easy and convenient meals To set a good example to those around me As part of meals that I post on social media When I want something I like		<b>Australia (%)</b>	<b>Singapore (%)</b>	<b>US (%)</b>
							38.8	41.3	36.3
							19.1	28.7	26.2
							16.6	20.8	19.3
							13.1	15.3	16.7
							5.0	9.2	10.5
13.2	17.2	17.5							

## Consumers' key motivations for not consuming cell-based meats

**Seven studies** reported consumers' motivations for **not** consuming cell-based proteins (i.e., **potential barriers to consuming or trying CBM**) – **three** appraised as **moderate quality** (Malavalli et al., 2021; Ruzgys and Pickering, 2020; Rosenfeld and Tomiyama, 2022) and **four low quality** (Wilks and Phillips, 2017, Bogueva and Marinova, 2020; Tucker, 2014; Verbeke et al., 2015). **Representative samples** were used in three studies (Wilks and Phillips, 2017, Bogueva and Marinova, 2020; Rosenfeld and Tomiyama, 2022). All studies investigated CBM. Four of the seven studies reported **quantitative** findings from online surveys conducted in NZ, the UK, the US, and Canada, with sample size ranging from 200 to 673 (Malavalli et al., 2021, Rosenfeld and Tomiyama, 2022, Ruzgys and Pickering, 2020, Wilks and Phillips, 2017). Survey questions typically required participants to rate how strongly they agreed with statements regarding potential barriers, or to select reasons why they might be unwilling to try CBM. Results of the quantitative studies are summarised in Table 22. Three studies reported **qualitative** findings from focus group discussions or online surveys conducted in Australia, NZ and the UK with sample size ranging from 60 to 227 (Bogueva and Marinova, 2020, Tucker, 2014, Verbeke et al., 2015). Results of qualitative studies are summarised in Table 23.

Only one of the seven studies presented a **neutral description** of CBM to participants (Rosenfeld and Tomiyama, 2022); three studies provided descriptions that used emotive language when referring to animal impact (Ruzgys and Pickering, 2020; Wilks and Phillips, 2017; Verbeke et al., 2015); one study provided a description that mentioned benefits to human health, animals, environment (Malavalli et al., 2021); one study reported that the CBM description mentions positive and negative aspects of CBM but the description was not provided by the authors (Tucker, 2014); and one study did not report whether a description was provided (Bogueva and Marinova, 2020);

**Feelings of disgust and unease** were consistently identified as barriers to consuming CBM in five studies (four low quality) (Rosenfeld and Tomiyama, 2022, Wilks and Phillips, 2017, Bogueva and Marinova, 2020, Tucker, 2014, Verbeke et al., 2015). The **feelings of disgust towards CBM** generally reflected participants' **negative perceptions/expectations of the sensory characteristics** of CBM (e.g., the look and anticipated taste/texture of CBM) (Bogueva and Marinova, 2020, Tucker, 2014) and/or participants' **perceived unnaturalness of CBM** (Bogueva and Marinova, 2020, Tucker, 2014, Verbeke et al., 2015). In two of these studies, participants were shown images of (Tucker, 2014) or a video about (Verbeke et al., 2015) CBM which **may have prompted these reactions**. Qualitative data showed CBM was commonly described as 'fake', 'synthetic', 'artificial', 'not natural', 'not normal', 'overly processed'. Further, some Australian and NZ participants who perceived CBM as unnatural, associated unnaturalness with unhealthiness; and some asserted they would prefer to adopt a meat-free diet over consuming CBM (Bogueva and Marinova, 2020, Tucker, 2014). Notably, a significantly lower level of disgust (as a barrier to trying CBM) was reported among meat-eaters who were presented with a definition of CBM framed to remind them that CBM originates from animals, compared to those shown a relatively neutral definition that presented a more objective overview of the production process (see Table 22) (Rosenfeld and Tomiyama, 2022).

**Price** was discussed as a barrier in three studies - two moderate quality (Malavalli et al., 2021; Ruzgys and Pickering, 2020) and one low quality (Wilks and Phillips, 2017). Specifically, 53% of NZers surveyed indicated they would not buy CBM over conventional meat if it was expensive (Malavalli et al., 2021); 45% of Canadians surveyed would not be

willing to pay a price premium for CBM (Ruzgys and Pickering, 2020); and 20% of US participants selected price as potential barrier to trying CBM (Wilks and Phillips, 2017).

**Perceived taste/sensory characteristics** of CBM as potential barriers to CBM consumption were examined **without reference to feelings of disgust** in two studies – one moderate quality (Ruzgys and Pickering, 2020) and one low quality (Wilks and Phillips, 2017). Overall, 79% of US participants surveyed identified ‘taste/appeal of the product’ as a reason why they might not try CBM (Wilks and Phillips, 2017), and 38% of Canadians surveyed agreed that ‘Cultured meat wouldn't taste the same as farmed meat’ was a potential barrier to consuming CBM (Ruzgys and Pickering, 2020).

Likewise, **health concerns** as potential barriers to trying CBM (**without reference to feelings of disgust or perceived unnaturalness of CBM**) were reported in one study (low-quality) where 4% of US participants surveyed selected this response option as a potential reason for not trying CBM (Wilks and Phillips, 2017).

**Perceiving uncertainty in scientific knowledge and lacking information regarding CBM** were identified as barriers to CBM consumption in two studies conducted with predominantly younger consumers (all or majority aged 18-30 years) in Australia (low quality) and Canada (moderate quality) (Bogueva and Marinova, 2020, Ruzgys and Pickering, 2020). Other studies did not directly examine these factors, nor were they raised in discussions or open/free-text responses. Overall, 45% of young Australians surveyed, expressed (in free-text responses) that CBM is not a desirable option due jointly to a lack of information on how CBM is produced and its unavailability on the Australian market (Bogueva and Marinova, 2020). Further, 34% of Canadians surveyed agreed that ‘Science does not understand enough about cultured meat to sell it as a viable alternative’ is a potential barrier to their consumption of CBM (Ruzgys and Pickering, 2020). Relatedly, a relatively small proportion of US consumers surveyed (3%) identified safety concerns as a potential barrier to CBM consumption in a ‘select all that apply’ multiple choice question. However, this reason was reported in free text under the ‘other (please specify)’ response option, rather than being selected from a list of response options. This need to enter a free-text response, may have influenced the proportion of consumers who identified safety concerns as a barrier but might also indicate that safety is not front of mind for consumers being asked about a ‘**potential new meat production method**’ that is not yet on the market (Wilks and Phillips, 2017).

**Ethical concern** was reported as a potential barrier to trying CBM in one low-quality study, where 24% of US participants selected this option from a list of responses in a multiple-choice question, with no further explanation of participants’ ethical concerns provided (Wilks and Phillips, 2017). Other reasons identified as potential barriers by a small proportion of participants in this study (and not directly examined or raised in discussions in other studies) were: **religious reason** 3%; **environmental concern** 1%; **economic impact** <1% (Wilks and Phillips, 2017). Additionally, a potential barrier to CBM consumption for 13% of young Australian consumers was their **pride in Australia and loyalty towards local industries** (Bogueva and Marinova, 2020).

- The overall evidence, based on multiple studies (all of moderate or low quality) suggests that the following factors are likely to be barriers or potential barriers to consuming CBM: feelings of disgust and unease towards CBM underpinned by perceived unnaturalness and high level of processing of CBM; higher price of CBM



relative to traditional meat; negative perceptions regarding taste/sensory characteristics; perceiving uncertainty in scientific knowledge and lacking information regarding CBM. Perceiving CBM consumption as an act of disloyalty to one's country/local industries may also be a barrier to consumption, identified in a single low-quality study.

## Motivations for consumption vs. Perceived benefits

**Overall, the available evidence suggests that both personal and societal factors may play a role in motivating consumption of CBM.**

### *Personal factors*

#### **Motivators:**

- On average, findings regarding the importance of personal factors in motivating consumption of CBM, indicate:
  - **specific health and safety factors** (e.g., including no toxicity, pathogens, foodborne diseases, growth hormones and/or antibiotics) and **price** are of **moderate to high importance**;
  - **general health considerations** and **sensory characteristics** are of **moderate importance**; and
  - **nutrition** is of **moderate or uncertain importance**.
- **Novelty** was also an **important** motivator, selected as the top motivating factor (from a predetermined list) by 36-41% of representative consumers in Australia, Singapore and the US.

**Perceived benefits:** All of the above motivating factors were discussed in the context of perceived benefits of CBM (including benefits relating to taste, price, nutrition, health, and safety). The limited available quantitative evidence suggests that consumers, on average, are uncertain about the personal benefits of CBM. Nonetheless, the findings regarding perceived benefits and motivating factors collectively suggest that among consumers who perceive these factors as personal benefits, these factors may also have the potential to motivate consumption of CBM.

### *Societal factors*

#### **Motivators:**

- Overall, findings regarding the importance of societal factors in motivating consumption of CBM consistently suggest that environmental benefits and animal welfare are, on average, of moderate to high importance in motivating consumption of CBM.
- Other societal factors that were identified as motivators of CBM consumption (but only in single and low-quality studies), were population growth, global food security, and supporting small-scale farmers.

**Perceived benefits:** Except for supporting small-scale farmers, all societal factors identified as motivators of CBM consumption were also identified as perceived benefits by some consumers. Findings regarding perceived benefits of CBM indicate that consumers, on average, have neutral views towards the societal benefits of CBM, including benefits for the environment, animal welfare, and future populations/food security; however, views can vary widely between consumers. Collectively, the findings regarding perceived benefits and motivating factors, suggest that when these societal benefits are perceived, they have the potential to motivate consumption of CBM.

## Barriers vs. Perceived benefits and risks

**Overall, the available evidence suggests that the following factors (all related to personal factors) may be potential barriers to consuming CBM:**

- **Feelings of disgust and unease towards CBM underpinned by perceived unnaturalness and high level of processing of CBM.**
  - **Perceived risks:** This was also examined in the context of perceived risks, with health and food safety concerns stemming from perceptions that CBM is unnatural or manufactured and uncertainty regarding the current scientific understanding of CBM, commonly perceived as risks of CBM; consumers, on average, perceived moderate risks related to these factors.
- **Higher price of CBM relative to traditional meat.**
  - **Perceived risks:** Price of CBM was not examined as a perceived risk or downside of CBM in the reviewed studies.
- **Negative perceptions regarding taste/sensory characteristics.**
  - **Perceived risks:** Sensory characteristics of CBM were not examined as a perceived risk or downside of CBM in the reviewed studies.
- **Perceiving uncertainty in scientific knowledge and lacking information regarding CBM.**
  - **Perceived risks:** This was examined as a perceived risk related to health and food safety, with uncertainty regarding the current scientific understanding of CBM contributing to worries about the potential unknown short- and long-term health effects of consuming CBM.
- **Perceiving CBM consumption as an act of disloyalty to one's country/local industries may also be a barrier to consumption, identified in a single low-quality study.**
  - **Perceived risks:** Related factors that were raised as perceived risks include concerns about the loss of agricultural jobs and the Irish economy and concerns about betrayal of one's country and perceived high-quality local meat industry.

**Several societal factors were discussed in the context of perceived risks but were not identified or raised as potential barriers to CBM consumption.** This includes risks to the environment, economy, and farmers; and ethical concerns related to the use of animals, moral issues and/or genetic alteration, and suspecting hidden agendas/potential for a lack of transparency.

**Table 22.** Summary of quantitative results in studies assessing consumers' reasons for not consuming cell-based meat.

Quality	Reference	Country	N	CBM defined	Question	Response options	Results		
							Distribution: Score 1–2	Distribution: Score 3	Distribution: Score 4–5
Moderate	(Malavalli et al., 2021)	NZ	206	Yes (bias)	Do you think you would buy in-vitro meat (IVM) over conventional meat even though it is expensive?	1=Definitely not, to, 5=definitely yes	53%	35%	11%
Moderate	(Ruzgys and Pickering, 2020)	Canada	200	Yes (bias) Refers to animals not being 'harmed' or 'killed' (uses emotive language)	Cultured meat wouldn't taste the same as farmed meat I would not be willing to spend more money on cultured meat Science does not understand enough about cultured meat to sell it as a viable alternative I do not see any personal benefits to eating cultured meat.	1=strongly agree, to 5=strongly disagree	<b>Moderately or strongly agree</b>	<b>Neither agree nor Disagree</b>	<b>Moderately or strongly disagree</b>
							38%	32%	30%
							45%	15%	40%
							34%	36%	31%
26%	15%	59%							
Low	(Rosenfeld and Tomiyama, 2022)	Multiple - US and UK	599	Yes (neutral)	"Cultured meat is too disgusting for me to try eating it"	7-point scale from 1 (Not at all) to 7 (Extremely much)	<b>Distribution: Score 1–3</b>	<b>Distribution: Score 4</b>	<b>Distribution: Score 5–7</b>
							45.8%	11.5%	42.7%
							43.5%	11.7%	44.8%
							42.7%	15.3%	42.0%
							<b>Control Mean±SD</b>	<b>Intervention Mean±SD</b>	
							3.52±1.93	3.03±1.88	P=0.030
4.83±2.30	5.08±2.02	P=0.317							
	<b>Meat-eaters, % Agree</b>	<b>Vegetarians, % Agree</b>							
	<b>35%</b>	<b>55%</b>							
Low	(Wilks and Phillips, 2017)	US	673	Yes (bias) Refers to animal suffering (uses emotive language)	Why might you be unwilling to try in vitro meat? Select all that apply.	Agree or disagree	<b>%</b>		
							Taste/appeal of the product	79	
							Ethical concern	24	
							Price	20	
							Health concerns	4	
							Safety concerns	3	
							Religious reason	3	
							Environmental concern	1	
							Economic impact	<1	

**Table 23.** Summary of qualitative results in studies assessing consumers' reasons for not consuming cell-based meat.

Quality	Reference	Design/sample	CBM defined	Results
Low	(Verbeke et al., 2015)	60 UK consumers participated in a focus group or completed an online survey. Participants were prompted to leave comments and questions on the content tester page pertaining to the video (online survey) or were encouraged to raise comments and queries in relation to the video (focus groups)	Yes (bias). Refers to animal cruelty (uses emotive language)	Judged cultured meat by its unnaturalness. Following initial reactions of disgust, many participants viewed cultured meat as unnatural and against nature, and expressed their preference for traditional (perceived as natural) meat simply because it is produced in a familiar, traditional way, both in terms of animal husbandry and meat processing. The artificial nature of cultured meat induced revulsion and discouraged the participants from being interested in consuming it. "Synthetic meat? I don't like that word 'synthetic'". (UK FG1,F, 45)
Low	(Tucker, 2014)	Focus groups with 69 NZ participants. Presented series of coloured handouts featuring seven different sets of images, including one set of images on in vitro meat. This was followed by a handout featuring seven quotes from the pilot run of the research project. The researchers introduced each series of images by providing a brief description of the practice, including the understood positive and negative aspects and implications of each. (specific wording not reported in article)	Mentions positive and negative aspects of CBM but description not provided by authors	<p><b>Look and perceived texture is unpalatable.</b></p> <ul style="list-style-type: none"> <li>• "It's not appetising. It creeps me out . . . the texture would probably be different – it would put me off" (43f)</li> <li>• "It looks absolutely revolting to me – just revolting" (39f)</li> <li>• "You would have to close your eyes to eat that; it's not normal. It's not meat. I mean even if it tasted really wonderful I wouldn't eat it if I knew it was in vitro meat. Just knowing it's artificial would put you right off . . . I'd go vegetarian I think if that was all there was." (21f)</li> </ul> <p><b>Perceived as unnatural and therefore unhealthy.</b></p> <ul style="list-style-type: none"> <li>• "I don't think of this as meat; I would rather eat 'real' meat" (34f)</li> </ul> <p>"If my wife cooked something like that it'd be grounds for divorce. It's an insult to meat. . ." (19m).</p>
Low	(Bogueva and Marinova, 2020)	Online survey with 226 young Australians (18-24y)	Not reported	<p>72% (n=163) associated CBM with a feeling of <b>uneasiness and discomfort</b>. Expressed with statements, such as: "It makes me really sick," "it's really disgusting," and "I may vomit. Sorry".</p> <p>32% (n = 73) Believed cultured meat is <b>not a healthy and nutritious food option</b> or did not know if it is healthy/nutritious.</p> <ul style="list-style-type: none"> <li>• "In vitro meat is overly processed. In our society, at school, uni, media, magazines, articles, everywhere we are told to limit the consumption of processed food...." (daily meat eater, sports coach, age group 18–20 years)</li> <li>• "There is a trend now people to become flexitarian and to eat meat alternatives, but all these including cultured meat are not healthy. I prefer to reduce meat intake but will not eat these modern things." (daily meat eater, university student, age group 18–20 years)</li> <li>• "You can't have ribs, steaks etc. out of fake meat and it's not appealing. Even in the future the scientists can grow these, it will be far too chemically processed to be normal and healthy thing to consume." (daily meat eater, mathematics tutor, age group 18–20 years)</li> <li>• "No idea how normal meat will be sourced from a lab instead of a farm. More likely not good and unhealthy for us to consume. I will incline toward opting it out." (daily meat eater, university student, age group 18–20 years)</li> <li>• "Not sure why we should think of meat substitutes as healthy. They never will be healthy and good for you like plain fruit and veggies. See the cultured meat, plant-based engineered burger. People will always associate them with engineering and modifications." (a few times per week meat eater, hairdresser, age group 21–24 years)</li> <li>• "Necessary with respect to the environment and the animals, but it's unknown how healthy cultured meat is for humans to consume on a regular basis like meat. More likely not that healthy having in mind the way it's produced." (a few times per week meat eater, office assistant, age group 21–24 years)</li> </ul> <p>13% (n = 29) <b>Australian pride/disloyalty to Australian meat and betrayal of their country.</b></p>

Quality	Reference	Design/sample	CBM defined	Results
				<ul style="list-style-type: none"> <li>• “Coming from a meat-eating nation with one of the best superior quality meats in the world, I feel we should be quite cautious not to betray our beautiful meat for this artificial meat.” (daily meat eaters, shop assistant, age group 18–20 years)</li> <li>• “I believe in vitro meat and other plant-based meat are not that essential, meat is plentiful in Australia and one among the best in the world. We don’t need to worry too much.” (a few times per week meat eater, legal secretary, age group 21–24 years)</li> <li>• “In Australia we produce lots of good meat the nation is proud of and more lab-grown meat is unnecessary.” (non-meat eater, yoga instructor, age group 21–24 years)</li> <li>• “Aussie meat is the best and part of our culture, no any other meats, even lab meat, can replace its quality.” (daily meat eater, electrician apprentice, age group 18–20 years)</li> <li>• “We love Aussie meat. The best in the world and I can’t replace it with gross lab meat.” (daily meat eater, planner, age group 21–24 years)</li> <li>• “Australia grows naturally exceptional livestock and produces the best meat cuts worldwide. Not clear how the lab meat is grown, what chemicals, preservatives they put into it to prevent it from rotting or to maintain its taste, texture.” (daily meat eater, clients’ relations, age group 21–24 years)</li> <li>• “Not normal for me to eat some fake, synthetic meat, especially living in Australia where the meat is with no doubt the best in the world.” (daily meat eater, pastry chef, age group 21–24 years)</li> <li>• “Right now, it is not natural at all to consume lab meat. It looks yuck, patty not like meat. It seems quite artificial and can’t even compete and beat the Australian meat which is number one.” (daily meat eater, laborer, age group 21–24 years)</li> </ul> <p>45% (n=103) <b>Lack of information</b> about the way cultured meat is created, the substrates and the processes used combined with it <b>not being yet available in Australia</b>, makes it an undesirable food option.</p> <ul style="list-style-type: none"> <li>• “It is absolutely not normal to consume cultured meat. It’s out of my food comfort zone. I even don’t want to try it.” (daily meat eater, office assistant, age group 21–24 years)</li> <li>• “Meat substitutes are normal and quite popular even fashionable lately among young people like me. But lab meat is purely food-based biotech. Very abnormal for me and I will never eat these foods.” (a few times per week meat eater, assistant, age group 21–24 years)</li> <li>• “I think cultured meat is an unnatural nonsense.” (occasional meat eater, shop assistant, age group 18–20 years)</li> <li>• “In vitro is completely unnatural thing. The meat gains its flavor from the animal, the amount of fat content, the marbling. It is a reflection of the way the animal is grown - the pasture it’s grazed on, the food it’s being fed. These all bring the flavor to the actual meat. While cultured meat is an artificially produced and flavored, not natural.” (a few times per week meat eater, library services, age group 18–20 years)</li> <li>• “I wouldn’t eat stem cell based artificial meat from a lab. Animal stem cells, muscles are used to create a piece of meat. It’s not normal. It’s totally sick. It’s really scary to think about, not even to consume it.” (a few times per week meat eater, office assistant, age group 18–20 years)</li> <li>• “Chemically produced cell grown food can’t be normal to consume. They can mimic the meat nutrition, but actually they are not as nutritious as meat. Marketers can say anything, but I am sure they serve someone’s agenda.” (few times a week meat eater, business development officer, age group 21–24 years)</li> <li>• “I rather go vegetarian or vegan than eating cultured meat. It’s not natural or normal....” (a few times per week meat eater, finance officer, age group 21–24 years)</li> </ul>

## Conclusion

Conclusive statements for each research question and grading of the available evidence are provided in Table 24. Some limitations of the review process and the available evidence should be considered when interpreting the findings of the review. These are discussed below.

- Study quality appraisals and evidence grading were conducted by a single reviewer. This was necessary to provide a timely review of the evidence and is a commonly used approach for conducting rapid reviews.
- Of the 43 included studies, 30 were appraised as having a risk of bias, which reduces confidence in the findings of these studies. Overall, most studies appraised as having a risk of bias had concerns related to bias in the description of CBM that was provided to participants prior to assessing outcomes, with only one-third of the included studies (13/43) providing neutral descriptions of CBM.
  - The 13 studies appraised as having a low risk of bias and none of them were conducted in Australia or NZ.
- Reliable comparison of findings between studies were limited by several factors related to study design, including differences in: CBM terminology; information about CBM provided prior to assessment; assessment methods, including question format and wording. Additionally, in 18/43 studies, study samples were not representative of the target population groups, thus limiting generalisability of the findings.
  - Notably, 25/43 studies used samples that were representative or largely representative - this included 3/3 Australian studies included in the review and 0/4 NZ studies.
- Overall, limited Australian and NZ data were available to address each research question, with the number of studies addressing each research question ranging between 0-3 for Australia and NZ. Further high-quality studies in Australia and NZ could provide additional information to help determine how best to support informed decision-making by consumers regarding cell-based proteins, particularly in the following areas:
  - The best (most understood and preferred) CBM names and descriptive phrases identified from the review could be tested for understanding and appropriateness in the Australian and NZ context.
  - Other important knowledge gaps that could be addressed include determining: consumers' objective knowledge of cell-based proteins with respect to both the manufacturing process and the end product;
  - How perceived risks and benefits of CB proteins are shaped by perceived knowledge of CBM and the information provided about the product;

- Consumers' expectations regarding the availability of information and terminology that will allow them to distinguish between cell-based proteins and traditional proteins, on foods that are not required to bear a label.
- Overall, this systematic review focused on CBM (which included both meat and seafood) and highlighted a lack of empirical evidence around consumers' responses to cell-based dairy products and limited evidence regarding cell-based seafood; both of which could be addressed in further research.
- Lastly, it is important to note that motivations for consuming/not consuming CBM were elicited in a hypothetical context, thus, motivations might differ once CBM enters the market and becomes a possible food option for consumers. Thus, further studies assessing motivations for consuming/not consuming CBM should be conducted once CBM becomes available, and consumers' views can be based on their own personal experiences and/or those of important/influential others.

**Table 24. Conclusions and grading of evidence, by research question.**

	Research Q	Conclusion	Grade	Body of evidence	Risk of bias	Consistency	Directness	Precision	Generalisability
<b>RQ1</b>	What are the levels of consumers' awareness of cell-based proteins?	Moderate evidence indicates a low level of consumers' awareness and familiarity regarding CBM.	Moderate	20 studies (19QTS & 1 QLS) including 2 Australian and 3 NZ studies. Quality of the studies: high (n=1), moderate (n=13), low (n=6).	Some concerns related to bias in in CBM description (n=6), potential bias in selection of participants (n=5) in measurement of outcomes (n=1), and selection of reported result (n=2).	Consistency was demonstrated in studies reporting familiarity and in the majority of studies reporting awareness except the NZ studies which indicates a moderate level of awareness	Few or no concerns	Few concerns	Few concerns
<b>RQ2</b>	What is consumers' knowledge of the manufacturing process and end product?	No evidence is available to determine consumers' knowledge of the manufacturing process and end product	GNA	0	NA	NA	NA	NA	NA
<b>RQ3</b>	What are consumers' perceived benefits of cell-based proteins (e.g., health, sustainability, animal welfare)?	Limited evidence indicates perceived neutral view on environmental, other societal, and personal benefits. However, there was some variation across consumers, with some perceiving these as benefits.	Limited	11 studies (6 QTS & 5 QLS) including one Australian and two NZ studies. Quality of the studies: high (n=2), moderate (n=5), low (n=4).	Concerns related to bias in CBM description (n=7), some concerns related to potential bias in selection of participants (n=3), in measurement of outcomes (n=1) and in selection of reported result (n=1).	Few or no concerns	Few or no concerns	GNA	Concerns related to measure of perceived benefits after exposure to bias in CBM description in the majority of studies
<b>RQ4</b>	What are consumers' perceived risks and/or downsides of cell-based proteins (e.g. taste, texture, health, sustainability, safety, 'unnaturalness', manufacturing process, cost)?	Limited evidence indicates perceived moderate risks associated with consumption of CBM, which mainly related to food safety, personal health, environmental and societal risks. The two main factors underlying health concerns were perceived unnaturalness/high level of processing of CBM and uncertainty regarding the current scientific understanding of CBM.	Limited	18 studies (13 QTS & 6 QLS with 2 of them were mixed methods) including 1 Australian and 2 NZ studies. Quality of the studies: moderate (n=9), low (n=9)	Some concerns related to bias in CBM definition (n=4), potential bias in selection of participants (n=6), in measurement of outcomes (n=2) & in selection of reported result (n=4).	Limited	Some concerns due to that perceived risks were assessed mostly in the context assuming CBM products were not yet available for sale on the market	GNA	Some concerns due to the uncertainty about sample representativeness in some studies and limited evidence from Australia (one study with a small sample size).
<b>RQ5</b>	Do consumers perceive cell-based proteins as the same or different to their traditional counterparts? Are they perceived as being as healthy as, and/or nutritionally equivalent (e.g., levels of	Limited evidence indicates CBM products are perceived as similar to their traditional counterparts in relation to healthiness or nutritional quality.	Limited	9 studies (7 QTS & 2 QLS) including 1 Australian and 1 NZ. Quality of the studies: moderate (n=5), low (n=4)	Some concerns related to bias in CBM definition (n=5), potential bias in selection of participants (n=2) & reported result (n=3)	Limited	Few concerns	GNA	Some concerns due to the uncertainty about representativeness of samples in some studies and limited evidence from Australia (one study with a small sample size).



	Research Q	Conclusion	Grade	Body of evidence	Risk of bias	Consistency	Directness	Precision	Generalisability
	protein/fat) to, their traditional counterparts?								
<b>RQ6</b>	Do consumers want a specific term to differentiate between cell-based protein and traditional protein, and what terminologies are best for consumer understanding?	Moderate evidence indicates names that containing the word 'cell' (e.g., 'Cultivated from the cells of_', 'Grown directly from the cells of_', 'Cell-based' or 'Cell-cultured'), the name 'lab-grown' and descriptive phrases 'grown from [animal] cells', 'not farmed [or fished]' are better understood by consumers to differentiate CBM products from conventional meat and fish but may decrease consumer appeal compared to 'cultured'/'cultivated'	Moderate	10 studies (9 QTS & 1 QLS), none are Australian or NZ studies. Quality of the studies: high (n=1), moderate (n=5), low (n=4)	Some concerns related to potential bias in CBM description (n=3), selection of participants (n= 1) & selection of reported result (n=2)	Consistency was demonstrated with the majority of studies	Few concerns	GNA	Some concerns due to the uncertainty about sample representativeness in some studies & none of the studies were conducted in Australia
<b>RQ7</b>	Do consumers expect this information (i.e., that it is cell-based protein) to be available when food is not required to bear a label (e.g., food sold for immediate consumption in a restaurant)?	Limited evidence indicates that consumers expect to see labelling information that identifies CBM product in general.	Limited	One QTS	Few concerns related to potential bias in selection of participants	GNA	Some concerns due to indirect measure (not specially related to when food is not required to bear a label.	GNA	GNA due to very limited evidence and no Australian studies
<b>RQ8</b>	Are consumers willing to consume cell-based proteins? If so, how are cell-based proteins likely to be incorporated into the diet (frequency, substitute or consume in addition to regular counterpart)?	Limited evidence indicates consumers either unsure or somewhat willing to consume CBM as a partial replacement for conventional proteins.	Limited	20 studies (19 QTS & 2 QLS) including 2 Australian, 1 multi-countries including Australia & and 2 NZ studies. Quality of the studies: High (n=2), Moderate (n=14), Low (n=4)	Severe concerns related to bias in CBM definition (n=15), some concerns related to potential bias in selection of participant (n=3), in measurement of outcomes (n=1) and in selection of reported outcomes (n=1).	Limited	Few concerns	GNA	Concerns due to inconsistency in findings and bias in CBM description
<b>RQ9</b>	What are consumers' key motivations for consuming or not consuming cell-based proteins (e.g., taste, health, sustainability, aversion to manufacturing process, cost etc.)?	Limited evidence indicates environmental benefits, animal welfare, health and nutrition considerations are the key motivations, and feelings of disgust and unease towards CBM, negative perceptions regarding taste/sensory characteristics, perceiving uncertainty in scientific knowledge are barriers for consuming CBM.	Limited	11 studied (8 QTS & 4 QLS with 1 of them was mixed methods) including 2 Australian, 1 multi-country including Australia & 2 NZ studies. Quality of the studies: Moderate (n=4), Low (n=3).	Concerns related to bias in CBM description (n=5), potential concerns in selection of participants (n=2) and selection of reported results (n=1)	Consistency was demonstrated with the majority of studies reporting motivations related to environmental benefits and animal welfare	Few concerns	GNA	Concerns due to bias in CBM description

GNA: Grade not assignable; QTS: quantitative study; QLS: qualitative study; NZ: New Zealand.

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## Appendix 1. Search strategies

Table 1A. Peer-reviewed publications search results

Database	Search	Citations
PubMed (Human only)	("plant protein"[Title/Abstract] OR "cultured"[Title/Abstract] OR "clean"[Title/Abstract] OR "vitro"[Title/Abstract] OR "cell-based"[Title/Abstract] OR "cultivated"[Title/Abstract] OR "lab-grown"[Title/Abstract] OR "cellular agriculture"[Title/Abstract] OR "plant-based"[Title/Abstract]) AND ("meat"[Title/Abstract] OR "beef"[Title/Abstract] OR "chicken"[Title/Abstract] OR "dairy"[Title/Abstract] OR "milk"[Title/Abstract] OR "cheese"[Title/Abstract] OR "yogurt"[Title/Abstract] OR "yoghurt"[Title/Abstract] OR "fish"[Title/Abstract] OR "seafood"[Title/Abstract]) AND ("health knowledge, attitudes, practice"[MeSH Terms] OR "Health Knowledge"[Title/Abstract] OR "attitude"[Title/Abstract] OR "practi"[Title/Abstract] OR "aware"[Title] OR "understand"[Title] OR "interpret"[Title] OR "familiar"[Title] OR "perce"[Title] OR "belie"[Title] OR "accept"[Title] OR "willing"[Title] OR "inform"[Title] OR "inten"[Title] OR "purchas"[Title] OR "value"[Title] OR "seek"[Title] OR "influenc"[Title] OR "benefit"[Title] OR "risk"[Title] OR "cons"[Title] OR "motiv"[Title] OR "confus"[Title] OR "mislead"[Title] OR "choice"[Title] OR "prefer"[Title] OR "ultra-processed"[Title] OR "term"[Title] OR "label"[Title] OR "Consumer Behavior"[MeSH Terms] OR "consumer behavio"[Title/Abstract] OR "Choice Behavior"[MeSH Terms] OR "Choice Behavior"[Title/Abstract] OR "Choice Behaviour"[Title/Abstract] OR "Food Preferences"[MeSH Terms] OR "food preference"[Title/Abstract] OR "food technology/ethics"[MeSH Terms] OR "market"[Title/Abstract])	1,359
	PubMed (Human only) & 2012-March 2023	766
WOS	(TS=("plant NEAR/2 protein" OR "cultured NEAR/2 meat" OR "cultured NEAR/2 dairy" OR "clean NEAR/2 meat" OR "clean NEAR/2 dairy" OR "cell NEAR/2 based meat" OR "cell NEAR/2 based dairy" OR "cultivated NEAR/2 meat" OR "cultivated NEAR/2 dairy" OR "lab NEAR/2 grown meat" OR "lab NEAR/2 grown dairy" OR "cellular agriculture" OR "plant NEAR/2 based meat" OR "plant NEAR/2 based dairy" OR "cultured NEAR/2 fish" OR "cultured NEAR/2 seafood" OR "clean NEAR/2 fish" OR "clean NEAR/2 seafood" OR "cell NEAR/2 based fish" OR "cell NEAR/2 based seafood" OR "cultivated NEAR/2 fish" OR "cultivated NEAR/2 seafood" OR "lab NEAR/2 grown fish" OR "lab NEAR/2 grown seafood" OR "cellular agriculture" OR "plant NEAR/2 based fish" OR "plant NEAR/2 based seafood")) AND (TS=("Health Knowledge" OR Attitude* OR Practi* OR "Consumer Behavio*" OR "Choice Behavior" OR "Choice Behaviour" OR "Food Preference*" OR market* OR Aware*, OR understand*, OR interpret* OR familiar* OR perce* OR attitude* OR belie* OR benefit* OR risk* OR accept* OR willing* OR inform* OR intent* OR purchas* OR motivation* OR influenc* OR value OR seek OR confus* OR mislead* OR choice* OR prefer* OR ultra-processed OR term* OR label*))	88
	Limit to 2012 – March 2023 (All citations from the above search were all published within the last 10 yrs)	88

Database	Search	Citations
Scopus	( TITLE ( "plant protein*" OR cultured OR clean OR vitro OR cell-based OR cultivated OR lab-grown OR "cellular agriculture" OR "plant-based" ) ) AND ( TITLE ( meat* OR beef OR chicken OR dairy OR milk* OR cheese* OR yogurt OR yoghurt OR fish* OR seafood* ) ) AND ( TITLE ( "health knowledge" OR attitude* OR practi* OR "consumer behavio*" OR "choice behavior" OR "choice behaviour" OR "food preference*" OR market* OR aware*, OR understand*, OR interpret* OR familiar* OR perce* OR attitude* OR belie* OR benefit* OR risk* OR accept* OR willing* OR inform* OR intent* OR purchas* OR motivation* OR influenc* OR value OR seek OR confus* OR mislead* OR choice* OR prefer* OR ultra-processed OR term* OR label* ) )	573
	Scopus & limit to 2012-March 2023	412
PsycINFO	((("plant protein*" or cultured or clean or vitro or cell-based or cultivated or lab-grown or "cellular agriculture" or plant-based) and (meat or beef or chicken or dairy or milk* or cheese* or yogurt or yoghurt or fish* or seafood*)).ti,ab. and (("Health Knowledge" or Attitude* or Practi* or "Consumer Behavio*" or "Choice Behavior" or "Choice Behaviour" or "Food Preference*" or market* or Aware*, or understand*, or interpret* or familiar* or perception* or perceive* or attitude* or belie* or benefit* or risk* or accept* or willing* or information* or intent* or purchas* or motivation* or influenc* or value or seek or confus* or mislead* or choice* or prefer* or ultra-processed or term* or label*).ti. or *Consumer Attitudes/ or *Consumer Behavior/ or *Motivation/ or *Consumer Ethics/ or *social values/ or *Consumer Protection/ or *Warning Labels/ or *Behavioral Intention/ or knowledge level/ or *"knowledge (general)"/)	145
	PsycINFO & limit to yr="2012 – 2023"	121

**Table 1B. ProQuest Dissertations & Theses Global Search Results**

Grey Literature	Search	Citations
ProQuest Dissertations & Theses Global	(title(plant AND meat) OR title(plant AND protein*) OR title(plant AND dairy) OR title(cultured AND meat) OR title(cultured AND dairy) OR title(clean AND meat) OR title(clean AND dairy) OR title(cell AND meat) OR title(cell AND dairy) OR title(cultivated AND meat) OR title(cultivated AND dairy) OR title(lab AND meat) OR title(lab AND dairy) OR title("cellular agriculture") OR title(cultured AND fish) OR title(cultured AND seafood) OR title(clean AND fish) OR title(clean AND seafood) OR title(cell AND fish) OR title(cell AND seafood) OR title(cultivated AND fish) OR title(cultivated AND seafood) OR title(lab AND fish) OR title(lab AND seafood) OR title("cellular agriculture") OR title(plant AND fish) OR title(plant AND seafood)) AND (title("Health Knowledge" OR Attitude* OR practise OR practice OR "Consumer Behavior*" OR "Consumer Behaviour*" OR "Choice Behavior" OR "Choice Behaviour" OR "Food Preference*" OR market*) OR abstract("Health Knowledge" OR Attitude* OR practise OR practice OR "Consumer Behavior*" OR "Consumer Behaviour*" OR "Choice Behavior" OR "Choice Behaviour" OR "Food Preference*" OR market*) OR subject("Health Knowledge" OR Attitude* OR practise OR practice OR "Consumer Behavior*" OR "Consumer Behaviour*" OR "Choice Behavior" OR "Choice Behaviour" OR "Food Preference*" OR market* or Aware*, or understand*, or interpret* or familiar* or perception* or perceive* or attitude* or belie* or benefit* or risk* or accept* or willing* or information* or intent* or purchas* or motivation* or influenc* or value or seek or confus* or mislead* or choice* or prefer* or ultra-processed or term* or label*))	63
	Limit to 2012 – March 2023 (All citations from the above search were all published within the last 10 yrs)	44

## Appendix 2. Study design and participants' characteristics

Table 2A. Summary of study design and participants' characteristics of the included studies.

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
<b>Anderson &amp; Bryant, 2018</b>	H	1	Yes	US	Survey. Each participant shown CBM description that mentions potential nutritional benefits and then shown one of four framed messages that each mention benefits (to human health, animals, and environment) and emphasise: <ul style="list-style-type: none"> <li>• Clean meat is natural</li> <li>• Conventional meat is unnatural</li> <li>• Challenging the appeal to nature</li> <li>• Control (mention benefits only).</li> </ul> Awareness (Have you heard of...) assessed before being shown CBM description, familiarity assessed after CBM description (Prior to this study, to what extent were you familiar with...); then shown one of four framed messages; all other Qs asked after showing framed messages.	1185	Recruited via research firm Ipsos online panel	Mean age: 47.3±16.8 yrs, 53%F, majority white & Omnivorous, 35% tertiary educated.	1,3,6,8
<b>Arango et al., 2023</b>	L	0	No	US	Survey. Participants were randomly assigned to either a demand vs. scarcity based appeal or control with and without providing information regarding the naturalness of the product. Participants were asked to rate their perceived risks if the product was available. Risk perceptions were measured using a 7-point scale	594	Online recruitment via Prolific.	Mean age: 41±13yrs, 50%F	4
<b>Asioli et al., 2022</b>	M	0	Yes	US	Survey including a discrete choice experiment (DCE). DCE examined preferences/willingness to pay for conventional vs. CBM chicken (fresh skinless boneless chicken breast products), and preferences for different names/terms for CBM (cultured, lab-grown and artificial).	625	Recruited via online platform Qualtrics LLC	≥18 yrs, approximately 1/3 of them aged in each of the three age groups: 18-35 yrs, 36-53yrs & 54-71yrs. 47%f, 54% tertiary educated, majority white	1, 6
<b>Baum et al., 2022</b>	M	0	Yes	UK	Survey. All Qs (except awareness) asked after providing description of CBM.	302	Recruited Online via Respondi		1
<b>Boykin et al., 2019</b>	M	0	Yes	US	Survey. Each participant shown neutral description of CBM, followed by one of three themed blog post messages. <ul style="list-style-type: none"> <li>• Neutral</li> <li>• Supportive of CBM - Mentioned benefits to human health, animals, environment</li> <li>• Against CBM - Mentioned risks/disadvantages for animals and environment.</li> </ul> All CBM Qs (except awareness) asked after providing framed messages about CBM.	238	Recruited using Marketing Systems Group (MSG) – an information systems company used to distribute survey instruments and collect survey data.	Primary food buyer for their household, ≥18 yrs, mean age: 45.7 (18-80) yrs, 42.7% were tertiary educated. Omnivorous.	3,4,8



Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
<b>Boereboom et al., 2022</b>	L	2	No	UK	Survey. Not reported whether CBM definition provided to participants.	509	Recruited from preexisting contact lists and convenient sampling techniques, such as distribution of the survey via social media platforms such as LinkedIn.	≥18 yrs. 52.5% aged 25-39 yrs & 46.2% aged ≤ 24yrs, 66.7%F, 23% Muslim.	3
<b>Bogueva &amp; Marinova, 2020</b>	L	4	Yes	Australia	Survey. Collected mainly qualitative data and some quantitative data. Not reported whether CBM definition provided to participants.	227	Recruited randomly from a pool of 30,000+ names registered in a database established by the researchers	18 years or older and Generation Z, mean age: 21.4 (18-24)yrs 45%F, majority Omnivorous.	3-5,8-9
<b>Bryant &amp; Barnett, 2019</b>	M	1	No	US	Survey. All Qs asked after providing description of CBM.	185	Recruited through Amazon Mturk	≥18 yrs, Mean age: 34.9±10.4 (20-68)yrs, 42%F, a younger population than a representative US sample	8
<b>Bryant &amp; Dillard, 2019</b>	M	0	No	US	Survey. Participants were allocated to 1 of 3 experimental conditions (framings), which contained an image and short text. There was no control framing. SOCIETAL BENEFITS group: "Clean meat has many benefits for society like reducing harm to the environment and helping animals". HIGH TECH group: "Clean meat is made using highly advanced technology in a state of the art laboratory". SAME MEAT group: "Clean meat tastes like conventional meat, is increasingly affordable, and can be healthier to eat".  All Qs (except awareness) asked after providing framed description of CBM.	480	Recruited through Amazon Mturk	≥16 yrs, 47.4% aged 16-35yrs & 17.5% aged 36-45yrs, 42%F, majority Omnivorous	3,8
<b>Bryant et al., 2019a</b>	M	1	Yes	US	Survey. All Qs (except awareness) asked after providing description of CBM.	987	Recruited via online research panel CINT	≥18 yrs, Mean age: 40±12yrs, 51%F, majority white, Christian & Omnivorous. 52% tertiary educated.	1,8
<b>Bryant et al., 2019b</b>	H	1	Yes	US	Survey. Each participant shown CBM description that mentions benefits for human health, animals and environment; and then shown one of four framed messages that each mention benefits (to human health, animals, and environment) and emphasise: <ul style="list-style-type: none"> <li>Clean meat is natural</li> <li>Conventional meat is unnatural</li> <li>Challenging the appeal to nature</li> </ul>	1185	Recruited via the research firm Ipsos online panel	Mean age: 47.3±16.8 yrs.	3,8

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
					<ul style="list-style-type: none"> <li>Control (mention benefits only).</li> </ul> All CBM Qs asked after providing description of CBM.				
<b>De Muth et al., 2023</b>	L	0	Yes	US	Survey. Participants were randomly assigned to view a CBM product labelled with either 'Just Meat' or 'Just Protein'.	1504	U.S. households identified via Survey Sampling International (Qualtrics)	Primary food buyer for their household, ≥18 years old, all Male	6
<b>de Oliveira Padilha et al., 2021</b>	M	1	Yes	Australia	Survey. All Qs (except awareness) asked after providing description of CBM.	1078	Recruited via a market research company (Dynata) provided the consumer panel and administered the survey among Australian food shoppers	≥18 yrs, mean age: 46.56 ±16.5 yrs, representative of general Australian adult 49%F, 37% were tertiary educated, 67% lived in an urban area.	1, 8
<b>de Oliveira Padilha et al., 2022</b>	M	1	Yes	Australia	Survey. All Qs (except awareness) asked after providing description of CBM.	1060	Recruited via a market research company (Dynata) provided the consumer panel and administered the survey among Australian food shoppers	≥18 yrs, mean age: 46.56 ±16.5 yrs, representative of general Australian adult 49%F, 37% were tertiary educated, Omnivorous, 67% lived in an urban area.	1,8
<b>Dillard &amp; Szejda, 2019</b>	L	1, 4	No	US	Focus groups. CBM description refers to social, environmental and economic, human health and animal benefits. Part 1: After listening to the narrative and reading along, participants considered their responses to the narrative and wrote down any immediate questions. Part 2: After viewing the corresponding visual analogy, participants considered their reactions to it, wrote comments, and noted aspects they liked and disliked. During group discussion, participants provided specific recommendations about words, phrases, and images that they felt worked well or should be changed. Part 3: After the facilitator explained the challenges involved in finding an appropriate name and specifying the criteria to use when evaluating appropriate, participants evaluated five potential names for this new type of meat— cultivated, cultured, cell-based, cell-cultured, and propagated—first by ranking them 1–5 (1= most appealing) and then by discussing their rankings.	27	NR - students at a liberal arts college	18-21 yrs, 59%F, Omnivorous or flexitarian	6
<b>Giezenaar et al., 2023</b>	M	1	No	NZ	Survey. All Qs (except awareness) asked after providing description of CBM.	572	Recruited via an online recruitment company (Dynata, Auckland, NZ)	Aged 25-55 yrs, meat eater (< than 7 days per week), were potentially interested in reducing their meat consumption, 7%F, majority white.	1,5,8

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
<b>Giacalone &amp; Jaeger, 2023</b>	M	1	Yes	Multiple (US, Aust, SG, India)	Survey. All Qs asked after providing description of CBM.	2494	Recruited via commercial web survey research provider with ISO 20252 accreditation	≥18 yrs, mean aged: 49 yrs for both US & Australia samples. 50%F, 62.8% tertiary educated, majority Omnivorous	8-9
<b>Hallman &amp; Hallman, 2020</b>	M	0	No	US	Survey. Participants were randomly assigned to view an image of a realistic package of either salmon, tuna, or shrimp labelled with one of best described the product as wild-caught, farm raised, neither wild-caught nor farm raised before given any description of CBM. Then Participants were asked to rate the clarity of each name to communicate the nature of the product after viewing a neutral description of CBM. the common names (Cultivated from the cells of_, Cultured, Cell-based, Cell-cultured, Cultivated, Farm raised, Grown directly from the cells of_, Produced using cellular agriculture, Wild caught or Control) and were asked which of the names	3186	Recruited from a web-based consumer panel with more than 3.2 million active members enrolled in the United States.	≥18 years, mean age: 49.7±15.9, 76% white, 49%F, 46% were tertiary educated	1, 4-6
<b>Hallman &amp; Hallman, 2021</b>	M	0	No	US	Survey. Participants were randomly assigned to view a salmon labelled with either 'Cell-based' and 'Cell-cultured', and were asked which of the three terms (Wild-caught, Farm-raised, Neither wild-caught nor Farm-raised) best describes this salmon? Qs asked after providing description of CBM: familiarity, appropriateness of term for describing the new way of producing seafood; how clearly the term communicated the product "was not caught in the ocean, was not farm-raised; level of agreement with whether CB seafood should be "sold in the same section of the supermarket as wild-caught and farm raised fish."; overall positive or negative reaction; interest in tasting the CB product; likelihood of buying the product in the next 6 months if it were sold in their grocery store; Qs for study 2 about ability to distinguish CB from conventional products.	1600	An online experiment with a nationally representative sample Of adult	Mean age: 47.4±17.7 yrs. 38.5%F. Majority black, 1/3 completed 2 <sup>nd</sup> educate & another 1/3 completed certificate, 20% tertiary educated.	1, 6,8
<b>Hamlin et al., 2022</b>	M	1	No	NZ	Individual interview. Concept described in picture and text (read or spoken) format. All Qs asked after providing the above description of CBM.	254	Direct personal approach on university campus; convenience sample	≥18 yrs, 72.4% aged 18-25 yrs, 52.7%F, 48% Asia, 44% Caucasian, all actively engaged in tertiary education. Majority Omnivorous	1,3-4
<b>Hubbard, 2022</b>	L	2, 4	No	US	Survey (Masters thesis). 'If you could give cell-based meat a better name or term that makes it more relatable and friendly to you, what would you call it?' Did not report whether CBM description was provided to participants.	153	Recruited via snowball & from network & students at a University	Approximately 41 were Gen Z, 30 were millennials and the rest were Gen X and boomers. Omnivorous. Almost one-third of the participants already shop at high-end supermarkets	6
<b>Juhasz et al., 2023</b>	L	2	Yes	Canada	Survey. A national survey. No CBM description provided.	10,019	Recruited via email and mobile platform	≥18 yrs, 48%F, 8% Gen Z.	1, 4-5, 7-8

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
							hosted by Agri-food Analytics Lab		
<b>Jenkins et al., 2020</b>	M	0	Yes	UK	Survey. All Qs asked after providing description of CBM.	907	Recruited online via Dynata	≥18 yrs, representative of US population age profile, 51.6%F	4
<b>Krings et al., 2022</b>	L	3, 4	No	Multiple (EU, UK, US)	Survey. Images of 6 dishes (same image was used for all), 3 showed dishes made with regular meat from farmed animals (i. e., a burger, meatballs, and meat-filled tacos) & 3 showed similar dishes made from clean meat, each with an accompany brief description of the type of meat. Each dish was presented as clean meat to half of the participants & as regular meat to the other half.	273	Recruited via Prolific online platform	Participants self-identified as omnivores, mean age 28±9 yrs, >80% white, 44%F.	4
<b>Laestadius &amp; Caldwell, 2015</b>	M	1	No	US	Other. Content analysis of comments made on 7 online US news articles (each discussing the 2013 CBM hamburger event – a media-attended event where scientists first revealed CBM to the public and tasted the world's first CBM hamburger patty).	814 comments from 462 commenters	Qualitative content analysis of the comments made on online news articles	Seven articles (US news articles discussing the 2013 IVM hamburger event) with total of 814 comments from 462 commenters	3-5
<b>Leong et al., 2022</b>	M	0	Yes	US	Survey. No CBM description provided.	326	Recruited via online crowdsourcing portal - Amazon Mechanical Turk	≥18 yrs, mean age: 40yrs, 46%F, majority white.	8
<b>Leung et al., 2023</b>	M	1	Yes	Singapore	Survey. All Qs asked after providing description of CBM plus one randomly allocated benefit message (one of five). Only aggregated results reported as no differences found between the five groups.	948	Recruited via the market research company inveritas Research	≥18 yrs, aged 18-69yrs, 44.8%F, 62% tertiary educated, majority Asian.	8,9
<b>Liu, 2022</b>	L	2	No	US	Survey. Q about familiarity and willingness to buy in the future asked prior to showing CBM description. Description shown to those who had previously heard of cultivated (cell-based) seafood; after which they were asked about their perceptions of and motivations for purchasing alternative seafood (including both plant-based and CB). All participants were then shown an additional description of CB seafood. This was followed by Qs assessing willingness to consume, perceived benefits, and consumption motivators/barriers.	2538	Used survey data from The Good Food Institute from 2019	US Residents, aged 18-65 yrs, 51%F,	9
<b>Lucius, 2020</b>	M	1,2	No	US	Mixed methods. Online survey followed by online video focus group.	18	Convenience sample. Recruited via email and community	US Residents, aged 18-65, 56%F	1
<b>Malavalli et al., 2021</b>	M	1	No	NZ	Survey. All Qs asked after providing description of CBM.	206	Majority recruited in person in public spaces and some online from social media posts	18-65 yrs, 74% were 18-25 yrs, 61%F, 47% tertiary educated.	1,4, 8-9
<b>Malerich &amp; Bryant, 2022</b>	M	0	Yes	US	Survey. Participants were randomly assigned to view a product (either salmon, chicken or beef) labelled with one of the 9	2653	Recruited via Prolific platform	≥18 yrs, (50% of 30-59yrs & 29% ≥60 yrs), 50.5% F.	4,6

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
					common names (Cell-cultivated, Cultivated, Cell-cultured, Cultured, Cell-based, Novari, Lab-grown, Artificial, or a descriptive phrase 'Grown from [animal] cells, not farmed [or fished]') and were asked to identify what the product was - whether it was hunted/fished in the wild, farm raised, produced by animal cells in a food facility, or was plant-based.				
<b>Rosenfeld et al., 2022</b>	M	0	Yes	US & UK	Survey. All Qs asked after providing description of CBM. Study 1: Assessed proportion of participants who find CBM too disgusting to eat (compared meat-eaters and vegetarians): 'Cultured meat is too disgusting for me to try eating it'. Study 2: no relevant outcomes Study 3: no relevant outcomes	1587	Recruited via Prolific platform	18-79 yrs, 75% F, similar % vegetarian/meat-eater	9
<b>Ruzgys et al., 2020</b>	M	1, 2	No	Canada	Survey Participants shown CBM description and five framed messages about CBM. Knowledge Qs assessed prior to being shown the above description of CBM. All other Qs (including open-ended question about opinion on consuming CBM) asked after reading the CBM description. Willingness to consume questions answered three times: 1) after reading the CBM description; 2) after reading all five framed messages regarding benefits of CBM (below); and 3) after reading five messages framing CBM as natural (below).	200	Recruited via University's SONA (research trial recruitment) system, posters, and social media posts	Convenience sample of college-aged Canadians 18-30 yrs Omnivorous.	1,3-4,8-9
<b>Shaw &amp; Mac Con Iomaire, 2019</b>	L	2, 4	Yes	Ireland	Mixed methods (Focus groups & survey). Focus group: Five questions asked about CBM to determine what participants viewed as the possible advantages and disadvantages of the technology and if they would be willing to try it. They were asked what other products or technology that it reminded them of; and were asked what would instil trust in the product for them, to assess whether labelling and quality assurance stamps would have an influence on their choices.  Online survey (few descriptive results reported in article apart from reporting P-value for difference between urban and rural respondents): Comparison with conventional meat and general opinion about cultured meat (two rating questions asking about concerns with and potential benefits of CBM).	23 & 312	Purposive sampling for interview & convenience sample for survey	≥19 yrs, 61% & 50%F, 55% tertiary educated, majority Omnivorous.	1, 4-5
<b>Szejda, 2018</b>	L	1	No	US	Survey. Phase 1 & 2: Not reported whether CBM description provided. Phase 3 & 4: Definition provided after introduction of the CBM name/label. All Qs asked after CBM description.	Phase 1: n=97 Phase 2: n=148 Phase 3: n=338	Phase 1: Phase 2 & 3: adults recruited from Amazon Mechanical Turk (mturk) using the Positly platform	Phase 1: Participants included individuals from cellular agriculture companies, individuals from advocacy groups, and consumer researchers Phase 2 & 3: ≥18 years, 74% Millennial, 51%F, 80%	1

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
								Caucasian, 55.5% tertiary educated, 84.5% Omnivorous	
<b>Szejda et al., 2021</b>	L	1	Yes	US & UK	<p>Survey.</p> <p>After 'Brief Technology Description': participants were asked to report their level of support for the technology and their prior familiarity; rated several names in terms of their appeal and descriptiveness; and ranked their name preferences in different contexts (social and package label).</p> <p>After 'Expanded Technology Description': asked Qs that assessed their level of support, the degree to which they would potentially adopt cultivated meat as a dietary option, reasons for potential adoption, labeling preferences, and preferences regarding use of genetic engineering in the production process.</p>	4502	Recruited via online research panel CINT panels	≥18 yrs, Majority white, 47% tertiary educated, Omnivorous	1,6, 8-9
<b>Tucker, 2014</b>	L	1	No	NZ	<p>Focus groups.</p> <p>Participants were presented a series of coloured handouts featuring seven different sets of images, including one set of images on CBM. This was followed by a handout featuring seven quotes from the pilot run of the research project. The researchers introduced each series of images by providing a brief description of the practice, including the understood positive and negative aspects and implications of each.</p> <p>Specific wording and images not provided in article.</p> <p>All Qs asked after providing description (handouts and images) of CBM</p>	69	Recruited via random phone calls using phone directory, advertising in small clubs/churches, personal contacts of researchers	Age: ≥16 yrs, 42.6% aged 36-65yrs, 53.6%F, majority NZ and meat-eater	3,9
<b>Verbeke, 2015</b>	L	1-3	No	UK	<p>Mixed methods (Each participant involved in either a focus group or survey)</p> <p>In both focus groups and online survey, participants were shown seven stimuli/content testers regarding various possible risks and benefits of red meat. One of these content testers was a two-minute YouTube video on CBM.</p> <ul style="list-style-type: none"> <li>Focus group: participants encouraged to raise comments and queries in relation to the video but were advised that questions would not be answered during the discussion.</li> </ul> <p>Online survey: participants prompted to leave comments and questions on the content tester page related to the video.</p>	24-60	Recruited using a market research company	Aged 18-65 yrs, 50-58%%F, meat consumers	1,3-4, 8
<b>Van Loo et al., 2020</b>	M	0	Yes	US	<p>Survey.</p> <p>Participants were asked: 'Should the following products (lab grown meat, plant-based meat using pea protein, and plant-based meat using animal-like proteins produced by yeast) be allowed to be labelled as 'beef'?'</p>	1830	Recruited by a market research agency	≥18 yrs, 47%F, majority white, 35% tertiary educated, majority Omnivorous.	6
<b>Vural et al., 2023</b>	M	2	No	UK	<p>Survey.</p> <p>Participants were randomly allocated to one of two study arms. Each arm included one cultured meat product (either</p>	195	Recruited through University of Bristol, School of Psychological	≥18 yrs, mean age: 29 ±13.4 yrs, 77%F, 44% tertiary educated.	5

Reference	Quality	RoB*	Rep	Country	Design	N	Sampling approach	Participant characteristics	Research Question(s) addressed
					cultured beef burger or cultured chicken nuggets) which was compared to a conventional counterpart.  Evaluation of the products included expected/anticipated liking, satisfaction, and healthiness, which likely combine to influence choice. Evaluation was based on a photo representing the target food and the text description provided [and participant's existing knowledge of similar products, including possible future products (i.e., cultured meat products)]. Products were evaluated one at a time rather than side by side.		Science Experimental Hours Scheme, and the Nutrition and Behaviour Unit's database		
<b>Wilks &amp; Phillips, 2017</b>	L	1, 4	Yes	US	Survey. Participants were asked about their familiarity about IVM and how they perceived IVM relative to conventional meat on a scale of 1-5. Two Qs (about awareness: 'Have you heard the term in vitro meat before?' and 'Do you know what in vitro meat is?') asked prior to showing description of CBM. All other Qs asked after showing description.	673	Recruited via Amazon Mechanical Turk	≥18 yrs, mean age of 32.6 yrs, 50.5% were female, 58% tertiary educated, 88% Omnivorous (5yrs younger than national average, lower income but higher % completed tertiary education	1,4-5,8-9
<b>Wilks et al., 2019</b>	M	1	Yes	US	Survey. All Qs asked after providing description of CBM.	1193	Online data collection company Survey Sampling International	Age: media: 47yrs, 43%F, 46% tertiary educated. Majority Omnivorous	8
<b>Wilks et al., 2021</b>	M	1	Yes	US	Survey. Participants were asked about their attitudes to CBM on a scale of 1-5. All Qs (except familiarity) asked after providing description of CBM.	862	Online data recruitment platform, Positly.	≥18 yrs (18-52), 50.5%F, mean age: 20.4 yrs, 37.8% tertiary educated,	1,4-5

\*RoB: risk of bias: 0=few or no bias; 1=bias in CBM definition; 2=potential bias in selection of participants; 3=potential bias in measurement of outcomes; 4=potential bias in selection of reported outcomes. Rep: representative of the target population groups

**Table 2B. Descriptions of cell-based meat (CBM) provided to participants and appraisal as 'neutral' or 'potential bias'.**

Reference	Country	Design	Participant characteristics	Neutral	Potential bias
Anderson & Bryant, 2018	US	Survey	"Clean meat (also called cultured meat or in-vitro meat) is real meat which is grown from animal cells without the need to raise animals. It should not be confused with meat substitutes such as soy, since it is real animal meat: it has the same taste, texture, and the same or better nutritional content as conventionally-produced meat."  <i>Participants were asked about awareness [Have you heard of the term 'clean meat before? (It has sometimes been referred to as 'cultured meat' or 'in-vitro meat' as well)], then shown above description of CBM, then asked about familiarity [Prior to this study, to what extent were you familiar with clean meat (including under another name, such as cultured meat or in-vitro meat)?], and then shown one of four framed messages, below:</i>  <u>Clean meat is natural</u>		• Mentions potential nutritional benefits  + Framed message refers to naturalness or benefits to human health, animals, and environment



			<p>Clean meat is real meat, grown from animal cells without the need to raise and slaughter farm animals. It has significant benefits for the environment, animals, and human health. Products include chicken (as shown), beef, and more! Clean meat products are made using a natural process very similar to the way yogurt and beer are fermented. This is a method which has been used in food manufacturing for thousands of years. The development of clean meat resembles how muscles naturally grow within an animal very closely. In fact, this process of cell growth is present in all natural life. Clean meat has many benefits for human health, animals, and the environment. But best of all, it's all-natural!</p> <p><u>Conventional meat is unnatural</u></p> <p>Clean meat is real meat, grown from animal cells without the need to raise and slaughter farm animals. It has significant benefits for the environment, animals, and human health. Products include chicken (as shown), beef, and more! Production of conventional meat today is far from natural. Animals are fed antibiotics and hormones so that they grow much faster and larger than they would in nature. Unsanitary farming conditions increase the risk of contamination from feces, as well as viruses and bacteria. The meat also contains additives, artificial coloring, and preservatives, and is often treated with radiation. Clean meat avoids all of those issues. It has many benefits for human health, animals, and the environment. But best of all, it's just meat!</p> <p><u>Challenging the appeal to nature</u></p> <p>Clean meat is real meat, grown from animal cells without the need to raise and slaughter farm animals. It has significant benefits for the environment, animals, and human health. Products include chicken (as shown), beef, and more! You might think that clean meat is unnatural, but naturalness does not necessarily mean goodness. Indeed, most modern food (including rice, tomatoes, milk, and – yes – meat) has been manipulated by people to make it suit our needs, and it is tastier and more nutritious as a result. On the other hand, some plants (like many types of poisonous mushroom) are completely natural but can easily kill you. Clean meat has many benefits for human health, animals, and the environment. It's a perfect example of humans improving on nature!</p> <p><u>Control</u></p> <p>Clean meat is real meat, grown from animal cells without the need to raise and slaughter farm animals. It has significant benefits for the environment, animals, and human health. Products include chicken (as shown), beef, and more! There are many reasons to eat clean meat: It requires much less water to produce and will cause far less climate change than conventionally-produced meat; it doesn't require animals to suffer or die; it can feed far more people from the same amount of land; and it has the same or better nutritional content as conventionally-produced meat. In sum, clean meat has many benefits for human health, animals, and the environment. But best of all, it's delicious real meat!</p> <p><i>All other Qs asked after providing framed messages.</i></p>	
Arango et al., 2023	US	Survey	NR	
Asioli et al., 2022	US	DCE	Same definition of IVM across all the treatments: "in cultured/lab-grown/artificial the product is produced by taking a number of cells from a live chicken. These cells are then transported to a food industry lab where the cells will proliferate in a nutrient-rich medium until a fresh boneless skinless chicken breast product is formed and then it will be packaged. No chicken is slaughtered".	•
Baum et al., 2022	UK	Survey	In-vitro meat (also called cultured, synthetic or lab-grown meat) is meat produced in laboratory conditions using a very small amount of cells carrying the animal's DNA and by putting them into a pre-tailored growth medium to grow muscle tissue. This alternate method of meat production should not be confused with meat substitute products (like tofu or Quorn) because it is real meat, only not obtained directly from living animals.	•
Boykin et al., 2019	US	Survey	<p><i>All CBM Qs (except awareness) asked after providing description of CBM.</i></p> <p>Lab grown meat (also known as in vitro meat, clean meat or cultured meat) is the process of harvesting stem cells from a living animal, then growing those cells in a bioreactor into 'meat' for human consumption.</p> <p>Each participant also shown one of three themed blog post messages.</p> <ul style="list-style-type: none"> <li>• Neutral</li> <li>• Supportive of CBM - Mentioned benefits to human health, animals, environment</li> <li>• Against CBM - Mentioned risks/disadvantages for animals and environment.</li> </ul> <p><i>All CBM Qs asked after providing description of CBM.</i></p>	• •



Bryant et al., 2019b	US	Survey	<p>Clean meat is real meat, grown from animal cells without the need to raise and slaughter farm animals. It has significant benefits for the environment, animals, and human health. Products include chicken (as shown), beef, and more!</p> <p><i>Each participant shown above description and then shown one of four framed messages, below:</i></p> <p><u>Clean meat is natural</u> Clean meat products are made using a natural process very similar to the way yogurt and beer are fermented. This is a method which has been used in food manufacturing for thousands of years. The development of clean meat resembles how muscles naturally grow within an animal very closely. In fact, this process of cell growth is present in all natural life. Clean meat has many benefits for human health, animals, and the environment. But best of all, it's all-natural!</p> <p><u>Conventional meat is unnatural</u> Production of conventional meat today is far from natural. Animals are fed antibiotics and hormones so that they grow much faster and larger than they would in nature. Unsanitary farming conditions increase the risk of contamination from feces, as well as viruses and bacteria. The meat also contains additives, artificial coloring, and preservatives, and is often treated with radiation. Clean meat avoids all of those issues. It has many benefits for human health, animals, and the environment. But best of all, it's just meat!</p> <p><u>Challenging the appeal to nature</u> You might think that clean meat is unnatural, but naturalness does not necessarily mean goodness. Indeed, most modern food (including rice, tomatoes, milk, and – yes – meat) has been manipulated by people to make it suit our needs, and it is tastier and more nutritious as a result. On the other hand, some plants (like many types of poisonous mushroom) are completely natural but can easily kill you. Clean meat has many benefits for human health, animals, and the environment. It's a perfect example of humans improving on nature!</p> <p><u>Control</u> There are many reasons to eat clean meat: It requires much less water to produce and will cause far less climate change than conventionally-produced meat; it doesn't require animals to suffer or die; it can feed far more people from the same amount of land; and it has the same or better nutritional content as conventionally-produced meat. In sum, clean meat has many benefits for human health, animals, and the environment. But best of all, it's delicious real meat!</p> <p><i>All Qs asked after providing description of CBM.</i></p>	<ul style="list-style-type: none"> <li>• Mentioned benefits to human health, animals, environment + Framed messages refers to naturalness and benefits to human health, animals, and environment</li> </ul>
Boereboom et al., 2022	UK	Survey	NR	
Bogueva & Marinova, 2020	Australia	Survey	NR	
Bryant & Barnett, 2019	US	Survey	<p>Participants were given the following description of IVM, where [X] was replaced by their allocated term: '[X] is meat which is grown from cells taken from an animal who is not killed, rather than being taken from a slaughtered animal.' Apart from the name, the description given to each participant was identical.</p> <p><i>All Qs asked after providing description of CBM.</i></p>	<ul style="list-style-type: none"> <li>• Refers to animals not being 'killed' (use of emotive language)</li> </ul>
Bryant & Dillard, 2019	US	Survey	<p>"Clean meat (also called cultured meat or in-vitro meat) is real meat which is grown from animal cells without the need to raise animals. It should not be confused with meat substitutes such as soy, since it is real animal meat it has the same taste, texture, and the same or better nutritional content as conventionally-produced meat."</p> <p>Participants were allocated to 1 of 3 experimental conditions (framings), which contained an image and a short piece of text. There was no control condition/framing. Then, they were provided with survey questions.</p> <p>SOCIETAL BENEFITS group: "Clean meat has many benefits for society like reducing harm to the environment and helping animals". HIGH TECH group: "Clean meat is made using highly advanced technology in a state of the art laboratory". SAME MEAT group: "Clean meat tastes like conventional meat, is increasingly affordable, and can be healthier to eat".</p>	<ul style="list-style-type: none"> <li>• Framing used</li> </ul>

			<i>All Qs (except awareness) asked after providing description of CBM.</i>	
Bryant et al., 2019a	US	Survey	What is clean meat? One food innovation is called clean meat. This type of meat is identical at the cellular level to conventional meat. This is real meat grown directly from animal cells. Clean meat is produced in a clean facility, similar to a brewery. The process does not involve raising and slaughtering farm animals. The final product has an identical taste and texture to conventional meat. Clean meat offers significant benefits for human health, the environment, and animal welfare. Several companies have already successfully produced and taste-tested clean meat. The products will be available for retail purchase in 1-5 years.	• Mentioned benefits to human health, animals, environment
De Muth et al., 2023	US	DCE	<i>All Qs (except awareness) asked after providing description of CBM.</i> NR	
de Oliveira Padilha et al., 2021	Australia	Survey	“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. 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.	• Refers to animal suffering
de Oliveira Padilha et al., 2022	Australia	Survey	<i>All Qs (except awareness) asked after providing description of CBM.</i> “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. 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.	• Refers to animal suffering
Dillard & Szejda, 2019	US	Focus group s	<i>All Qs (except awareness) asked after providing description of CBM.</i> Part 1: [NARRATIVE DESCRIPTION] Saving Nature Through Discovery Our Purpose: <ul style="list-style-type: none"> <li>• Mother Nature is feeling the weight of humanity. She is being asked to feed more and more people with fewer and fewer resources. This pressure is unsustainable, and if we don’t do something to help, the way we live and eat will be changed forever.</li> <li>• Our goal is to develop, through science and technology, safe ways to help Mother Nature do her thing with less social, environmental, and economic burden.</li> </ul> Our Solution: Embracing the Science of Nature <ul style="list-style-type: none"> <li>• There will always be a desire for conventional animal farming. As a complement to it, there’s now a new way to take a few cells from those living farm animals and grow them into familiar meat, poultry, and fish products in something called a cultivator. The cultivator creates an environment that allows for cell growth... like the fertile soil, water, and nutrients used to help plant cuttings take root.</li> <li>• The inputs for these meats are simply the basic building blocks of meat and life itself: amino acids and simple sugars.</li> <li>• This meat grows the way animal cells multiply naturally. We harness the wonders of nature but do it in a different environment.</li> <li>• The result is an abundance of pure, wholesome meat that was made with a fraction of the natural resources, without the need for antibiotics, and without having to raise and slaughter animals.</li> </ul> Part 3: NAMING PREFERENCES  This new type of meat will be a new product on the market, unfamiliar to most consumers. Therefore, when selecting a name, we’re looking for a name that: <ol style="list-style-type: none"> <li>1. Helps consumers understand what they are buying (real meat but produced in a new way)</li> <li>2. Differentiates from other types of meat (not conventional meat or plant-based meat)</li> </ol>	• Mentions health, animal welfare, social, environmental, and economic benefits)

			3. Has overall appeal (sounds appetizing)	
			<p><i>Part 1: After listening to the narrative and reading along, participants considered their responses to the narrative and wrote down any immediate questions.</i></p> <p><i>Part 2: After viewing the corresponding visual analogy, participants considered their reactions to it, wrote comments, and noted aspects they liked and disliked. During group discussion, participants provided specific recommendations about words, phrases, and images that they felt worked well or should be changed.</i></p> <p><i>Part 3: After the facilitator explained the challenges involved in finding an appropriate name and specifying the criteria to use when evaluating appropriate, participants evaluated five potential names for this new type of meat— cultivated, cultured, cell-based, cell-cultured, and propagated—first by ranking them 1–5 (1= most appealing) and then by discussing their rankings.</i></p>	
Giezenaar, 2023	NZ	Survey	<p>“Cultivated meat is a future alternative to the meat we consume today (animal products). It is still under development; you can’t currently buy it in supermarkets or restaurants. To make cultivated meat, tissue is removed from an animal (e.g., a salmon, cow or duck) and grown into cuts of meat/fish in a laboratory by feeding the tissue with essential nutrients. Cultivated meat could produce 80,000 burgers from tissue the size of a sesame seed, where conventional farming requires 100 cows.”</p> <p>Animal meat and cultivated meat look, cook, and taste identical because they are both made of animal muscle. This makes them different from plant-based alternatives like tofu or the Beyond burger, which are made from plants. The nutritional benefits of cultivated meat are expected to be equal or better than animal meats.</p> <p>Cultivated meat is also known as (cell-)cultured meat, cell-based meat, clean meat, and lab-grown meat. In this study, we use the term ‘cultivated meat’ and assume that cultivated meat does not require any further animal material after the removal of cells from the animal.</p> <p><i>All Qs (except awareness) asked after providing description of CBM.</i></p>	<ul style="list-style-type: none"> <li>• Mentions nutritional benefits</li> </ul>
Giacalone & Jaeger, 2023	Multiple (US, Aust, SG, India)	Survey	<p>Laboratory-cultured meat/fish, produced from cultured animal cells, is a potential game-changer from an environmental point of view. There is still some way to go before this way of producing food can feed large numbers of people, but it may become the norm in future.</p> <p><i>All Qs asked after providing the above description of CBM.</i></p>	<ul style="list-style-type: none"> <li>• Environmental benefits</li> </ul>
Hallman & Hallman, 2020	US	Survey	<p>“The term Cell-based Seafood indicates that this salmon differs from both wild-caught and farmed salmon. It tastes, looks, and cooks the same and has the same nutritious qualities as Atlantic Salmon produced in traditional ways. Yet, it involves a new way of producing just the parts of Salmon that people eat, instead of catching or raising them whole. Cell-based Seafood means that a small number of cells from Atlantic Salmon were placed in a nutrient solution, where they grew and reproduced many times. The resulting meat was then formed into fillets that can be cooked or eaten raw.”</p> <p><i>Qs asked after providing description of CBM: familiarity, appropriateness of term for describing the new way of producing seafood; how clearly the term communicated the product “was not caught in the ocean, was not farm-raised; level of agreement with whether CB seafood should be “sold in the same section of the supermarket as wild-caught and farm raised fish.”; overall positive or negative reaction; interest in tasting the CB product; likelihood of buying the product in the next 6 months if it were sold in their grocery store; Qs for study 2 about ability to distinguish CB from conventional products.</i></p>	<ul style="list-style-type: none"> <li>•</li> </ul>
Hallman & Hallman, 2021	US	Survey	<p>The term Cell-Based Seafood indicates that this salmon differs from both wild-caught and farmed salmon. It tastes, looks, and cooks the same and has the same nutritious qualities as Atlantic Salmon produced in traditional ways. Yet, it involves a new way of producing just the parts of salmon that people eat, instead of catching or raising them whole. Cell-Based Seafood means that a small number of cells from Atlantic Salmon were placed in a nutrient solution, where they grew and reproduced many times. The resulting meat was then formed into fillets that can be cooked or eaten raw.”</p> <p><i>Qs asked after providing description of CBM: familiarity, appropriateness of term for describing the new way of producing seafood; how clearly the term communicated the product “was not caught in the ocean, was not farm-raised; level of agreement with whether CB seafood should be “sold in the same section of the supermarket as wild-caught and farm raised fish.”; overall positive or negative reaction; interest in tasting the CB product; likelihood of buying the product in the next 6 months if it were sold in their grocery store; Qs for study 2 about ability to distinguish CB from conventional products.</i></p>	<ul style="list-style-type: none"> <li>•</li> </ul>
Hamlin et al., 2022	NZ	Individual interview	Concept described in picture and text (read or spoken) format.	<ul style="list-style-type: none"> <li>•</li> </ul>

			<p>'Clean meat, also known as cultured meat, is real meat produced by cultivating animal cells in the laboratory through genetic engineering. Clean beef is created by harvesting muscle cells from a living cow with no harm to the animal involved. A single cell can produce 175 million quarter pounders. This product should not be confused with other meat substitutes like tofu because it is real meat, the same as the one produced by traditional meat farming systems. Tissue engineers take a sample from a live adult animal and ideally that's all they have to endure. Then they grow the adult stem cells in vats of nutrient-rich broth, convert them to muscle cells, because meat is muscle, and grow them on a mono-biodegradable scaffold. The only hitch is muscle cells need exercise to survive and they are stimulated with tiny electrical impulses. The development of clean meat resembles how muscles naturally grow within an animal very closely. Clean meat is not yet available on the market. Clean meat helps prevent food borne illnesses associated with traditional meat production and healthier fat can be added to muscle cells in replacement of unhealthy saturated fat in traditional products. Without the need to slaughter a cow to produce beef, clean meat stands to provide ethical and environmental benefits. Because clean meat is real meat, this beef steak tastes just like your regular beef steak, cooked just the way you know it.'</p> <p><i>All Qs asked after providing description of CBM.</i></p>	Mentioned personal, ethical and environmental benefits
Hubbard, 2022	US	Survey (Master thesis) via Qualtrics platform	Not reported.	
Juhasz et al., 2023	Canada	Survey	None	
Jenkins et al., 2020	UK	Survey	Lab-grown meat uses stem cell technology, in which tissue is taken from a live animal, and stem cells extracted, which are then grown into muscle fibres in a bioreactor.	•
Krings et al., 2022	Multiple (EU, UK, US)	Survey	Clean meat: "The food in these pictures is made from clean meat, which is structurally identical to traditional meat but cultured in the laboratory" Regular meat: " <i>The food in these pictures is made from regular meat</i> '.	•
Laestadius & Caldwell, 2015	US	Other	US news articles discussing the 2013 CBM hamburger event. Different descriptions provided in articles (articles not provided by authors)	
Leong et al., 2022	US	Survey	None	
Leung et al., 2023	Singapore	Survey	<p>Cultivated meat is real meat which is grown in a sterile, controlled environment from a single animal cell, removing the need to raise animals. Cultivated meat should not be confused with plant-based meats such as Impossible and Beyond. Since it is real animal meat, it has similar taste, texture, and the same or better nutritional content as conventionally produced meat.</p> <p><i>All Qs asked after providing description of CBM plus one randomly allocated benefit message (one of five).</i></p> <p>The five message frames:</p> <ul style="list-style-type: none"> <li>• Message A: Cultivated meat enables consumers to avoid undesirable elements that are found in some food products (e.g., foodborne diseases, growth hormones or GMOs)</li> <li>• Message B: Cultivated meat enables the nutritional value of meat to be enhanced</li> <li>• Message C: Cultivated meat contributes to animal welfare and reduces animal slaughter</li> <li>• Message D: Cultivated meat helps reduce carbon emissions and global warming</li> <li>• Message E: Cultivated meat helps ensure that the country's meat supply is stable and sufficient</li> </ul> <p>Results showed that messages presenting different benefits of cultivated meat (e.g., benefits to health, animal, the environment) did not have any significant effects on the variables measured in this research.</p>	• Framed messages highlight different benefits
Liu, 2022	US	Survey	<i>Q about familiarity and willingness to buy in the future asked prior to showing below description. Description shown to those who had previously heard of cultivated (cell-based) seafood; after which they were asked about their perceptions of and motivations for purchasing alternative seafood (including both plant-based and CB).</i>	•

			<p>We would now like to talk a little bit more about a protein you are at least a little bit familiar with, alternative seafood. Alternative seafood includes plant-based seafood and cultivated seafood –forms of seafood that do not come from fish but are instead created from plants or cultivated directly from cells.</p> <p><i>All participants were then shown the below description of CB seafood. This was followed by Qs assessing willingness to consume, perceived benefits, and consumption motivators/barriers.</i></p> <p>We would now like to introduce you to a protein you may be familiar with, cultivated seafood. Rather than catching fish or shellfish, seafood can be cultivated directly. This starts with the basic building block of all life—the cell. From a small sample of fish or shellfish cells, the same seafood we enjoy eating today can be grown. In conventional animal farming, cell growth occurs in an animal. But the same cells can be grown in what is known as a cultivator. The cultivator facilitates the same biological process that happens inside an animal, similar to growing plants from cuttings in a greenhouse, which provides warmth, fertile soil, water, and nutrients.</p>		
Lucius, 2020	US	Mixed methods	Informational video – content not specified.	Unclear	Treated as potential bias
Malavalli et al., 2021	NZ	Survey	<p><i>Definition provided in the pre-survey information. Thus, all Qs asked after providing description of CBM.</i></p> <p>In order to address the growing environmental and ethical concerns amidst the negativity associated with production and consumption of meat, the production and perception of in vitro meat (IVM) has been increasingly researched. IVM production involves the culturing of stem cells from farm animals in bioreactors by employing advanced tissue engineering techniques. IVM advantages include being environmentally friendly, requiring lower energy consumption, lowering greenhouse gas emission, lowering land and water consumption, and resulting in low carbon footprint. In addition, IVM is high in protein, low in unhealthy fats, highly sustainable, environmentally friendly, ethical and animal friendly. Hence, IVM is quickly becoming the best sustainable alternative to conventional meat.”</p>		<ul style="list-style-type: none"> <li>• Mentions benefits to human health, animals, environment</li> </ul>
Malerich & Bryant, 2022	US	Survey	Not reported.		
Rosenfeld, 2022	US & UK	Survey	<p><i>All Qs asked after providing description of CBM.</i></p> <p>Study 1 &amp; 2: Cultured meat is meat grown from animal muscle cells in isolation without the need to raise animals. The world's first cultured meat hamburger was created in 2013. Currently, cultured meat is not publicly available, though it will likely become available in the near future.</p> <p>Study 3: Cultured meat frame: “Cultured meat is meat grown from animal muscle cells in isolation without the need to raise animals. Cultured meat is 100% pure animal flesh, so eating a hamburger made from cultured beef feels like eating something that came directly from a cow. Every single bit of any cultured meat originates entirely from a real living animal.” Control frame: “Cultured meat is meat grown from animal muscle cells in isolation without the need to raise animals. The world's first cultured meat hamburger was created in 2013. Currently, cultured meat is not publicly available, though it will likely become available in the near future.”</p>	•	
Ruzgys et al., 2020	Canada	Survey	<p>Cultured meat (“lab-grown meat”) is produced using tissue-engineering technology where animals cells are grown in a controlled environment outside of and independently of the animal, which results in no animals being harmed or killed in the process. The end product is comparable to traditional meat with regard to texture and taste.</p> <ul style="list-style-type: none"> <li>• <i>Knowledge Qs assessed prior to being shown the above description of CBM.</i></li> <li>• <i>All other Qs (including open-ended question about opinion on consuming CBM) asked after reading the CBM description.</i></li> <li>• <i>Willingness to consume questions answered three times: 1) after reading the CBM description; 2) after reading all five framed messages regarding benefits of CBM (below); and 3) after reading five messages framing CBM as natural (below).</i></li> </ul> <p><u>Benefits framing</u></p>		<ul style="list-style-type: none"> <li>• Refers to animals not being ‘harmed’ or ‘killed’ (use of emotive language)</li> </ul>

			<p>Cultured meat is produced using tissue-engineering technology and does not involve the traditional methods of rearing and slaughtering animals;  Cultured meat could greatly reduce the number of food-borne illnesses such as salmonella; There is no animal suffering involved in the production of cultured meat;  Cultured meat is produced in a lab and therefore does not require nearly as much land as traditional animal agriculture; Cultured meat could be used to combat starvation and malnutrition in third world countries.</p> <p><u>Natural framing</u>  Cultured meat can be enhanced to contain healthy vitamins and reduce the amount of unhealthy fats;  Cultured meat contains no artificial colors/flavors, preservatives, or additives; No chemicals, hormones, or pesticides are used in the production of cultured meat;  Cultured meat is free of all GMOs (genetically modified organisms);  Cultured meat could reduce the carbon footprint of the animal agriculture industry and reduce its greenhouse gas emissions by up to 90%.</p>	
Shaw & Mac Con Iomaire, 2019	Ireland	Mixed methods (Focus groups & survey)	<p>Focus group: Text explanation and YouTube video  Online survey: Text explanation and image  Explanation: Cultured meat is a way of producing meat outside of the animal. Stem cells are extracted from the animal of choice, without harming the animal, and these cells are then grown into muscle tissue in a culture media in a lab. The muscle tissue is biologically the same as the muscle tissue that would be made inside the animal. The muscle tissues can then be used to create meat products.</p> <p><i>All Qs asked after providing description of CBM.</i></p> <p>Focus group:</p> <ul style="list-style-type: none"> <li>• Five questions asked about CBM to determine what participants viewed as the possible advantages and disadvantages of the technology and if they would be willing to try it.</li> <li>• They were asked what other products or technology that it reminded them of; and were asked what would instill trust in the product for them, to assess whether labelling and quality assurance stamps would have an influence on their choices.</li> </ul> <p>Online survey (few descriptive results reported in article apart from reporting P-value for difference between urban and rural respondents):</p> <ul style="list-style-type: none"> <li>• Comparison with conventional meat (Qs provided in article)</li> <li>• General opinion about cultured meat: (Qs provided in article)</li> <li>• Two rating questions asking about concerns with and potential benefits of CBM.</li> </ul>	•
Szejda, 2018	US	Survey	<p>Phase 1 &amp; 2: Not reported.  Phase 3 &amp; 4: <i>Definition provided after introduction of the CBM name/label.</i>  What is [NAME]? One recent breakthrough in food innovation allows us to produce meat in a new way. [NAME] is identical at the cellular level to conventional meat. This meat is real meat grown directly from animal cells. [NAME] is produced in a clean facility, similar to a brewery. The process does not involve raising and slaughtering farm animals. The final product has an identical taste and texture to conventional meat. [NAME] offers significant benefits for human health, the environment, and animal welfare. Several companies have already successfully produced and taste-tested [NAME]. The products will be available for retail purchase in 1-5 years.</p>	• Mentions benefits to human health, animals, environment
Szejda et al., 2021	US & UK	Survey	<p>Part 1: TECHNOLOGY (brief description) – "One recent breakthrough in food innovation is meat production without raising and slaughtering animals. This new method of meat production mirrors the biological process of building muscle but does so outside of the animal and under controlled conditions. A small sample of starter cells grows into genuine meat—the same as it would inside the animal—when it is given essential nutrients like proteins, vitamins, and minerals. The final product looks, cooks, and tastes the same".</p> <p>Part 2: TECHNOLOGY (expanded description) – "We can now diversify and strengthen the protein supply by producing meat in a new, more efficient way. Rather than raising and slaughtering animals, we can cultivate meat directly. This starts with the basic building block of all life—the cell.</p>	• Mentions benefits to human health, animals, environment

			<p>A few years ago, the first hamburger was prepared from meat cultivated directly from cow cells. By isolating the cells needed to produce meat and enabling them to grow under controlled conditions, researchers demonstrated that it is possible to produce genuine beef outside of a cow.</p> <p>In fact, we can grow not only beef but also pork, poultry, and seafood without needing to farm pigs, chickens, and fish. Instead, we can use what is known as a cultivator. The cultivator facilitates the same biological process that happens inside an animal by providing warmth and the basic elements needed to build muscle: water, proteins, carbohydrates, fat, vitamins, and minerals. Cultivating meat is similar to growing plants from cuttings in a greenhouse, which provides warmth, fertile soil, water, and nutrients.</p> <p>This new method of meat production enables the natural process of cell growth but in a more efficient environment. The result is an abundance of cultivated meat, identical to conventional meat at the cellular level but free from pathogens and trace contaminants such as antibiotics. Cultivated meat looks, cooks, and tastes the same. Cultivated meat companies are aiming to produce real meat that offsets the need to raise animals in intensive [In the United States, 99% of conventional meat is produced in industrial confinement systems and 1% is produced on smallholder farms.] confinement systems Compared with conventional meat production, meat cultivation is less resource-intensive, decreasing methane emissions, deforestation, biodiversity loss, water use, water pollution, antibiotic resistance, and foodborne illnesses.</p> <p>Food companies and universities around the world are working on scaling this method of meat production and bringing cultivated meat to market in the next 2-3 years. [The FDA and the USDA will jointly regulate cultivated meat in the United States.]. This will expand the protein options available to consumers, providing the meat so many people desire, simply produced in a new and more sustainable way.</p> <p>Note: In the UK survey, the above bracketed sentences were replaced respectively with the following sentences: 1) In the United Kingdom, 73% of conventional meat is produced in industrial confinement systems and 27% is produced on smallholder farms. 2) The FSA will regulate cultivated meat in the United Kingdom".</p> <p><i>After 'Brief Technology Description': participants were asked to report their level of support for the technology and their prior familiarity; rated several names in terms of their appeal and descriptiveness; and ranked their name preferences in different contexts (social and package label).</i></p> <p><i>After 'Expanded Technology Description': asked Qs that assessed their level of support, the degree to which they would potentially adopt cultivated meat as a dietary option, reasons for potential adoption, labeling preferences, and preferences regarding use of genetic engineering in the production process.</i></p>	
Tucker, 2014	NZ	Focus groups	<p>Presented series of coloured handouts featuring 7 different sets of images (on intensive agricultural production, 'alternative' [low input] farming production, genetic modification in agriculture, in vitro meat, nose-to-tail eating, extending the living protein range [to include insect eating or entomophagy for example] and reducing meat consumption) followed by handout featuring seven quotes from the pilot run of the research project.</p> <p>Each series of images was introduced by the researcher by providing a brief description of the practice, including the understood positive and negative aspects and implications of each.</p> <p>Specific wording and images not provided in article.</p> <p><i>All Qs asked after providing description (handouts and images) of CBM</i></p>	<ul style="list-style-type: none"> <li>• Mentions positive and negative aspects of CBM but description not provided by authors</li> </ul>
Verbeke, 2015	UK	Mixed methods (Focus groups & survey)	<p>YouTube video: 'Would you eat synthetic meat?', produced by the Royal Institution of Australia as part of the series 'Three technologies which may change the way we live'. <a href="http://www.youtube.com/watch?v=iO9q_paCcWA">http://www.youtube.com/watch?v=iO9q_paCcWA</a>.</p> <p>Meat is an excellent source of protein and quite tasty. But at what cost? The resources required to feed nine billion people meat are vast, even if it's just the wealthy ones. Many people are rejecting the cruelty of factory farming and practices like live animal export. And though they haven't been surveyed, it's likely the billions of primary providers, cows, sheep, pigs, fish and the rest are dead against it. ['You monster' is flashed across the screen].</p> <p>Could synthetic meat be the solution? It is meat, not tofu-based meat substitutes. And despite the name, not really synthetic. It's actual animal cells. Tissue engineers take a sample from a live adult animal and ideally that's all they have to endure. Then they grow the adult stem cells in vats of nutrient-rich broth, convert them to muscle cells, because meat is muscle, and grow them on</p>	<ul style="list-style-type: none"> <li>• Refers to animal cruelty (uses emotive language when referring to animal impact)</li> </ul>



			<p>a mono-biodegradable scaffold. The only hitch is muscle cells need exercise to survive and you can't run these ones around the paddock. You can stimulate them with tiny electrical impulses, but on an industrial scale it's prohibitively expensive. Research continues. Thus far, the biggest cut contains millions of cells and is roughly the size of a contact lens. But when synthetic meat becomes a mainstream reality, will you eat lab-grown steak? And will knowing that no animals were harmed in the making of your burger change the way you relate to animals? [video ends with three questions displayed on the screen: What excites you? What frightens you? How might it change the way we live?].</p> <p>In both focus groups and online survey, participants were shown seven stimuli/content testers regarding various possible risks and benefits of red meat. One of these content testers was a two-minute YouTube video on CBM (above).</p> <ul style="list-style-type: none"> <li>• Focus group: participants encouraged to raise comments and queries in relation to the video but were advised that questions would not be answered during the discussion.</li> <li>• Online survey: participants prompted to leave comments and questions on the content tester page related to the video.</li> </ul>	
Van Loo et al., 2020	US	DCE	NR	
Vural et al., 2023	UK	Survey	<p>Cultured beef burger: This cultured beef burger is made from meat grown in a UK factory from a small sample of cow cells. Cultured meat is produced without animal slaughter.</p> <p>Cultured chicken nuggets: These cultured chicken nuggets are produced from chicken meat grown in a UK factory from a small sample of chicken cells. Cultured meat is made without animal slaughter.</p>	•
Wilks & Phillips, 2017	US	Survey	<p>In vitro meat is an animal flesh product that has never been part of a living animal, but is instead grown in a laboratory using muscle stem cells. These stem cells are extracted without suffering to the animal. In vitro meat is also referred to as cultured meat, schmeat or synthetic meat. In August 2013, scientists unveiled (and tasted) the world's first in vitro grown hamburger patty. Currently it is not commercially available, though research is being conducted to introduce it as a potential new meat production technique for the future. The unveiling of the world's first in vitro hamburger in London, August 2013</p> <p>Two Qs (about awareness: 'Have you heard the term in vitro meat before?' and 'Do you know what in vitro meat is?') asked prior to showing description of CBM. All other Qs asked after showing description.</p>	• Refers to animal suffering
Wilks et al., 2019	US	Survey	<p>Cultured meat is an animal flesh product that has never been part of a living animal, but is instead grown in a laboratory using muscle stem cells. These stem cells are extracted without suffering to the animal. Cultured meat is also referred to as clean meat, or in vitro meat. In August 2013, scientists unveiled (and tasted) the world's first cultured hamburger patty. Currently it is not commercially available, though research is being conducted to introduce it as a potential new meat production technique in the future.</p> <p><i>All Qs (except familiarity) asked after providing description of CBM.</i></p>	• Refers to animal suffering
Wilks et al., 2021	US	Survey	<p>Cultured meat is meat made from cells instead of from a farmed animal. A small number of cells are extracted harmlessly from a living animal and grown using a growth medium. Cultured meat is also referred to as clean meat, cell-based meat, or lab-grown meat. It is different to plant-based meat, such as the impossible burger, which is made from plants. In August 2013 researchers unveiled the world's first cultured hamburger patty. Since then over 20 companies worldwide are developing cultured meat, though it is not yet commercially available because of high production costs.</p> <p><i>All Qs (except familiarity) asked after providing description of CBM.</i></p>	• Refers to cells being 'extracted harmlessly' (uses emotive language when referring to animal impact)