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Supporting document 2

Consumer literature review - Application A1269

Cultured quail as a novel food

Executive summary

Food Standards Australia New Zealand (FSANZ) undertook a rapid systematic evidence review to inform consideration of Application A1269 – Cultured quail as a novel food. The review examined available evidence on consumers' understanding, preference and acceptance of different terminologies for cell-cultured meats, as well as consumers' perceptions of cell-cultured meat relative to conventional meat. This report outlines the methodological approach to the literature review and summarises the available evidence.

Searches of electronic databases and hand-searching were used to identify 26 studies for this literature review. The literature review includes peer-reviewed articles published in academic journals as well as grey literature, such as non-government organisation reports and unpublished theses. The majority of the available studies were conducted outside of Australia and New Zealand, but mostly included countries where cell-cultured meat is not currently available (e.g. the USA; similar to Australia and New Zealand). Findings across studies were narratively synthesised.

The key findings are summarised below, grouped by research question:

Do consumers want a specific term to differentiate between cell-cultured meat and conventional meat? What terminologies are best for consumer understanding?

- Terms that incorporate the word 'cell' (e.g. 'cell-cultured', 'cell-cultivated' and 'cell-based') best enable consumers' to correctly identify the true nature of the product and are perceived as being the most descriptive by consumers, but may decrease consumer appeal compared to 'cultured' or 'cultivated'.

- The terms ‘cultured’ and ‘cultivated’ produce low levels of consumer understanding. This is the case for both seafood and chicken/beef, but is more pronounced for seafood. The term ‘artificial’ meat/seafood also produces low levels of consumer understanding.

- Although the term ‘lab-grown’ enabled consumers to correctly identify the product, it has lower levels of perceived safety than other terms.

- Consumer understanding of allergenicity of cell-cultured meat/seafood is not high, even for the best performing terms (‘cell-cultured’, ‘cell-cultivated’). Up to 66% of consumers correctly identified that the product was not safe to consume for those with an allergy to the traditional counterpart. The term ‘cell-based’ produced low levels of perceived allergenicity for beef products in particular, with only 38% of consumers identifying an allergenicity concern. Regardless, the overall findings suggest that terminology alone cannot sufficiently convey allergen information to consumers.

Do consumers perceive cell-cultured meat as the same or different to conventional meat? Are they perceived as being as healthy as, and/or nutritionally equivalent (e.g. levels of protein/fat)?

- When provided with a neutral description of cell-cultured meat, consumers consistently perceived it as less healthy and/or nutritious than conventional meat, regardless of the terminology employed. One study suggests this may be because consumers do not see cell-cultured meat as compositionally the same as conventional meat.

- However, consumer perceptions of the healthfulness/nutritional value of cell-cultured meats appear to be highly malleable depending on the information received (neutral vs. biased descriptions) and product categories compared (chicken/beef vs. chicken nuggets/beef burgers).

- Qualitative findings also suggest that levels of trust in scientists/experts and/or cell-cultured meat companies may impact perceptions of healthfulness of cell-cultured meat, in both positive and negative directions.

Table of contents

1. Introduction

In February 2023, Food Standards Australia New Zealand (FSANZ) accepted an application from Vow Group Pty Ltd seeking to permit cultured quail as a novel food (Application A1269). The assessment process will involve two calls for submission (CFS).

FSANZ commissioned the University of Adelaide to conduct a systematic literature review examining consumers' levels of awareness, understanding, perceived risks and benefits, and prospective behaviour regarding alternative proteins, including cell-cultured meats[1]. While the full literature review was being prepared, FSANZ conducted a rapid systematic review on two research questions of key importance to inform the first CFS, with the intent that the full systematic literature review will inform the second CFS.

The rapid systematic literature review investigated two research questions:

1. Do consumers want a specific term to differentiate between cell-cultured meat and conventional meat? What terminologies are best for consumer understanding of cell-cultured meat?
2. Do consumers perceive cell-cultured meat as the same or different to conventional meat? Are they perceived as being as healthy as and/or nutritionally equivalent (e.g., levels of protein/fat)?

2. Methods

2.1 Literature search strategy

FSANZ undertook a rapid systematic search for literature on consumers' understanding, preference and acceptance of different terminologies for cell-cultured meats, and consumers' perceptions of cell-cultured meat relative to conventional meat. It includes peer-reviewed articles published in academic journals, as well as grey literature, such as unpublished theses and non-government organisation reports.

Literature was identified by:

- Searching six online databases for peer-reviewed studies
- Requesting any published and unpublished research relevant to the review from the International Social Science Liaison Group (ISSLG)[2]
- Requesting any published and unpublished research from other known relevant researchers, and searching their publication records
- Searching references FSANZ already had on file
- Examining the reference lists of included studies
- Examining studies that cited included studies
- Examining the reference list of the FAO report

[1] There are many terminologies used to describe cell-cultured meat, such as 'cultured meat', 'cultivated meat', 'cell-based meat', 'artificial meat', 'lab-grown meat', 'clean meat' and 'slaughter-free meat'. Throughout this document, the term 'cell-cultured meat' is used, and is intended to include both meat and seafood.

[2] The ISSLG consists of members from international food regulatory agencies involved in social sciences in food regulation.

No restrictions were placed in respect to year of publication, study location, study type, or participant characteristics.

Studies that examined the effect of different terminologies on consumer acceptance without also examining consumer understanding were excluded in order to keep the literature review manageable, and to ensure that the review provided a clearer picture of which terminology achieved a balance between consumer acceptance and understanding.

A total of 26 studies were included in the literature review. More detail on the literature search strategy and research review process are available in Appendix 1.

2.2 Study quality assessment

The quality of each individual study was not assessed using a standardised quality assessment tool, given the high number of included studies and the need to produce a timely evidence synthesis. Rather, the general strengths and limitations were considered in the narrative when describing each individual study. This is appropriate given that a more comprehensive literature review on consumer responses to alternative proteins (that will undertake formal quality assessments) will be completed at a later date.

2.3 Evidence synthesis

The evidence from each study was collated thematically under the research questions in order to present a narrative overview of the available evidence.

When making conclusions for each research question, consideration was given to the general principles of the GRADE framework (Guyatt et al., 2011). That is, consideration was given to the strengths and limitations of the individual studies, the consistency of the findings across studies, and the direct relevance of the evidence (e.g., relevance of the study's target sample). For example, confidence in the findings will be low if there are inconsistencies in the findings across studies, unless the inconsistencies can be explained (e.g., participant exposure to different types of information about cell-cultured meats).

Write-up and synthesis was conducted by two officers.

The draft literature review was reviewed by FSANZ staff members. Peer review comments were considered and incorporated into the final version of the report.

3. Findings

3.1 Overview of study characteristics

26 studies were eligible for inclusion. 16 studies were peer-reviewed articles published in academic journals, and 10 were grey literature (i.e., unpublished theses, research reports produced by non-government organisations). Most studies used quantitative research designs (surveys or experiments).

Most studies were based in the USA (n = 11). Only three studies were based in Australia (n = 2) or New Zealand (n = 1). Other countries represented in studies were China (n = 4), the UK (n = 2), Brazil (n = 2), Germany (n = 2), Colombia (n = 1), Finland (n = 1), India (n = 1), Ireland (n = 1), Italy (n = 1) and Switzerland (n = 1). Some studies covered more than one country.

Some studies examined consumer perceptions of cell-cultured meat by asking participants about the terminology alone, with no further information provided to participants about the product (n = 5). Whereas other studies provided an accompanying description of the product, which was either biased (i.e., only emphasised the benefits [n = 11] or downsides [n = 1] of cell-cultured meat), neutral (n = 8) or not reported (n = 1). However, it is important to note that across all studies that provided accompanying descriptions to participants, the product was described as “not involving the harming of animals” and/or “not involving the killing of animals”.

3.2 Consumer understanding, preferences and acceptance of different terminologies

11 studies examined the effect of different cell-cultured meat terminologies on consumer understanding. Five of these studies were experimental designs, 5 were quantitative surveys and one was qualitative (focus groups).

Consumer understanding of cell-cultured meat was measured in several different ways. Two studies measured objective (actual) understanding, where participants were provided with a terminology and asked to accurately identify the product (e.g., not wild-caught salmon or a farm-raised animal), and asked whether the product would be safe for people with allergies to the conventional counterpart. These two studies that measured objective understanding did not provide participants with a description of what cell-cultured meat is. That is, consumer understanding was measured based on the terminology alone.

The remaining 9 studies examined *perceived* understanding, which may or may not align with actual understanding. These measures of perceived understanding included the extent to which participants thought the name accurately described the product, and whether they thought the name would help them to differentiate the product from conventional meat or plant-based meat alternatives. These 9 studies tended to provide participants with biased descriptions of cell-cultured meat (referred to positive benefits such as benefits to human health and the environment, and/or that the product will be similar in taste/texture/nutrition to conventional meat), prior to measuring their perceptions.

10 of the 11 studies also examined consumer preferences and/or acceptance of the different cell-cultured meat terminologies. This was measured in several different ways, including: perceived appeal; interest in tasting the product; how likely participants are to purchase the product; and asking participants to rate how positive their first thought, image or feeling is that comes to mind when viewing the product.

Studies compared a variety of different terms, and the terms that were compared were not always consistent across studies. Comparisons are therefore made across studies where possible. The most commonly examined terms were ‘cultured meat’ (n = 11), ‘cell-based meat’ (n = 11), ‘cell-cultured meat’ (n = 8), ‘cultivated meat’ (n = 8), ‘clean meat’ (n = 4), ‘slaughter free meat’ (n = 3), ‘lab-grown meat’ (n = 3) and ‘in vitro meat’ (n = 2). Three studies also examined consumer understanding of a descriptive phrase (e.g., “grown from [animal name] cells, not farmed [or fished]”).

Most studies were based in the USA (n = 9). Other countries represented in studies were Brazil (n = 1), Germany (n = 1) and the UK (n = 1). One study covered both the USA and the UK. No studies were based in Australia or New Zealand.

3.2.1 Overview of key findings

- Terms that incorporate the word ‘cell’ (‘cell-cultured’, ‘cell-cultivated’, ‘cell-based’ ‘grown from [animal] cells, not farmed [or fished]’) **best enable consumers’ to correctly identify the true nature of the product**, but may decrease consumer appeal compared to ‘cultured’/‘cultivated’.

- Consumers also perceive terms that incorporate the word ‘cell’ to be the most descriptive and best able to differentiate from conventional meat/plant-based meat alternatives.

- The terms ‘cultured’ and ‘cultivated’ meat/seafood **produce low levels of consumer understanding of the true nature of the product**. This is the case for both seafood and chicken/beef, but is more pronounced for seafood.

- However, consumers still *perceive* ‘cultured’ and ‘cultivated’ to enable them to differentiate cell-cultured meat products from conventional meat/plant-based meat alternatives to a moderate extent (although perceived understanding was not tested with seafood where difficulties with the terms “cultured” and ‘cultivated’ are more pronounced).

- The term ‘artificial’ meat/seafood also **produces low levels of consumer understanding**, as consumers tend to incorrectly interpret this name to mean that the product is plant-based meat/seafood alternatives.

- Although the term ‘lab-grown’ enables consumers to correctly identify the product as not being farmed/fished/wild-caught, it has **lower levels of perceived safety** than other terms.

- **Consumer understanding of allergenicity of cell-cultured meat/seafood is not high, even for the best performing terms** (‘cell-cultured’, ‘cell-cultivated’), as only up to 66% of consumers correctly identified that the product was not safe to consume for those with an allergy to the traditional counterpart

- The term **‘cell-based’ produced low levels of perceived allergenicity for beef products in particular** (38% for beef; 54.8 - 61.3% for chicken and salmon). Regardless, the overall findings indicate that the **terminology alone cannot sufficiently convey allergen information to consumers.**

A more detailed description of the studies is provided below, grouped by the nature of the research (consumer acceptance and objective understanding of different terminologies vs. consumer acceptance and *perceived* understanding of different terminologies).

3.2.2 Consumer acceptance and understanding of different terminologies using objective measures

As Table 1 below shows, two studies examined the effects of different terminologies on USA consumers' acceptance and understanding of cell-cultured meat, using objective measures. These two studies did not provide consumers with any further descriptions of what is meant by the terms tested (Hallman & Hallman, 2020; Malerich & Bryant, 2022).

Table 1 *USA consumers' accurate product identification and appeal using different cell-cultured meat terminologies*

Terminology	Accurately identified product (% participants)				Appeal (Mean ± SD, note differing scales)			
	Hallman and Hallman (2020)	Malerich and Bryant (2022)			Hallman and Hallman (2020) Scale: 1 = Extremely negative, 7 = Extremely positive	Malerich and Bryant (2022) Scale: 1 = Not appealing at all, 5 = Very appealing		
	Seafood	Beef	Chicken	Salmon	Seafood	Beef	Chicken	Salmon
Conventional meat terms	Wild caught: 92.6% Farm raised: 89.4%	N/A	N/A	N/A	Wild caught: 5.56 ± 1.58 Farm raised: 5.25 ± 1.73	N/A	N/A	N/A
Control (animal name only)	52.8%	N/A	N/A	N/A	5.24 ± 1.77	N/A	N/A	N/A
Cell-cultured	55.0%	84.4%	89.5%	90.0%	4.99 ± 1.92	1.95	2.29	2.28
Cell-cultivated	N/A	83.8%	93.7%	94.7%	N/A	1.99	2.02	2.34
Cell-based	58.4%	82.3%	81.7%	81.3%	5.16 ± 1.74	2.13	1.95	2.01
Cultured	40.8%	61.6%	54.6%	53.5%	5.09 ± 1.74	2.10	2.53	2.23

Terminology	Accurately identified product (% participants)				Appeal (Mean ± SD, note differing scales)			
	Hallman and Hallman (2020)	Malerich and Bryant (2022)			Hallman and Hallman (2020) Scale: 1 = Extremely negative, 7 = Extremely positive	Malerich and Bryant (2022) Scale: 1 = Not appealing at all, 5 = Very appealing		
	Seafood	Beef	Chicken	Salmon	Seafood	Beef	Chicken	Salmon
Cultivated	29.9%	46.2%	42.2%	35.4%	5.25 ± 1.76	2.21	2.45	2.63
Lab-grown	N/A	82.8%	96.0%	94.4%	N/A	2.26	1.89	2.10
Artificial	N/A	33.3%	52.9%	42.5%	N/A	1.89	1.55	1.58
Novari*	N/A	3.1%	3.0%	0.0%	N/A	2.62	2.71	3.20
‘Cultivated from the cells of’	60.9%	N/A	N/A	N/A	4.47 ± 1.98	N/A	N/A	N/A
‘Grown directly from the cells of’	53.7%	N/A	N/A	N/A	4.75 ± 1.90	N/A	N/A	N/A
‘Produced using cellular aquaculture’	40.3%	N/A	N/A	N/A	5.32 ± 1.69	N/A	N/A	N/A
‘Grown from [animal] cells, not farmed [fished]’	N/A	96.7%	98.0%	98.1%	N/A	2.21	2.18	2.39

* Novari is a term coined by Malerich and Bryan (2022), from the Latin verb ‘novo’ or ‘to make new’, to assess how a term with no previous connection to meat or seafood (conventional or cultured) would perform in terms of appeal.

Hallman and Hallman (2020) used an experimental design to compare the effects of various terminologies on consumer understanding and acceptance of cell-cultured seafood among a nationally representative sample of 3,186 consumers in the USA. The study also included a control condition (in which no name was provided – e.g., only 'salmon') and traditional counterpart conditions ('wild caught' and 'farm raised' salmon).

Consumer understanding was measured by asking participants "which of the following best describes this salmon/tuna/shrimp?" (response options: wild caught; farm raised; neither wild caught nor farm raised) and "if you are allergic to fish/shrimp, is it safe for you to eat this salmon/tuna/shrimp?" (response options: 1 (definitely not); 2 (probably not); 3 (probably yes); 4 (definitely yes)). Consumer acceptance was measured by showing participants an image of the product with their allocated terminology and asking them their first thought, image or feeling that comes to mind when seeing it (open-ended response), and rating these from 1 (extremely negative) to 7 (extremely positive). Participants also rated the term regarding perceived nutrition (1 = not at all nutritious; 2 = slightly nutritious; 3 = moderately nutritious; 4 = very nutritious; 5 = extremely nutritious), their interest in tasting the product, and how likely they would be to purchase the product in the next 6 months if it was sold in their grocery store.

The terms 'cultivated,' 'cultured,' and 'produced using cellular aquaculture' performed poorly in signalling to participants that the product is neither wild nor farm-raised seafood (correctly identified by 29.9%, 40.8%, and 40.3% of participants, respectively). The four names incorporating the word 'cell' ('cultivated from the cells of', 'cell-based', 'cell-cultured', and 'grown directly from the cells of') resulted in the largest percentage of participants correctly identifying the product as neither wild nor farm-raised seafood, and there were no significant differences among these percentages (53.7% - 60.9%).

There was no significant difference among the different terminologies regarding their ability to signal allergenicity (Median = 2.0, indicating that it's 'probably not' safe to eat if you are allergic; $p = 0.083$).

Although reactions to the different terminologies were all generally positive (rated above the midpoint of the scale), the terms 'cell-based' and 'cell-cultured' outperformed the terms 'cultivated from the cells of' and 'grown directly from the cells of.' 'Cell-based' was perceived as being just as positive as 'wild caught' and 'farm raised', with equal interest in tasting and purchasing 'cell-based' compared to these traditional counterparts. Whereas 'cell-cultured' was perceived as significantly less positive than traditional counterparts, and only generated equal interest in tasting and purchasing compared to 'farm raised' (not wild caught). Furthermore, 'cell-cultured' was perceived to be significantly less nutritious compared to traditional counterparts ($M = 3.80$ vs. 3.53, $p < 0.05$), whereas there were no significant differences in perceived nutrition between traditional counterparts and the other terms examined ($p > 0.05$). 'Cell-based' therefore resulted in the highest levels of consumer acceptance, and at comparable levels to traditional counterparts. The authors therefore concluded that 'cell-based' was the best label in terms of consumer clarity and appeal.

Malerich and Bryant (2022) conducted a similar experiment to Hallman and Hallman (2020) on a nationally representative sample of 2,653 USA-based participants, except that they extended the scope to include beef and chicken (as well as salmon). Consistent with Hallman and Hallman (2020), Malerich and Bryant (2022) found that the terms 'cultured' and 'cultivated' resulted in relatively low levels of accurate product identification for chicken and beef (42.2% - 61.6% of participants correctly identified that the products were produced by animal cells in a food facility, as opposed to hunted/fished in the wild/farm-raised/plant-based). Accurate product identification was even lower for seafood using these terms (35.4% - 53.5% for 'cultivated' and 'cultured', respectively). Also consistent with Hallman and Hallman (2020), the names incorporating the word 'cell' ('grown from [animal] cells, not farmed [or fished]', 'cell-cultivated', 'cell-cultured', 'cell-based') resulted in higher levels of accurate product identification (by over 80% of participants, across all products), although these names had generally decreased consumer appeal[3]. The term 'lab-grown' also resulted in high levels of accurate product identification ('lab-grown' was not examined in the Hallman and Hallman study). These well-understood terms also had similar levels of appeal, purchase intent and perceived safety, except for 'lab-grown' which had the lowest level of perceived safety for chicken. Across all products, the term 'artificial' (not examined in Hallman & Hallman, 2020) was often incorrectly interpreted as referring to plant-based products.

In contrast to Hallman and Hallman (2020), Malerich and Bryant (2022) found significant differences among the different naming conditions regarding their ability to signal allergenicity ($p < 0.001$ across all products). Across all products, the three terms that performed the best (out of the terms that had the highest levels of correct product identification) were 'grown from [animal] cells, not farmed [or fished]' (61.2 - 65.2% of participants), 'cell-cultivated' (62.1 - 66.3% of participants) and 'cell-cultured' (62.1 - 63% of participants). 'Cell-based' produced low levels of perceived allergenicity for beef products (38% for beef; 54.8 - 61.3% for chicken and salmon), and perceived allergenicity was consistently lower for 'lab-grown' across all products (43.7 - 57.4%). These inconsistencies with Hallman and Hallman (2020) can be explained by the fact that Hallman and Hallman did not examine perceived allergenicity for beef products, or for the term 'lab-grown'. However, it is important to note that levels of understanding regarding allergenicity were not overly high, even for the top three terms. This is consistent with Hallman and Hallman (2020), who found that perceived allergenicity could be higher (average response was 'probably not safe to eat', as opposed to 'definitely not safe to eat'). This indicates that terminology alone cannot sufficiently convey this important information to consumers.

Overall, Malerich and Bryant (2022) concluded that 'cell-cultivated', 'cell-cultured' and the phrase 'grown from [animal] cells, not farmed [or fished]' were the best labels in terms of consumer clarity, appeal, and communicating safety and allergenicity. The authors ruled out 'cell-based', presumably because of its inability to communicate allergenicity in beef products (a measure that was not examined in Hallman and Hallman, 2020). Regardless, across both studies, terminologies with the word 'cell' incorporated have been shown to consistently produce the highest levels of consumer understanding (as measured by their ability to produce correct product identification), and allergenicity was not high across any product names. Taken together, these findings indicate that any of the above 'cell'-type names may suffice for consumer acceptance and understanding, provided that additional information is provided to consumers that communicates allergenicity.

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[3] For example, on a scale from 1-5 (not at all appealing to very appealing) for chicken products, 'cultivated' ($M = 2.45$) and 'cultured' ($M = 2.53$) were rated significantly higher than 'cell-based' ($M = 1.95$), $p < 0.05$. 'Cultured' was also rated significantly higher than 'cell-cultivated' ($M = 2.02$), $p < 0.05$.

3.2.3 Consumer acceptance and perceived understanding of different terminologies

Nine studies examined the effects of different terminologies on consumer acceptance and *perceived* levels of understanding, rather than objective levels of understanding. Participants in these studies were firstly provided with descriptions of what cell-cultured meat is (except for Janat & Bryant, 2020; where the information provided to participants is not clarified in the paper).

Szejda and colleagues conducted seven of these nine studies, using similar measures (Dillard & Szejda, 2019; Szejda, 2018, Phase 2 survey; Szejda, 2018, Phase 3 experiment; Szejda, 2018, Phase 4 experiment; Szejda et al., 2020, March survey; Szejda et al., 2020 May survey; Szejda et al., 2021). These seven studies included a range of different research designs (quantitative surveys and experimental designs, qualitative focus groups) which produced highly consistent findings.

Across Szejda and colleagues' quantitative studies, nationally representative samples of the USA and/or UK populations were provided with a description of cell-cultured meat that emphasised its benefits (benefits to human health, the environment, and/or a statement that it has identical taste and texture to conventional meat). Participants were then provided with several terminologies and were asked to rate them on the following aspects: Perceived appeal; how likely they are to purchase the product; the extent to which the name accurately describes this type of meat; whether the name helped them to differentiate the product from conventional meat and plant-based meat alternatives[4].

Although Szejda and colleagues' quantitative studies did not always compare the same terminologies (see Table 2 below), it was consistently found that consumers found 'cell'-type terminologies ('cell-based meat', 'cell-cultured meat', 'cell-cultivated meat') to be more descriptive and differentiating from conventional meat/plant-based meat alternatives, but less appealing, compared to the terms 'cultured' and 'cultivated'. That is, the terms 'cultured' and 'cultivated' were generally perceived to be 'somewhat to moderately appealing', whereas the 'cell'-type terminologies were generally perceived to be "not at all to somewhat appealing." Conversely, the terms 'cultured' and 'cultivated' were perceived to be "moderately descriptive" and "somewhat to moderately differentiating" from other products, whereas the 'cell'-type terms were generally perceived to be "moderately to very descriptive", and "moderately to very differentiating" from other products.

[4] All measures were rated on a five point scale, where 1 = "Not at all" and 5 = "Extremely".

Table 2 *Quantitative studies that examined consumer's perceptions of the appeal (app.), purchase intent (pur.), accurate descriptiveness (desc.), and/or differentiation from conventional meat (diff.) of various cell-cultured meat terminologies. All measures were rated on a five point scale, where a higher rating means a greater degree of the measure.*

Terminology	Szejda 2018, Phase 3 USA population (N = 338) Mean ± SD			Szejda 2018, Phase 4 USA population (N = 1,004) Mean ± SD			Szejda et al. 2020, March survey USA population (N = 161) Mean		Szejda et al., May Survey USA population (N = 183) Mean			Szejda et al. 2021 USA population (N = 2018) Mean		Szejda et al. 2021 UK population (N = 2034) Mean		Bryant and Krelling (2020) Brazilian population (N = 983) Mean		
	App.	Desc.	Diff.	App.	**Desc.**	Diff.	App.	Desc.	App.	Desc.	Diff.	App.	Diff.	App.	Diff.	Pur.	Desc.	Diff.
Clean	2.80 ± 1.34	2.73 ± 1.28	3.03 ± 1.29	2.80 ± 1.46	3.19 ± 1.34	3.28 ± 1.35	-	-	-	-	-	-	-	-	-	3.89	3.53	3.43
Cultured	2.37 ± 1.29	3.33 ± 1.19	3.45 ± 1.19	2.70 ± 1.47	3.39 ± 1.19	3.43 ± 1.31	2.34	3.21	2.50	3.04	2.90	2.48	2.84	2.36	2.58	3.64*	3.93*	4.06*
Cell-based	2.16 ± 1.21	3.57 ± 1.05	3.70 ± 1.19	2.31 ± 1.46	3.56 ± 1.19	3.81 ± 1.19	1.82	3.79	1.83	3.50	3.27	1.86	3.40	1.73	3.20	3.62	3.81	3.92
Craft	2.42 ± 1.34	2.82 ± 1.19	3.15 ± 1.33	2.86 ± 1.38	3.24 ± 1.33	3.37 ± 1.34	-	-	-	-	-	-	-	-	-	-	-	-
Slaughter-free	2.68 ± 1.34	3.41 ± 1.20	3.29 ± 1.25	2.89 ± 1.50	3.70 ± 1.16	3.74 ± 1.23	-	-	-	-	-	-	-	-	-	3.67	3.97	4.10
Cultivated	-	-	-	-	-	-	2.49	3.43	2.73	3.27	2.86	2.45	2.83	2.30	2.61	3.64*	3.93*	4.06*
Made	-	-	-	-	-	-	1.96	3.39	-	-	-	-	-	-	-	-	-	-
Nanopastured	-	-	-	-	-	-	1.87	2.64	-	-	-	-	-	-	-	-	-	-
Cell-cultured	-	-	-	-	-	-	1.76	3.88	1.74	3.70	3.51	1.83	3.44	1.73	3.20	-	-	-
Cell-raised	-	-	-	-	-	-	1.75	3.65	-	-	-	-	-	-	-	-	-	-
Propagated	-	-	-	-	-	-	1.68	2.81	-	-	-	-	-	-	-	-	-	-
Cellstock	-	-	-	-	-	-	1.68	3.31	-	-	-	-	-	-	-	-	-	-

* NB: The Brazilian term tested (‘carne cultivada’) is translated into English as ‘cultured/cultivated meat’ and has therefore been reported under both terms.

Similar findings were obtained by Dillard and Szejda (2019), which used focus groups with 27 USA-based university students. In this study, participants were asked to rank four different terms in order of appeal, based on three considerations: 1) Helps consumers understand what they are buying (real meat but produced in a new way), 2) Differentiates from other types of meat (not conventional meat or plant-based meat alternatives), 3) Has overall appeal (sounds appetizing). Participants ranked the four terms in the following order: 'cultivated meat'; 'cultured meat', 'cell-based meat', 'cell-cultured meat'. However, quotes from participants indicated that the ordering of these rankings was mostly based on appeal, rather than descriptiveness. For example, for the term 'cultivated', quotes from participants included: "sounds most natural", "less accurate" and "not straightforward." For 'cultured', quotes included: "sounds new, innovative" and "culture has a double meaning." Conversely, for the terms 'cell-based' and 'cell-cultured', quotes included: "simple, "the most accurate" "differentiates it from regular meat", "cell…not appetizing." The findings from this qualitative study therefore align with the previously described quantitative studies. That is, although consumers may prefer the terms 'cultured' and 'cultivated', they perceive them to be less descriptive.

The remaining two studies were similar to those undertaken by Szejda and colleagues, except that the questionnaires and terminologies provided to participants were not in English (Bryant & Krelling, 2020; Janat & Bryant, 2020).

Bryant and Krelling (2020) used an experimental design where 983 Brazilian participants were randomly allocated to view one of four different terminologies for cell-cultured meat (see also Table 2). The four terminologies tested were (translated from Portuguese): 'cultured/cultivated meat'; 'cell based meat'; 'clean meat'; and 'slaughter free meat'. Similar to Szejda and colleague's studies, participants were first provided with information about cell-cultured meat (described using the terminology they were randomly allocated) that emphasised its benefits and molecular equivalence with conventional meat. Participants were then asked to rate their allocated term on the following aspects: purchase intent; name descriptiveness; and whether the name helped them to differentiate the product from conventional meat and plant-based meat alternatives.

The study found that the term 'clean meat' was significantly less descriptive and significantly less differentiating from conventional meat than the other terms ($p < 0.05$), which did not differ significantly from one another. The term 'clean meat' was associated with significantly greater purchase intent than 'cell-based meat' ($p < 0.05$), but neither of these terms differed significantly from 'cultured/cultivated meat' or 'slaughter free meat'. While Bryant and Krelling (2020) recommended the term 'cultured/cultivated meat' as the best term "for strategic and consistency purposes", there is no evidence to support this recommendation based on their study, given that the term was not rated as significantly different to any other, except for 'clean meat'. In addition, an important difference between this study and all previous studies is that 'cultured/cultivated meat' was tested as one single term (translated into English from 'carne cultivada'), rather than tested as two separate terms. It is unclear how non-Portuguese speaking consumers would perceive the merged term 'cultured/cultivated meat' relative to other terms, which limits its generalisability to the Australian/New Zealand context.

Janat and Bryant (2020) used a quantitative survey and asked German participants to rate ten terminologies on the extent to which they perceived the name to be appealing, accurately descriptive, and clear that it describes cultured meat as opposed to animal-based or plant-based meat alternatives. All measures were rated on a scale from 1-5, similar to other

studies described in Table 2[5]. The authors concluded that there are four feasible names for cell-cultured meat (directly translated from German): 'cultured meat', 'meat from cell culture', 'cultured protein', 'cell-based meat', as these four names had the highest levels of perceived appeal, perceived accuracy and perceived ability to differentiate from conventional meat or plant-based meat alternatives. However, this is only based on mean group ratings; the paper did not provide any measures of variability or statistical testing. Therefore it is not possible to know whether the names significantly differed on any of these measures. Additionally, the terms 'cultured meat' and 'cultured protein' may have received higher ratings given that 'cultured meat' was the term used throughout the survey that was provided to participants. The term 'direct meat' was also tested and produced the highest levels of appeal, perceived accuracy and perceived ability to differentiate from other products. However, the authors discarded this term due to low acceptability to industry stakeholders and too much dissimilarity to other names in English. It is unclear how non-German speaking consumers would perceive the term 'direct meat'.

3.3 Consumer perceptions of cell-cultured meat relative to conventional meat

15 studies examined consumer perceptions of cell-cultured meat relative to conventional meat. 11 of these studies were quantitative, one was qualitative (focus groups), and three employed mixed methods. The majority of studies (n = 13) examined consumers' perceptions of the healthfulness of cell-cultured meat relative to conventional meat, although the way in which this was asked differed between studies. Other outcome measures for comparing cell-cultured meat to conventional meat were: nutritional value (n = 2) and molecular equivalence (n = 1).

In contrast to the previous section, these studies did not compare the effects of different terminologies on consumer perceptions. Rather, general perceptions of cell-cultured meat relative to conventional meat were examined, and studies only used one type of term. The majority of studies (n = 8) used the term 'cultured meat' or 'cultured beef/chicken/pork' in their data collection. Other terms used were: 'artificial meat' (n = 1), 'cell-based meat' (n = 1), 'clean meat' (n = 1), 'cultivated meat' (n = 2), 'in-vitro meat' (n = 1), and 'lab-grown meat' (n = 1). Eight studies provided a neutral description of their preferred terminology, three provided a biased description (positive benefits), one provided a biased description (negative), and three provided no description (terminology only).

Two studies were based in Australia and one in New Zealand. Other countries represented in studies were Brazil (n = 1), China (n = 4), Colombia (n = 1), Finland (n = 1), Germany (n = 1), India (n = 1), Ireland (n = 1), Italy (n = 1), Switzerland (n = 1), the UK (n = 1), and the USA (n = 2). Note that some studies covered more than one country.

[5] The Janat and Bryant (2020) paper does not provide exact means, as these are only conveyed in a bar graph. Therefore this study is not included in Table 2.

3.3.1 Overview of key findings

- Across four studies that used comparable methodologies in four different countries, consumers consistently perceived cell-cultured meat (or equivalent terminology) as less healthy and/or less nutritious than conventional meat when provided with a neutral description of cell-cultured meat.

- Similarly, another study that provided participants with a neutral description of cell-cultured meat and asked them whether they perceived it to be “molecularly the same as real meat” found that consumers on average disagreed.

- There is a high level of variance in consumer perceptions across the other reported studies. This is likely due to the differing terminologies used, question wording/response options, descriptions provided (neutral vs. biased descriptions), and the types of conventional meat products that were compared with their cell-cultured equivalents (e.g. chicken vs. chicken nuggets). This may indicate that consumer perceptions of the healthfulness or nutritional value of cell-cultured meats are highly malleable depending on the type of information received and product categories compared.

- Qualitative findings suggest that levels of trust in scientists, experts and/or cell-cultured meat companies may impact perceptions of the healthfulness and/or nutritional value of cell-cultured meat. That is, those participants who had confidence in those involved in the production process had confidence that they would make it equivalent to conventional meat on these measures, and vice versa..

3.3.2 Perceived healthfulness and/or nutritional value of cell-cultured meat compared to conventional meat

A more detailed description of the studies is provided below, grouped by the type of measures used

Studies using five-point Likert scales

Four studies examined consumer perceptions of the healthfulness and/or nutritional value of cell-cultured meat relative to conventional meat using similar five-point Likert scales (see Table 3). The four studies were each based in a different country (Brazil, China, Ireland, and the USA) and used different terminology to refer to cell-cultured meat, however all provided a neutral (unbiased) description of the chosen term. Across the four studies, the mean perception was consistently below the midpoint, indicating that, on average, consumers perceive cell-cultured meat to be less healthy than conventional meat.

The consistency across these results, supported by the use of similar questions and Likert scales, gives confidence to these findings. However, it is important to note that there was a high percentage of university students in the study samples relative to the population of each country, which may impact the generalisability of this finding to the broader populace.

Perceptions of cell-cultured meat as more, less, and/or equally healthy/nutritious compared to conventional meat

Six studies (including two reported as means in the above section: Chriki et al. 2021 and Liu et al. 2021) reported on the percentages of consumers who perceived cell-cultured meat as less or more healthy and/or nutritious than conventional meat, and those who perceived them as equally healthy or who were neutral or unsure (see Table 4 Table 4).

As seen in Table 4, there was substantial variation in consumers' perceptions of the healthfulness of cell-cultured meat in relation to conventional meat across these studies, with between 48% and 87.5% believing that cell-cultured meat was at least as healthy as conventional meat. This may be for a number of reasons. The six studies covered eight different countries (Brazil, China, Colombia, Finland, Germany, India, Switzerland, and the USA). For three of the studies, the exact wording of the question and the available response options was not provided. It is possible that the wording may have had an impact on consumers' responses. Different terminology was also used across the studies – three used 'cultured' or 'cultivated' meat, one used 'cell-based' meat, one used 'clean meat', and one used 'artificial meat' – and there is some evidence (see Hallman and Hallman's (2020) study as described in section Consumer acceptance and understandings of different terminologies) that terminology may impact perceptions of nutritional value. In addition, two of the studies supplied a neutral description of their chosen terminology, two studies supplied a biased description (one positive, one negative), and two studies did not provide any description. These different variables make it challenging to draw an overall conclusion from these studies.

Four of the studies investigated Chinese consumers. Two (Dempsey and Bryant 2020 and Sun et al. 2023) found that 75% and 87% of Chinese consumers respectively perceived cell-cultured meat to be at least as healthy as conventional meat. However, a third study (Hansen et al. 2021) found that a substantial proportion of people (49%) were unsure, and a fourth study (Liu et al. 2021) found that 52.6% believed that cell-cultured meat would be less healthy than conventional meat.

The variance in these findings may be due to the different terminology and descriptions used; the studies with a high percentage of consumers perceiving it to be at least as healthy used the term 'cultured' (Sun et al. 2023) or 'cultivated' (Dempsey and Bryant 2020) meat and either provided no description (Sun et al. 2023) or a biased one that emphasised health benefits (Dempsey and Bryant 2020). The studies that found a lower level of perceived healthfulness provided either a neutral (Liu et al. 2021) or biased (Hansen et al. 2021) description of cell-cultured meat that emphasised that the health benefits were not certain. As not all of these studies provided the exact question wording or response options, it is not possible to determine if there were also additional factors that may have influenced the results.

Table 3 *Studies that used a five point Likert style to measure healthfulness and/or nutritional value perceptions of cell-cultured meat relative to conventional meat.*

Study	Country	Sample	Terminology and Description	Question and Response Scale	Mean ± SD
Chriki et al. (2021)	Brazil	N = 4,471 91.4% university-educated	Cell-based meat Neutral description	"How healthy, safe, and with a high-nutritional-value do you think cell-based meat will be compared to conventionally produced meat (i.e., in terms of proteins, vitamins…)? 5-point Likert scale (1 = Much less, 5 = Much more)	2.69
Liu et al. (2021)	China	N = 4666 participants 82% university-educated	Artificial meat Neutral description	"How healthy, safe and nutritional do you think artificial meat would be compared to conventional meat?" 5-point Likert scale (1 = Much less, 5 = Much more)	2.41 ± 1.06
Shaw and Mac Con Iomaire (2019)	Ireland	N = 312 42.3% university-educated	Cultured meat Neutral description	"How healthy do you think cultured meat would be in comparison with conventional meat? 5 point Likert scale (1 = Much less, 5 = Much more)	Rural: 1.28 ± 1.19 Urban: 1.53 ± 1.12
Wilks and Phillips (2017)	USA	N = 673 58.2% university-educated	In-vitro meat Neutral description	"How healthy do you think IVM is compared to farmed meat?" 5 point Likert scale (1 = Much less, 5 = Much more)*	2.91 ± 0.95

***** The raw data for this variable was reversed in magnitude and the mean recalculated so that all scales in this table use a higher number to indicate a greater perception of healthfulness of cultured meat in relation to conventional meat.

Table 4 *Studies that collected responses on whether consumers perceived cell-cultured meat to be less, equally, or more healthy and/or nutritious than conventional meat.*

Study	Country	Sample	Terminology and Description	Question*	Less Healthy	Neutral/Unsure	More Healthy
Chriki et al. (2021)	Brazil	4,471 convenience sample 91.4% university-educated	Cell-based meat Neutral description	"How healthy, safe, and with a high-nutritional-value do you think cell-based meat will be compared to conventionally produced meat (i.e., in terms of proteins, vitamins…)? 5-point Likert scale (1 = Much less, 5 = Much more)	41.3%	33.8% neutral/unsure	24.9%
Liu et al. (2021)	China	4666 participants 82% university-educated	Artificial meat Neutral description	"How healthy, safe and nutritional do you think artificial meat would be compared to conventional meat?" 5-point Likert scale (1 = Much less, 5 = Much more)	52.6%	34.5% neutral/unsure	12.7%
Dempsey and Bryant (2020)	China	1020 participants Nationally representative	Peiyangrou (literally: cultured/cultivated meat, 培养肉) Biased description (health benefits)	Whether cultured/cultivated meat is at least as healthy as conventional meat. Unknown response options.	Not examined	75% of respondents considered cultured/cultivated meat to be at least as healthy as conventional meat	

Study	Country	Sample	Terminology and Description	Question*	Less Healthy	Neutral/Unsure	More Healthy
Hansen et al. (2021)	China, India, Colombia, and Switzerland	80 participants (20 from each country) University students (aged 18-45)	Cultured meat Biased description (negative health)	Whether cultured meat is healthier than conventional meat.	Not examined	49% unsure if cultured meat is healthier	36%
Sun et al. (2023)	China	3015 participants 75% university-educated	Cultured pork No description	Health impacts of cultured pork compared to conventional pork Better, same, worse	13% worse health impacts	47% same health impacts	40% better health impacts
Tiaga (2018)	Finland, Germany, and the USA	163 respondents 109 from USA 17 from Finland 15 from Germany	Clean meat No description	"Please fill in the blank to complete these statements: I believe cultured meat is [more/less/equally] healthy than conventional meat."	Finland and Germany: 12.5% USA: 52% Less healthy	Finland and Germany: 87.5% USA: 48% At least as healthy	

* Questions have been provided verbatim where the exact wording is available (as indicated by quotation marks), and paraphrased where not.

Perceptions that cell-cultured meat would be more healthy than conventional meat

Two studies asked consumers whether cell-cultured meat would be healthier or more nutritious than their conventional equivalent.

One study (Giezenaar et al., 2023) was based in New Zealand, and involved 572 people aged 25-55 years who consume meat less than 7 days/week. The terminology used in the study was 'cultivated meat' and participants were provided with a biased description that emphasised positive health benefits and nutritional equivalence compared to conventional meat. The study asked participants to indicate their agreement with the statement "compared to conventional meat, I think cultivated meat would be healthier" on a 7 point scale (1 = Strongly disagree, 7 = Strongly agree). The mean score was 4.3 (SD = 0.06), indicating that, on average, consumers believed that cell-cultured meat would be healthier.

When disaggregated, the mean score was significantly ($p < 0.0001$) higher among those who were aware of cell-cultured meat (M = 4.5, SD = 0.06) compared to those who were not aware (M = 4.1, SD = 0.05), significantly ($p = 0.026$) higher among men (M = 4.5, SD = 0.05) compared to women (M = 4.2, SD = 0.06), and significantly ($p = 0.013$) higher among those who consumed plant-based meat alternatives more frequently. It is important to note, however, that both gender ($p = 0.036$) and higher plant-based meat alternative consumption frequency ($p = 0.0003$) were significantly associated with awareness of cell-cultured meats.

The other study (Mancini and Antonioli 2020) was based in Italy, and involved 525 participants. The terminology used in the study was 'cultured meat', and participants were provided two sets of information in stages. Participants were first provided with a neutral description, after which they were asked to indicate their agreement with the statement "A cultured meat burger will be more nutritious than a conventional burger" on a 5 point scale (1 = I don't agree at all, 5 = I definitely agree). Participants were then provided with a biased description that emphasised environmental, safety, and nutritional benefits, and asked to once again indicate their level of agreement with the same statement using the same scale.

After being provided only with the neutral description, the mean score was 2.4 (SD = 1.1). As this is below the midpoint it indicates that consumers generally did not agree that "a cultured meat burger will be more nutritious than a conventional burger". However, after being provided with the biased description, the mean score increased to 2.9 (SD = 1.3), a significant difference ($p < 0.05$), although still slightly below the midpoint. This suggests that biased information influenced consumers to become closer to neutral on the question of whether cell-cultured meat would be more nutritious than a conventional burger.

3.3.3 Molecular equivalence of cell-cultured and conventional meats

One study (Wilks et al. 2021) asked 862 participants living in the USA to read a neutral description of 'cultured meat' and then indicate their level of agreement with the statement "Cultured meat is molecularly the same as real meat" on a 5 point Likert scale (1 = Strongly disagree, 5 = Strongly agree). The mean score was 2.77 (SD = 1.12), indicating that consumers overall disagreed with the statement. Broken down into interval categories, 49.2% disagreed with the statement, 19.4% were neutral, and 31.2% agreed.

3.3.4 Absolute healthfulness of cell-cultured and conventional meats

Two studies asked participants to separately rate the perceived healthfulness of cell-cultured meat products and their conventional equivalents on a common scale, providing a point of comparison (see Table 5 below).

Table 5 *Studies that compared healthfulness ratings of cell-cultured meat with their conventional meat equivalents*

Study	Country	Sample	Terminology and Description	Question	Mean ± SD
de Oliveira Padilha et al. (2022)	Australia	N = 1060 Nationally representative.	Conventional chicken Lab-grown chicken Neutral description	Healthfulness of conventional chicken vs lab-grown chicken 7 point scale (-3 to +3)	Conventional chicken: 0.87 ± 1.40* Lab-grown chicken: -0.72 ± 1.64*
			Conventional beef Lab-grown beef Neutral description	Healthfulness of conventional beef vs lab-grown beef 7 point scale (-3 to +3)	Conventional beef: 0.58 ± 1.49* Lab-grown beef: -0.77 ± 1.59*
Vural et al. (2023)	UK	N = 100	Cultured beef burger Neutral description	In your opinion, how HEALTHY is this food? Cultured meat vs conventional equivalents. 100 point scale^	Cultured beef burger: < 40% Conventional beef burger: < 40%
		N = 100	Cultured chicken nuggets Neutral description		Conventional chicken nuggets: Approx. 25% Cultured chicken nuggets: Approx. 30%

* Significant difference ($p < .05$)
^ Results for this study were only provided on a bar chart. Estimations have been made for each of the scale points based on these charts.

An Australian study (Padilha et al. 2022) found that conventional beef and chicken were both rated as significantly healthier than their 'lab-grown' equivalents ($p < 0.05$), with both forms of conventional meat being rated above the midpoint and both forms of 'lab-grown' meat being rated below the midpoint.

A UK study (Vural et al. 2023) found that both meat-eaters and non-meat eaters rated 'cultured beef burgers' as similarly unhealthy as 'conventional beef burgers', whereas 'cultured chicken nuggets' were rated as slightly but significantly ($p < 0.05$) healthier than 'conventional chicken nuggets', although both were still rated as unhealthy overall by both meat-eaters and non-meat eaters.

The different scales, different terminology, and the different meat products used (beef and chicken vs. beef burgers and chicken nuggets) make it difficult to compare the findings between these studies. In particular, the different levels of processing implied between 'beef' and 'beef burgers', and 'chicken' and 'chicken nuggets', may have had an impact on their perceived healthfulness relative to their cell-cultured equivalents.

3.3.5 Qualitative findings

Further insight into why people may perceive cell-cultured meat to be more or less healthy and/or nutritious than conventional meat can be obtained through two studies, one qualitative, and one mixed methods. In both of these studies, participants were not provided with a description of cell-cultured meat. That is, they were only provided with the term (Bogueva & Marinova 2020 asked about 'cultured meat', whereas Tiaga 2018 asked about 'clean meat').

Bogueva and Marinova (2020) conducted an online qualitative survey among 227 Sydney residents born between 1995 and 2001. Although it does not appear that any questions specifically asked about the healthfulness or nutritional value of cell-cultured meat relative to conventional meat, some respondents spontaneously offered comparisons. It is not possible to get a sense of the overarching themes around health/nutritional equivalence, because it was not a key area of investigation, however the following quotes provide some insight into the considerations that take place:

> *"… 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)

> *"A replacement for meat with in vitro – the scientists are trying hard to replicate real meat, so it should be healthy and nutritious if they get it right."* (A few times per week meat-eater, administrator, age group 18-20 years)

> *"In vitro mimic the taste, texture and protein content of meat. Honestly, I have no idea how good it is for you. I have absolutely no idea whether these alternatives are having similar iron, zinc and magnesium content to say if they are nutritious like real meat. I'll say they are fake and not healthy for us to eat."* (A few times per week meat-eater, office administrator, age group 21-24 years)

Tiaga (2018) conducted a mixed methods study that involved interviews with 30 consumers across three countries, aged 22-66, of whom 53% were students. When asked, "Would you say that clean meat is healthy? Why or why not?", participants responded with some of the following quotes:

> *"It depends on other things you're eating as well, but if I say that conventional meat is healthy, then I think clean meat is healthy."* (US, female, aged 28 years, student, eats meat daily)

> *"I don't think there is a difference between lab-grown meat and the meat we eat today, because it's the same cells and the same diseases that would follow into the lab. I don't think we could get rid of the diseases even though it's lab-grown. So, the risks are the same."* (Finland, female, aged 37 years, employed part-time, eats meat 1-3 times/week)

> *"My guess is that clean meat would be leaner than traditional meat, which would be healthier."* (US, male, aged 27 years, employed full-time, eats meat 1-3 times/week)

"I think it might be healthier in that it's free of any weird medication, because I know if you feed animals medication, some of the remnants stay in the meat and you eat that along with the meat. That can't be healthy… […] *I think the experts producing clean meat know how to produce it so that the nutritional value is the same."* (Germany, female, aged 27 years, student, eats meat 1-3 times/week)

"If it's very controlled, then it should be healthier than the industrial meat. It could also be healthier than the organic meat, depending on how it's grown. But, it would be produced by a company, and you never know what's going [on]. It should be healthy but not if there were industrial mistakes." (Germany, male, aged 45, employed full-time, eats meat daily)

"It's still meat, even though it would be lab-grown, so I think that would be the reason why I would say I think it's not healthy for me." (Finland, male, aged 27, employed full-time, eats meat 1-3 times/week)

The limited amount of qualitative material available makes thematic analysis challenging. However, a key theme that appears to come out of these quotes is that trust in scientists, experts and/or cell-cultured meat companies may impact perceptions of the healthfulness of cell-cultured meat (both positively and negatively). That is, those participants who expressed confidence in those involved in the production process believed that they would make it nutritionally and healthfully equivalent to conventional meat, and vice versa.

It is also important to note the suggestion in two of these quotes that perceptions of nutritional equivalence with conventional meat may not always result in cell-cultured meat being perceived as healthy overall. That is, consumer perceptions of nutritional equivalence between cell-cultured meat and conventional meat may either positively or negatively impact their perceptions of healthfulness of cell-cultured meat depending upon how healthy they perceive conventional meat to be.

4. Limitations

There was little research available that was based on Australian/New Zealand samples. Therefore the review has also included studies based on international samples, which may not generalise to Australian/New Zealand populations. Nevertheless, cell-cultured meat is not currently available for sale in most countries sampled, therefore consumers' exposure to and knowledge regarding cell-cultured meat is likely to be comparable. Findings that may be less generalisable to Australia and New Zealand (e.g., studies where terms were translated from a different language) are acknowledged where appropriate. In addition, many of the studies examining consumer perceptions of cell-cultured meat relative to conventional meat had a high proportion of university students in their sample, which may limit the generalisability of their findings to the broader population.

The methodological approach of this review is also not without limitations. Firstly, relevant literature was found from searching six databases. While we selected databases based on their appropriateness for the search topic (and availability to FSANZ), it is possible that additional relevant literature was missed from other databases. However, this possibility was mitigated by searching for further literature via other sources (e.g., by emailing known researchers and searching the reference lists and citing studies of all obtained studies).

Secondly, it is acknowledged that only one officer screened and extracted data for each study (i.e., no study was double coded). However, this was necessary in order to provide a timely evidence synthesis, and having only one reviewer screen and extract data from each study is a commonly used approach when conducting rapid systematic reviews (Tricco et al., 2015).

5. Conclusions

The review examined the literature on consumers' understanding, preference and acceptance of different terminologies for cell-cultured meats, and consumers' perceptions of cell-cultured meat relative to conventional meat. The review is based on 26 studies. The majority of the available studies were conducted outside of Australia and New Zealand, but mostly included countries where cell-cultured meat is not currently available (similar to Australia and New Zealand). General conclusions may be drawn based on the consistency of the findings across studies. These are grouped by the research questions below.

Do consumers want a specific term to differentiate between cell-cultured meat and conventional meat? What terminologies are best for consumer understanding?

Terms that incorporate the word 'cell' ('cell-cultured', 'cell-cultivated', 'cell-based' 'grown from [animal] cells, not farmed [or fished]') enable consumers' to correctly identify the true nature of the product, but may decrease consumer appeal compared to 'cultured'/'cultivated'. Consumers also *perceive* terms that incorporate the word 'cell' to be the most descriptive and best able to differentiate from conventional meat/plant-based meat alternatives.

The terms 'cultured' and 'cultivated' meat/seafood produce low levels of consumer understanding of the true nature of the product. This is the case for both seafood and chicken/beef, but is more pronounced for seafood. However, consumers still *perceive* 'cultured' and 'cultivated' to enable them to differentiate cell-cultured meat products from conventional meat/plant-based meat alternatives to a moderate extent (although perceived understanding was not tested with seafood where difficulties with the terms 'cultured' and 'cultivated' are more pronounced).

The term 'artificial' meat/seafood also produces low levels of consumer understanding, as consumers tend to incorrectly interpret this name to mean that the product is plant-based meat/seafood alternatives. Although the term 'lab-grown' enables consumers to correctly identify the product as not being farmed/fished/wild-caught, it has lower levels of perceived safety than other terms.

Overall, levels of understanding regarding allergenicity were not overly high, even for the best performing terms/phrases ('grown from [animal] cells, not farmed [or fished]', 'cell-cultivated', 'cell-cultured'), as only up to 66% of consumers correctly identified that the product was not safe to consume for those with an allergy to the traditional counterpart. The term 'cell-based' produced low levels of perceived allergenicity for beef products in particular (38% for beef; 54.8 - 61.3% for chicken and salmon). Regardless, the overall findings indicate that the terminology alone cannot sufficiently convey allergen information to consumers.

Do consumers perceive cell-cultured meat as the same or different to conventional meat? Are they perceived as being as healthy as, and/or nutritionally equivalent (e.g. levels of protein/fat)?

Across four studies that used comparable methodologies in four different countries, consumers consistently perceived cell-cultured meat (or equivalent terminology) as less healthy and/or nutritious than conventional meat when provided with a neutral description of cell-cultured meat. Similarly, another study that provided participants with a neutral description of cell-cultured meat and asked them whether they perceived it to be “molecularly the same as real meat” found that consumers on average disagreed.

However, there is a high level of variance in consumer perceptions across the other reported studies. This is likely due to the differing terminologies used, question wording/response options, descriptions provided (neutral vs. biased descriptions), and the types of conventional meat products that were compared with their cell-cultured equivalents (e.g. chicken vs. chicken nuggets). This may indicate that consumer perceptions of the healthfulness/nutritional value of cell-cultured meats are highly malleable based on the type of information received and product categories compared.

Qualitative findings suggest that levels of trust in scientists, experts and/or cell-cultured meat companies may impact perceptions of the healthfulness and/or nutritional equivalence of cell-cultured meat. That is, those participants who had confidence in those involved in the production process had confidence that they would make it equivalent to conventional meat on these measures, and vice versa.

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Appendices

Appendix 1: Literature review methods

All decisions regarding inclusion/exclusion criteria were made prior to the literature search commencing, except where otherwise stated.

Inclusion criteria

The review included studies that examined:

1. The effect of different terminologies on consumer understanding and acceptance of cell-cultured meat (e.g., 'cell-based meat' vs. 'cultivated meat' vs. 'lab-grown meat' vs. 'cell-based protein', etc.).
2. Consumer perceptions regarding cell-cultured meat relative to conventional counterpart (e.g., perceived nutritional composition, healthfulness of cell-cultured meat compared to conventional counterpart)

Given that little research was expected to be available, no restrictions were placed with respect to year of publication, study type (e.g., experiments, surveys, focus groups, interviews, observational studies), participant characteristics (e.g., age, geographic location) or specific outcome measures.

No restrictions were placed on the type of information that participants were exposed to in studies regarding cell-cultured meats. That is, in some studies, participants were provided with terminologies only (e.g. "cell-based meat"), or terminologies with accompanying descriptions that could be neutral or emphasising the benefits/downsides of cell-cultured meats. All studies were included if they met all other inclusion criteria, and studies were grouped appropriately based on similarities in methodologies.

Peer-reviewed publications, as well as grey literature (e.g., unpublished theses, research produced by governmental agencies and non-governmental organisations) were included. Studies were defined as primary research papers where empirical data were collected/reported.

Exclusion criteria

The current review excluded studies that only addressed other research questions that will be addressed by FSANZ's procured literature review (currently being undertaken by the University of Adelaide – see Introduction section). These additional research questions were:

1. What are the levels of consumers' awareness of cell-cultured meat?
2. What is consumers' knowledge of the manufacturing process of cell-cultured meats?
3. What are consumers' perceived benefits of cell-cultured meat?
4. What are consumers' perceived risks and/or downsides of cell-cultured meat?
5. Do consumers expect this information (i.e., that it is cell-cultured meat) to be available when food is not required to bare a label (e.g., food sold for immediate consumption in a restaurant)?
6. Are consumers willing to consume cell-cultured meats? If so, how are cell-cultured meats likely to be incorporated into the diet (frequency, substitute or consume in addition to regular counterpart)?
7. What are consumers' key motivations for consuming or not consuming cell-cultured meat?

After screening all studies based on their full text (but before undertaking data extraction), it was decided that studies that examined the effect of different terminologies on consumer acceptance without also examining consumer understanding would be excluded (n = 10). This was necessary to keep the literature review manageable. This also ensured a clearer picture of which terminology achieved a balance between consumer acceptance and understanding.

Systematic reviews were excluded from the current review. However, their reference lists were used to search for further in-scope studies. Opinion pieces that did not cite empirical studies were excluded.

Online database searches

The following six databases were searched in March 2023 via EBSCO Discovery (available through the FSANZ library):

- Science Direct
- Food Science Source
- FSTA - Food Science and Technology Abstracts
- MEDLINE with Full Text
- SocINDEX with Full Text
- EconLit with Full Text

The search was limited to peer-reviewed journal articles in English. The search string used was:

TI ("cell-based meat" OR "cell-cultured meat" OR "lab grown meat" OR "cultured meat" OR "cultivated meat" OR "in vitro meat") AND (know* OR understand* OR aware* OR belie* OR perc* OR interpret* OR influenc* OR intent* OR behav* OR purchas* OR consum* OR value* OR seek* OR motivate*)[6]

Other sources/grey literature

To ensure the literature review incorporated a suitably broad range of references, further literature was sought by:

- Emailing members from the International Social Science Liaison Group (ISSLG)
- Emailing a social scientist at the Singapore Food Agency
- Emailing a social scientist at CSIRO
- Searching references FSANZ already had on file
- Searching publication records of known relevant researchers via ResearchGate/university websites (Dr Lenka Malek, Dr Diana Bogueva, Prof Dora Marinova)
- Examining the references lists of included studies
- Examining studies that cited included studies
- Examining the reference list of the FAO report

[6] 'TI' indicates that the terms must be in the title of the study. 'AB' indicates that the terms must be in the abstract of the study.

Research review process

The search process initially identified 562 potentially relevant documents. References were exported to EPPI-Reviewer web, a web-based software program for managing and analysing data for literature reviews. Duplicates were removed using EPPI-Reviewer web duplicate management tools; references allocated a similarity score of at least 0.95 by the software were automatically excluded, and remaining potential duplicates identified by the software were manually screened and excluded by one officer.

Following removal of duplicates, out of scope papers were removed based on title and/or abstract. Finally, documents identified as out of scope on the basis of full-text review were excluded. This resulted in 23 full text documents (consisting of 26 unique studies) being included. The screening process was split among two officers (one officer screened the reference lists of all included studies, and a second officer screened references obtained from all other sources).

Figure A1 shows the number of documents retrieved at various stages of the review process. The information depicted in Figure A1 is based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA; Moher et al., 2010).

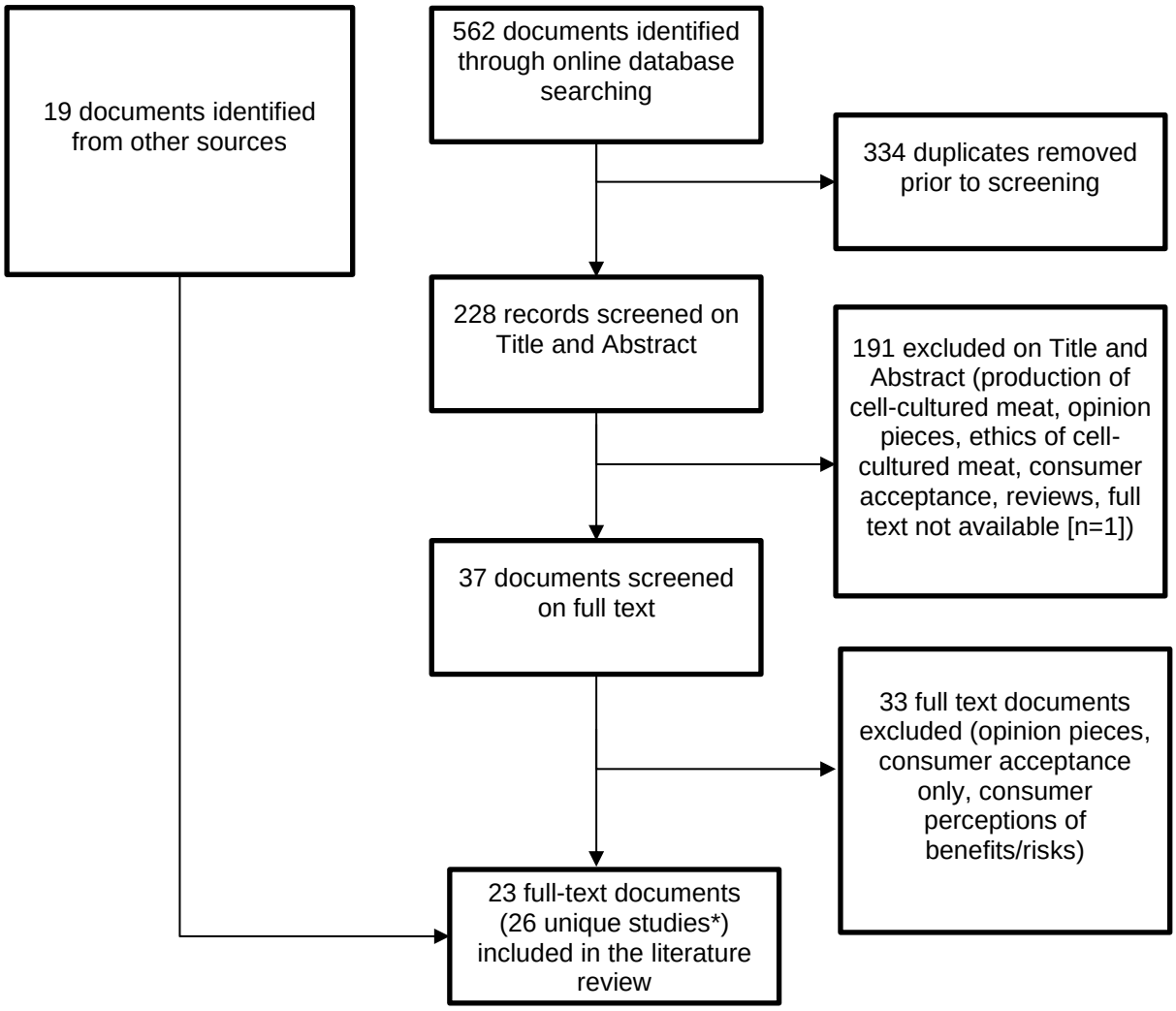

Figure A1 *Number of documents retrieved at various stages of the review process.*
* Two documents contained more than one unique study (Szejda, 2018; Szejda, et al., 2020)

Data extraction

The data extracted from each study included: Country and sampling approach, summary of data collection methods, research question(s) addressed relevant to the literature review, key strengths and limitations. Data extraction was split among two officers (one officer completed data extraction for studies examining Research Question #1, whereas a second officer completed data extraction for studies examining Research Question #2).