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1 **Consumer Acceptance of Cultured Meat: A** 2 **Systematic Review**

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7 **Abstract**

8 Cultured meat grown in-vitro from animal cells is being developed as a way of addressing
9 many of the ethical and environmental concerns associated with conventional meat
10 production. As commercialisation of this technology appears increasingly feasible, there is
11 growing interest in the research on consumer acceptance of cultured meat. We present a
12 systematic review of the peer-reviewed literature, and synthesize and analyse the findings of
13 14 empirical studies. We highlight demographic variations in consumer acceptance, factors
14 influencing acceptance, common consumer objections, perceived benefits, and areas of
15 uncertainty. We conclude by evaluating the most important objections and benefits to
16 consumers, as well as highlighting areas for future research.

17 **1. Introduction**

18 The ethical and environmental concerns associated with meat production will be exacerbated
19 as millions rising out of poverty in developing countries drive a 73% increase in demand for
20 meat by 2050 (Food and Agriculture Organization, 2003, 2011). Meanwhile, consumers in
21 the West are unwilling to reduce their meat consumption (Tobler, Visschers, & Siegrist,
22 2011), yet are increasingly concerned about the implications of meat for sustainability and
23 animal welfare (Vinnari & Tapio, 2009). Alongside changes to conventional farming
24 systems, various types of artificial meat may play a role in addressing these issues (Bonny,
25 Gardner, Pethick, & Hocquette, 2017).

26 One proposed solution is cultured meat, which can be grown from animal cells in a culture
27 medium rather than being taken from slaughtered animals (Post, 2012). Cultured meat largely
28 circumvents the need for animals in the meat production system, alleviating a milieu of
29 animal welfare, public health, and environmental concerns associated with conventional meat
30 (Hopkins & Dacey, 2008; Mattick, Landis, & Allenby, 2015; Tuomisto & de Mattos, 2011;
31 Zhi-Chang, Qun-Li, & Lin, 2015).

32 Several prototypical cultured meat products have been made (BBC, 2013; The Telegraph,
33 2017), and whilst it is not yet available commercially, several producers are aiming to sell
34 cultured meat within five years (BBC, 2015; Business Insider UK, 2017). Given the expected
35 commercialisation of the technology, and widespread consumer rejection of other
36 conceptually similar food technologies such as GMOs (Bánáti, 2011), there is now significant
37 interest in consumer acceptance of cultured meat. Some have claimed that consumer
38 acceptance could be the biggest barrier cultured meat faces (Sharma, Thind, & Kaur, 2015).

39 Consumer acceptance of cultured meat has been the subject of several studies in recent years.
40 Hartmann and Siegrist (2017) recently explored this as part of a systematic review. However,
41 this review was restricted to quantitative studies, which meant valuable insights from several
42 qualitative studies were omitted (O'Keefe, McLachlan, Gough, Mander, & Bows-Larkin,
43 2016; Verbeke, Marcu, et al., 2015). Moreover, several relevant studies have been published
44 since that review, such is the present interest in cultured meat (including Siegrist & Sütterlin,
45 2017; Wilks & Phillips, 2017).

46 Given the increasing urgency of addressing sustainability in meat production and the
47 impending commercial feasibility of cultured meat, it is imperative to synthesize the current
48 evidence base about public perceptions of cultured meat. The present systematic review,
49 therefore, aims to provide an updated and comprehensive answer to the question, ‘What is
50 known about consumer acceptance of cultured meat?’ It is hoped that the findings will be of
51 use to researchers looking at public understanding of novel food technologies, and those in
52 the industry developing cultured meat.

53 **2. Methodology**

54 This systematic review sought to identify, collate, and synthesize the findings of empirical
55 studies looking at consumer acceptance of cultured meat. The review followed the five steps
56 outlined by Khan, Kunz, Kleijnen, and Antes (2003): framing the question, identifying
57 relevant publications, assessing study quality, summarising the evidence, and interpreting the
58 findings.

59 ***2.1. Framing the question***

60 This review addressed the question: what is known about consumer acceptance of cultured
61 meat? We applied the inclusion/exclusion criteria listed in Table 1.

62 **<TABLE 1>**

63 ***2.2 Identifying relevant publications***

64 We searched a broad variety of literature databases using a search term¹ including a wide
65 range of alternative terms for ‘consumer acceptance’ and ‘cultured meat’. Figure 1 depicts
66 how these records were subsequently filtered:

67 **<FIGURE 1>**

68 ***2.3 Assessing study quality***

69 The 14 studies identified as relevant were then subject to a quality assessment using the
70 Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety
71 of Fields (Kmet, Lee, & Cook, 2004). Since all the eligible studies identified achieved
72 reasonable quality ratings, none were excluded from the review. The quality assessment did,
73 however, highlight methodological concerns in some studies, which led to caveats being
74 issued in relation to their findings.

¹ Available from author.

75 **3. Results**

76 A summary of each included study’s design, sample, description given of cultured meat, and
77 main findings is shown in Table 2.

78 **<TABLE 2>**

79 These findings will be further discussed in four sections. First, we will review the overall
80 picture of consumer acceptance, including survey data, demographic variations, and factors
81 which may influence acceptance. Secondly, we will discuss common personal and societal
82 objections to cultured meat. Thirdly, we will highlight some areas in which there is
83 significant consumer uncertainty. Finally, we will discuss some of the perceived benefits of
84 cultured meat.

85 ***3.1 Consumer acceptance***

86 First, we will discuss findings which relate to overall willingness to eat cultured meat.

87 ***3.1.1 Personal willingness to eat cultured meat***

88 Three surveys have investigated the rate of personal willingness to consume cultured meat,
89 each with different findings (Hocquette et al., 2015; Slade, 2018; Wilks & Phillips, 2017).
90 These differences are likely underpinned by differences in the samples, descriptions of
91 cultured meat, and question design.

92 Wilks and Phillips (2017) give an overall positive view of consumer acceptance, reporting
93 that 65.3% would be willing to try cultured meat, of whom 32.6% would be willing to eat it
94 regularly, 47.7% would be more willing to eat it compared to soy-based meat substitutes, and
95 31.5% would be willing to eat it as a replacement for farmed meat. Hocquette et al. (2015),
96 meanwhile, found that between 5 and 11% of their respondents said they would eat cultured
97 meat, and Slade (2018) report that 11% chose cultured meat over conventional and plant-
98 based alternatives.

99 Whilst Wilks and Phillips (2017) and Slade (2018) surveyed reasonably representative
100 samples with minor deviations from census populations, Hocquette et al. (2015) did not
101 intend their sample to be representative, thus limiting generalizability: 40.4% of their total
102 sample were scientists, 9.3% were working in the meat sector, and a further 11.3% were

103 scientists working on meat, whilst some respondents were from ‘mailing lists or groups of
104 people known by researchers’ (p. 275).

105 Furthermore, as shown in Table 2, the descriptions of cultured meat given to participants
106 differed greatly. More importantly, respondents in each survey answered very different
107 questions: Wilks and Phillips (2017) asked participants whether they would try, buy
108 regularly, prefer to other products, and pay more for cultured meat, and participants used
109 Likert scales to indicate their propensity to do each of these. Conversely, Slade (2018) used a
110 hypothetical choice experiment, asking participants to choose between cultured meat burgers,
111 plant-based burgers, and conventional burgers. Similarly, Hocquette et al. (2015) asked
112 respondents to choose between eating cultured meat, reducing their meat consumption,
113 becoming vegetarian, or changing nothing in their meat consumption. In practice these
114 options are not mutually exclusive, and therefore the conclusion that ‘only a minority of
115 respondents (from 5 to 11%) would recommend or accept to eat *in vitro* meat instead of meat
116 produced from farm animals’ (p. 273) should be taken with some scepticism.

117 Overall, these studies indicate that most consumers are willing to try cultured meat, but a
118 relatively small proportion would choose it over conventional meat or other meat alternatives.
119 In practice, this preference is likely predicated on a number of factors such as taste, price, and
120 popularity. Since cultured meat is not currently available commercially, these things cannot
121 be accounted for.

122 Nonetheless, studies suggest some demographic variation in willingness to engage with
123 cultured meat. Wilks and Phillips (2017) report that males (vs. females), liberals (vs.
124 conservatives), and low income respondents (vs. high income respondents) were significantly
125 more willing to try cultured meat. They also find that, whilst vegetarians and vegans had
126 more positive perceptions of some aspects of cultured meat, they were significantly less
127 willing to consume it than were omnivores. Slade (2018) provide further support for males
128 having higher preference for cultured meat, and note the same preference amongst younger
129 and more educated respondents. Some of these trends are also observed in the qualitative
130 work of Tucker (2014) who reported that men, younger people, and city-dwellers showed
131 more willingness to eat cultured meat compared to women, older people, and rural
132 participants respectively. There is also some evidence of cultural variation in the way
133 consumers relate to cultured meat (Bekker, Tobi, & Fischer, 2017), though this is based on
134 non-generalizable qualitative work.

135 **3.1.2 Factors influencing acceptance**

136 Some evidence suggests that increased familiarity with cultured meat is associated with
137 increased acceptance (Bekker, Fischer, Tobi, & van Trijp, 2017; Wilks & Phillips, 2017),
138 though this has not been tested statistically. Verbeke, Marcu, et al. (2015) reported that
139 participants were less resistant to the concept at the end of focus group discussions compared
140 to the start. Indeed, such a relationship would be in line with what one would expect based on
141 the mere exposure effect (Zajonc, 2001). Lack of familiarity may underpin many of the
142 ‘sense-making strategies’ identified by Marcu et al. (2015, p. 11): these included using
143 metaphors such as ‘Frankenfoods’ and ‘zombies’, as well as using commonplaces such as
144 ‘playing God’ and ‘interfering with nature’ as bottom line arguments which closed off further
145 debate. Anchoring cultured meat to more familiar technologies (such as GMOs and cloning)
146 and attempting to define cultured meat in terms of its similarities and differences compared to
147 conventional meat also indicated an attempt to locate the concept in a network of the familiar.
148 Conversely, some participants engaged in pragmatic reasoning, weighing up the costs and
149 benefits of cultured meat, reflecting on the process of public acculturation to new
150 technologies, revealing dilemmas and ultimately expressing ambivalence.

151 Meanwhile, experimental data indicates that measures of acceptance are sensitive to
152 information provision. Verbeke, Sans, and Van Loo (2015) found that self-reported
153 willingness to try, purchase, and pay more for cultured meat increased when participants
154 were given additional information about the benefits for the environment and public health,
155 compared to when they just had basic information. Whilst this study is somewhat limited by
156 the sample and before/after design, its findings are corroborated by Bekker, Fischer, et al.
157 (2017), who report that positive or negative information about cultured meat changed explicit
158 (but not implicit) attitudes towards cultured meat in the direction of the information.
159 Subsequent experiments in this study found that providing positive/negative information
160 about solar panels (a related product in the ‘sustainability’ category) also affected attitude
161 measures towards cultured meat, leading the authors to speculate that ‘The pre-activated
162 associations with sustainability in turn may have facilitated making sense of the unfamiliar
163 attitude object.’ (p. 252). This interpretation of their results seems to be in line with Marcu et
164 al.’s (2015) identification of anchoring to familiar technologies as a key part of the sense-
165 making process surrounding cultured meat.

166 Additionally, Siegrist, Sütterlin, and Hartmann (2018) found a significantly higher rate of
167 acceptance when participants were given a non-technical description of cultured meat
168 compared to a technical description due to a difference in perceived naturalness and evoked
169 disgust. The authors recommend that advocates give non-technical descriptions of cultured
170 meat which focus on the similarity of the product to conventional meat, rather than the
171 difference of the production process.

172 Finally, Slade (2018) found that preference for cultured meat was significantly higher when
173 its price was lower, and when its perceived market share was higher. Whilst the former is in
174 line with other research (see Section 3.2.1 on anticipated price), the latter indicates that
175 perceived popularity is a predictor of acceptance; the author speculates that this could be due
176 to a desire to conform to social norms, or because consumers use popularity to infer product
177 quality. In any case, it must be considered that existing research has framed cultured meat as
178 a future technology, unverified by other consumers, and therefore consumer acceptance in
179 practice may differ significantly from the observations of these studies.

180 ***3.2 Common objections to cultured meat***

181 Common objections to cultured meat broadly relate to either personal or societal concerns.

182 ***3.2.1 Personal concerns***

183 *Unnaturalness*

184 Amongst the most common objections to cultured meat is that it is unnatural. Marcu et al.
185 (2015) report that ‘natural vs. artificial’ is one of the polarities participants established in
186 order to locate cultured meat relative to conventional meat. Indeed, participants in other
187 studies have referred, unprompted, to ‘real meat’ (as opposed to cultured meat) in the context
188 of these discussions (Tucker, 2014; Verbeke, Marcu, et al., 2015), or have described cultured
189 meat as ‘fake’ (Bekker, Tobi, et al., 2017). Laestadius (2015) observed that, unlike other
190 concerns, the unnaturalness objection has been recorded universally across a range of
191 cultures.

192 As well as forming the basis for some claims that it may be dangerous to consume or cause
193 environmental harm (Laestadius & Caldwell, 2015; Verbeke, Marcu, et al., 2015), perceived
194 unnaturalness causes some to believe that cultured meat is inherently unethical (Laestadius,

195 2015). As Marcu et al. (2015, p. 9) argue, some deploy nature as an ideology within which
196 anything natural is construed as being good/healthy, and anything unnatural is bad or carries
197 risks. This ideology may have formed the ground for some to dismiss cultured meat using the
198 commonplace ‘interfering with nature’ argument.

199 Laestadius (2015) provides an insightful analysis of the unnaturalness perception, arguing
200 that ethical concerns stemming from the alleged unnaturalness of cultured meat fall into two
201 categories: practical concerns about unknown consequences of the technology causing
202 tangible harm to human health or the environment, and a more fundamental conceptualisation
203 of unnaturalness as inherently unethical. She argues that the former could be addressed by
204 further research or exposure over time, whilst the latter may be insensitive to evidence, and
205 further cautions against dismissing such concerns as naturalistic fallacy, arguing that
206 prevailing ethics have real world consequences regardless of whether they are, in themselves,
207 sound.

208 Nonetheless, there is some evidence of people overcoming the unnaturalness objection.
209 O’Keefe et al. (2016) found that participants considered that many other phenomena in
210 modern society are unnatural, yet widely accepted, a finding mirrored by Verbeke, Marcu, et
211 al. (2015). Laestadius (2015, p. 997) identified some comments arguing that conventional
212 meat is also unnatural (‘riddled with... hormones and bacteria’, as one commenter said),
213 though she notes that this argument did not necessarily extend to the conclusion that
214 naturalness should not matter.

215 Quantitative studies highlight the role perceived unnaturalness plays in acceptance. Whilst
216 Wilks and Phillips (2017) report overall agreement that cultured meat is unnatural compared
217 to conventional meat, Siegrist and Sütterlin (2017) demonstrate experimentally that perceived
218 naturalness mediated respondents’ acceptance of health risks associated with conventional vs.
219 cultured meat. Siegrist et al. (2018) also found perceived naturalness to mediate willingness
220 to consume cultured meat, directly and indirectly via evoked disgust.

221 Other evidence supports the link between perceived naturalness and disgust: Verbeke, Marcu,
222 et al. (2015) report that this was one of the first reactions observed, and was experienced as a
223 shared emotion in focus groups. Some of their participants described cultured meat as ‘vile’,
224 ‘freakish’ and ‘weird’ (p. 52). In their content analysis of online comments, Laestadius and
225 Caldwell (2015) report that 10% of the commenters observed expressed disgust, and many

226 used terms like ‘lab-meat’ and ‘test-tube’ in a pejorative way. Although disgust is likely to be
227 partly explicable through traditional notions that it guards against ingesting potentially
228 harmful substances (Rozin & Fallon, 1987), Laestadius (2015) notes that some disgust was
229 morally grounded.

230 Safety

231 A common related concern regarding cultured meat was food safety. Safety concerns were
232 reported in many of these studies; Verbeke, Marcu, et al. (2015) report that this concern was
233 linked to the perception of unnaturalness (mirroring the findings of Siegrist and Sütterlin
234 (2017) and Siegrist et al. (2018)) and to a sense of scientific uncertainty. Laestadius and
235 Caldwell (2015) report some concerns that cultured meat could be linked to cancer, for
236 example. Hocquette (2016) explains that cancerous cells could develop through cell
237 proliferation, but are unlikely to harm consumers as they are dead when digested. However,
238 many studies also report some participants perceiving potential safety benefits; O’Keefe et al.
239 (2016), in particular, highlight this in relation to BSE affecting conventional meat, and report
240 that participants expressed confidence that cultured meat would not be allowed to be sold
241 unless it was proven safe. Verbeke, Marcu, et al. (2015) also reported that participants
242 perceived possible safety benefits, though they expressed concerns about regulation in this
243 context.

244 On balance, there are more concerns than optimism expressed around the issue of safety in
245 the qualitative literature. However, the quantitative data seems to tell a different story:
246 Verbeke, Sans, et al. (2015) report that participants gave a mean rating slightly favouring
247 ‘safe’ rather than ‘not safe’ on a 7-point scale, whilst Wilks and Phillips (2017) reported
248 similarly favourable figures on a question about the risk of zoonoses from cultured compared
249 to conventional meat. It seems that, whilst people discuss safety concerns in focus groups and
250 online comments, when asked directly about this issue in surveys, overall results err towards
251 a perception of safety. This may reflect the difference between perception of risk and
252 acceptability of risk highlighted by the results of Siegrist and Sütterlin (2017): because the
253 risk is perceived as coming from an unnatural source, it is worthy of more attention, though
254 the level of risk itself may be low.

255 Healthiness

256 A further common concern observed in the literature relates to the nutritional content of
257 cultured meat. Verbeke, Marcu, et al. (2015) report that participants generally thought that
258 cultured meat would be less healthy than conventional meat, a concern also observed by
259 Laestadius and Caldwell (2015). Both of these studies noted that some participants were open
260 to perceiving health benefits relative to conventional meat, especially in relation to its lower
261 fat content, although such perceptions were outnumbered by concerns about unhealthiness.
262 Bekker, Tobi, et al. (2017) also observe mixed perceptions here, whilst Tucker (2014) notes
263 that although some participants said cultured meat was likely to be unhealthy, this was not a
264 key reason for rejection. Hocquette et al. (2015) found that 28.6% of their respondents
265 thought that cultured meat would be healthy, whilst 37.9% thought it would not be (33.5%
266 did not know). Both Verbeke, Sans, et al. (2015) and Wilks and Phillips (2017) reported
267 mean figures almost exactly in the middle of the 'healthiness' scales included in their studies,
268 indicating that there is overall uncertainty as to the healthiness of cultured meat.

269 Anticipated taste/texture/appearance

270 Many consumers anticipate cultured meat having an inferior taste, texture, or appearance
271 compared to conventional meat. This is a major theme highlighted by Tucker (2014), who
272 argues that lack of sensory appeal was the main reason underpinning rejection of cultured
273 meat. Similarly, Verbeke, Marcu, et al. (2015) reported that many participants anticipated
274 inferior taste, and those who said they might eat it said that tasting as good as conventional
275 meat would be a condition of regular consumption. O'Keefe et al. (2016) highlighted some
276 participants wanting to be able to compare cultured meat side-by-side with conventional meat
277 for aesthetic appeal, whilst Bekker, Tobi, et al. (2017) find evidence of concerns about taste
278 and texture (some anticipated a 'soft' or 'boring' texture) were held by participants from all
279 three countries in their study. Laestadius and Caldwell (2015) found comments on online
280 news articles anticipating a good and bad taste in equal measure; those who were pessimistic
281 about the taste and texture often mentioned the lack of fat, which was mentioned in several of
282 the news articles from which comments were gathered. Hocquette et al. (2015) found that just
283 23.6% of their respondents thought that cultured meat would be tasty; 39% thought it would
284 not be, and 37.5% did not know. Wilks and Phillips (2017) and Verbeke, Sans, et al. (2015)
285 both report that their samples, on average, thought that cultured meat would be less tasty than
286 conventional meat, whilst Slade (2018) found that almost 90% of their sample believed

287 cultured meat would taste worse than conventional meat, though most thought it would taste
288 better than plant-based meat alternatives.

289 Anticipated price

290 Bekker, Tobi, et al. (2017) report that price was a theme discussed by participants from all
291 cultures; some participants anticipated cultured meat being cheaper whilst others thought it
292 would be more expensive. Verbeke, Marcu, et al. (2015) also report such uncertainty, further
293 noting that some participants said they would buy cultured meat if it was cheaper, whilst
294 others thought the perceived ethical benefits would justify paying the same price. O'Keefe et
295 al. (2016) report that their participants said it would have to be cheaper to achieve
296 mainstream acceptance, but also discussed the possibility of producing superior cuts of meat
297 at a cheaper price. Slade (2018) found that a lower price was a significant predictor of
298 preference for cultured meat, indicating that price competitiveness will likely be important
299 for consumers in practice. Laestadius and Caldwell (2015) note that many commenters
300 reacted to the very high 'price' of around \$350,000 reported in the media, which was in fact
301 the cost of the entire research project. This sensationalist reporting may contribute to the
302 perception that cultured meat is expensive.

303 Whilst Verbeke, Sans, et al. (2015) report that their participants anticipated a slightly higher
304 price, Wilks and Phillips (2017) found that their participants, on average, expected it would
305 be cheaper 'on a global level' to meet demand for meat using cultured rather than
306 conventional meat. This discrepancy is likely due to framing; the phrasing of the latter
307 question may have triggered the idea that cultured meat could be produced cheaply to feed
308 the global poor. Indeed, the idea that cultured meat could be used to feed the global poor who
309 cannot afford conventional meat is a common theme in the literature (Bekker, Tobi, et al.,
310 2017; Tucker, 2014). Verbeke, Marcu, et al. (2015) note that this idea allowed some
311 participants to accept cultured meat in principal, whilst rejecting it in practice. Laestadius
312 (2015) reports that some commenters thought this was a good thing, whilst others perceived
313 an injustice whereby only the rich would get 'real' meat.

314 **3.2.2 Societal concerns**

315 There is also evidence of societal concerns relating to the end of traditional animal
316 agriculture, distrust of companies producing cultured meat, and the energy required for
317 production.

318 Wilks and Phillips (2017) found that, overall, survey respondents agreed that cultured meat
319 would have negative impacts on traditional farmers. Such concerns were mirrored by the
320 participants of Bekker, Tobi, et al. (2017), whilst Verbeke, Marcu, et al. (2015) stress that the
321 anticipated losses to farming were social and cultural as well as economic: participants also
322 worried that cultured meat might take away from cultural rituals in which meat plays a
323 central role, such as barbecues and Sunday roasts. Furthermore, they expressed regret about
324 the possible erosion of the countryside, as well as the tradition and heritage of farming (see
325 Fiddes, 1994). In general, the end of traditional farming was thought of as unwelcome.

326 Interestingly, Laestadius and Caldwell (2015) comment that these concerns seem less
327 prominent amongst American consumers, perhaps because much of US agriculture is already
328 industrialised (Laestadius, 2015). However, some did worry about the consolidation of power
329 in the food system which could accompany a shift towards cultured meat production. Indeed,
330 Laestadius and Caldwell (2015) report that 4% of commenters expressed such concerns, with
331 one commenter claiming that the innovation was motivated by ‘vast profits, or fame’ (p.
332 2463). Similarly, Verbeke, Sans, et al. (2015) note that in the aftermath of debates about
333 GMOs, consumers are likely to see such products as being ‘driven by corporate interests’ (p.
334 56).

335 Many consumers expressed concerns that in the future, they may be consuming cultured meat
336 without their knowledge (Laestadius & Caldwell, 2015). O’Keefe et al. (2016) reported
337 participants discussing maintaining food choice in this context, whilst Verbeke, Marcu, et al.
338 (2015, p. 54) quote one participant as saying ‘If they can get your money, I don’t think you
339 will never [sic] know what you will eat.’ This perception led some consumers to demand that
340 regulation should ensure transparency in cultured meat labelling, marketing, and information
341 provision. Laestadius (2015) quotes one commenter who alluded to the idea that cultured
342 meat would be ‘slipped’ into the diets of the poor, whilst the rich would continue to have
343 access to conventional meat. Marcu et al. (2015) and Laestadius and Caldwell (2015) report
344 some going further, alluding to dystopian sci-fi-like future visions involving Jurassic Park
345 and Soylent Green. The latter observed some concerns that cultured meat could enable a
346 future where cannibalism is acceptable (see Leroy & Praet, 2017).

347 Rather more practical societal concerns pertain to the amount of energy needed for cultured
348 meat production. Verbeke, Marcu, et al. (2015) and Laestadius and Caldwell (2015) both

349 report this concern amongst consumers, although in general these concerns seem to be
350 outweighed by perceptions that cultured meat will be relatively sustainable.

351 ***3.3 Doubts and uncertainty***

352 Consumers express doubt and uncertainty regarding some aspects of cultured meat, in
353 particular its feasibility, ethical status, and how it will be regulated.

354 ***3.3.1 Feasibility***

355 Verbeke, Marcu, et al. (2015) and O'Keefe et al. (2016) both report some scepticism about the
356 feasibility of cultured meat, although participants recognised that other food technologies
357 were once thought to be unfeasible (including microwave meals and astronauts eating 'food
358 in a tube'). Laestadius and Caldwell (2015) report some specific aspects perceived as
359 unfeasible, including the idea that cultured meat could never be made affordable, and that it
360 could never be made without foetal bovine serum as a culture medium, so could never be
361 truly animal-free. Quantitative data indicates that, whilst people tend to favour the view that
362 cultured meat is feasible, overall results are far from decisive, and significant scepticism
363 remains (Hocquette et al., 2015; Wilks & Phillips, 2017).

364 ***3.3.2 Ethical status***

365 There is some disagreement among consumers regarding the ethical status of cultured meat.
366 Laestadius (2015) has argued that both those in favour of and those against the technology
367 often express the same values, but interpret the role of cultured meat relative to those values
368 differently. For example, whilst both claim to care about animal welfare, those in favour of
369 cultured meat claim that the technology will reduce animal suffering, whereas those opposed
370 to it object that it will reduce the number of living animals. However, this apparent ethical
371 indecision is not replicated in the quantitative data: both Verbeke, Sans, et al. (2015) and
372 Wilks and Phillips (2017) report fairly strong agreement that cultured meat is ethical,
373 especially compared to conventional meat. Other issues including the economic impacts
374 (Laestadius & Caldwell, 2015) and the perception of unnaturalness (Verbeke, Marcu, et al.,
375 2015) appear to underpin ethical uncertainty about other aspects of cultured meat.

376 ***3.3.3 Regulation and control***

377 Verbeke, Marcu, et al. (2015) and O'Keefe et al. (2016) both report that consumers were
378 anxious to ensure proper regulation around cultured meat. Whilst participants in the latter
379 study wanted to ensure that food producers maintained quality and choice, and that
380 consumers would know what they are eating, Verbeke, Marcu, et al. (2015) report more
381 detailed demands, including transparency in labelling, marketing, and information provision.
382 Laestadius and Caldwell (2015) highlight regulation as a potential tool for building public
383 trust and acceptance.

384 *3.4 Positive perceptions*

385 Whilst the most common benefits of cultured meat consumers perceive are to animals and the
386 environment, some also acknowledge potential benefits to food security and public health.
387 O'Keefe et al. (2016) note that positivity towards science and progress generally underlie
388 many positive perceptions of cultured meat. This stands in opposition to the naturalistic
389 ideology discussed above, instead holding science and technology as a source of valuable
390 progress.

391 Avoiding animal slaughter was the most commonly perceived benefit of cultured meat for
392 meat-eaters and vegetarians alike (O'Keefe et al., 2016; Tucker, 2014). Whilst some
393 consumers have expressed concern that cultured meat will lead to a reduction in the number
394 of living animals, reinforce demand for meat, or change our relationship to animals and
395 nature (Laestadius & Caldwell, 2015; Verbeke, Marcu, et al., 2015), Wilks and Phillips
396 (2017) report that on average, people agreed that cultured meat would improve animal
397 welfare conditions, and disagreed that it would reduce the number of happy animals on earth.

398 Consumers also perceive benefits to the environment of cultured meat, mainly in relation to
399 reduced greenhouse gas emissions (Bekker, Tobi, et al., 2017; Laestadius & Caldwell, 2015;
400 Verbeke, Marcu, et al., 2015). Some express a belief that cultured meat will have
401 environmental costs or be less efficient (Laestadius & Caldwell, 2015; Verbeke, Marcu, et al.,
402 2015), but again the quantitative data indicates that consumers believe cultured meat will be
403 more environmentally friendly than conventional meat, especially in terms of greenhouse gas
404 emissions (Verbeke, Sans, et al., 2015; Wilks & Phillips, 2017).

405 Some studies report perceived benefits of cultured meat for public health, particularly with
406 regards to the potential for reduced fat content (Bekker, Tobi, et al., 2017; Laestadius &
407 Caldwell, 2015), and avoiding zoonotic diseases (Bekker, Tobi, et al., 2017; O'Keefe et al.,

408 2016). Wilks and Phillips (2017) report that their participants perceived less risk of zoonoses
409 from cultured meat, whilst Verbeke, Sans, et al. (2015) report that their sample considered it
410 safe overall, although they were undecided about its healthiness. Hocquette et al. (2015) also
411 report split opinions on the healthiness of cultured meat.

412 Several studies report a perception that cultured meat will enable the global poor to afford
413 meat (Laestadius, 2015; Tucker, 2014; Verbeke, Marcu, et al., 2015). Indeed, Tucker (2014)
414 reports that 'higher capacity protein production' was the second most common reason given
415 in support of cultured meat. This is seemingly underpinned by the assumption that cultured
416 meat could be produced more cheaply and on a larger scale than conventional meat, which is
417 unlikely to be the case initially. Cultured meat may have benefits for global food security, but
418 these are more likely to be a result of reducing the food input of meat (which could otherwise
419 be fed to humans) and mitigating some harmful effects of climate change.

420 **4. Discussion**

421 Research on consumer acceptance of cultured meat has found significant demographic
422 variation in rates of acceptance and identified several common objections, perceived benefits,
423 and areas of uncertainty. Further, identifiable sense-making strategies underlie discourses of
424 acceptance or rejection, and attitudes and intentions are sensitive to the information available
425 to consumers. In the following discussion, we place these findings in the context of wider
426 literature, and consider some implications for the future of meat consumption.

427 *4.1 Overall acceptance and demographic variation*

428 The demographic trends we observe in acceptance of cultured meat are in line with those
429 observed for other novel food technologies and related theory. In particular, studies on
430 acceptance of genetically modified food (which many consumers consider conceptually
431 similar to cultured meat (Marcu et al., 2015)) have observed higher acceptance amongst
432 males vs. females (Moerbeek & Casimir, 2005), amongst younger vs. older people
433 (Magnusson & Hursti, 2002), and amongst those with more education and familiarity with
434 the technology (Huang, Qiu, Bai, & Pray, 2006).

435 Tucker (2014) points to theory which may underpin some of these trends; Bäckström, Pirttilä-
436 Backman, and Tuorila (2003) have argued that women may be more reluctant with regards to
437 novel foods based on heightened concerns about safety, whilst Nath (2011) highlights
438 toughness and daring as components of western masculinity being reasons for increased
439 willingness of males to embrace novel foods. Youth and education, meanwhile, are
440 characteristics of early adopters of new technology according to Rogers' (2003) diffusion of
441 innovation framework. Age has been shown to be negatively correlated with openness to
442 experience (McCrae et al., 1999), suggesting that older people are more likely to stick to
443 established habits. Meanwhile, those with more education are more likely to engage in
444 analytic, deliberative thinking (Sinclair, 2014) and less likely to make decisions based on
445 heuristics such as naturalness. In the context of cultured meat, this may be more likely to lead
446 to acceptance. Finally, increased liking for more familiar objects is well documented,
447 particularly with regards to food (Crandall, 1985; Pliner, 1982), though this has yet to be
448 statistically demonstrated with regards to cultured meat.

449 Whilst there is limited peer-reviewed evidence around cultural variation in acceptance of
450 cultured meat (Bekker, Tobi, et al., 2017), this is supported by evidence from outside of the
451 peer-reviewed literature. Eurobarometer (2005) reported considerable differences in
452 acceptance of cultured meat between different European countries, whilst Surveygoo (2018)
453 found substantially higher acceptance in the USA compared to the UK. Given limited
454 evidence on this issue and the increasing importance of addressing these issues in developing
455 countries, further research is warranted. Additionally, though several analyses of media
456 coverage of cultured meat have been published (Dilworth & McGregor, 2015; Goodwin &
457 Shoulders, 2013; Hopkins, 2015), research thus far has not explored how media
458 representations of cultured meat will impact consumer acceptance.

459 One issue in this literature is the inconsistency in descriptions given to participants and
460 measures of acceptance used, which renders most separate studies effectively incomparable.
461 This is an issue which accounts for the drastically different conclusions of Wilks and Phillips
462 (2017) and Hocquette et al. (2015), but which also affects data on acceptance of cultured
463 meat from outside the peer-reviewed literature (Flycatcher, 2013; Pew Research, 2014;
464 Surveygoo, 2018). These surveys often report drastically different rates of acceptance, even
465 for similar populations. Using standardised descriptions and questions would allow future
466 research to be more comparable across time and cultures.

467 **4.2 Objections**

468 Although consumers in these studies raised a wide variety of objections to cultured meat, it
469 seems that only a few are important drivers of behaviour. Wilks and Phillips (2017) asked
470 why participants might be unwilling to try cultured meat, and found that these concerns were
471 cited at dramatically different rates: 79% of their sample had concerns about the taste/appeal,
472 whilst 24% had ethical concerns, and 20% were worried about the price. Interestingly, other
473 concerns (including safety) accounted for no more than 4% of responses to this question, but
474 this can likely be explained by the response formats; whilst the three most commonly cited
475 concerns could be expressed by checking a box, 'other' concerns required participants to
476 enter text, meaning that it is likely that safety concerns in particular were under-reported in
477 this study. Indeed, The Grocer (2017) report that, amongst a UK sample, the most prominent
478 concerns about cultured meat were about what chemicals or ingredients it contains (56%),
479 possible long-term side effects (49%), and its unnaturalness (48%). Less important were
480 concerns about its taste (29%) and price (23%). Taken together, these results indicate that

481 healthiness, safety, taste, and price are likely to be the most important consumer concerns.
482 This view is corroborated by Lusk and Briggeman (2009, p. 184), who found that, regarding
483 food choice, ‘the values of safety, nutrition, taste, and price were among the most important
484 to consumers...’

485 Grunert (2005) has characterised food safety as a ‘sleeping giant’: whilst it is not a concern
486 for consumers under normal circumstances, when a risk is perceived, safety becomes the
487 single most important consideration. Siegrist and Sütterlin (2017) demonstrate that safety
488 concerns about cultured meat are inextricably linked to concerns relating to naturalness. This
489 is in line with Yeung and Morris (2001), who argue that the perceived high level of scientific
490 uncertainty underpin perceived risks from food technology. A recent systematic review
491 identified perceived naturalness as crucial for the acceptance of food technologies across
492 cultures (Roman, Sanchez-Siles, & Siegrist, 2017), reflecting Laestadius’ (2015) observation
493 that such concerns regarding cultured meat transcend cultures. Acknowledging Marcu et al.’s
494 (2015) conceptualisation of naturalness as an ideology, future research might investigate how
495 cultured meat advocates might address this concern; would reframing cultured meat as
496 natural relative to conventional meat be effective, or should producers attempt to deconstruct
497 the appeal to nature?

498 It is possible that many concerns about the safety of cultured meat will dissipate once it is
499 available to consumers: whilst safety concerns have been recorded in the context of cultured
500 meat as a future food, Van Wezemael, Verbeke, Kügler, de Barcellos, and Grunert (2010)
501 found that safety was considered a precondition of beef being allowed to be sold, and
502 consumers might therefore infer that cultured meat is safe merely by its availability.
503 Hocquette (2016) has argued that cultured meat could entail some safety risks, whilst Bonny,
504 Gardner, Pethick, and Hocquette (2015) have highlighted that it also brings about safety
505 benefits including reduced pathogens and contaminants.

506 Objections based on anticipated taste or price are more straightforward. Unlike safety, which
507 is considered a credence attribute that cannot be verified by experience (Font-i-Furnols &
508 Guerrero, 2014), taste is an experiential characteristic, meaning that consumers can make
509 their own judgements based on trying the product. Indeed, Wilks and Phillips (2017) found
510 that, whilst relatively few people were willing to eat cultured meat regularly, most were
511 willing to try it. This was amongst a sample for whom the primary concern was taste,
512 indicating that consumers may be willing to verify this aspect for themselves.

513 Whilst some consumers anticipated a high price, others thought it would be cheaper; this may
514 be dependent on the extent to which it is framed as a solution for those in poor parts of the
515 world. Most said they would not be willing to pay more for cultured meat (Wilks & Phillips,
516 2017), which is in line with Slade's (2018) findings that lower price predicted higher
517 preference for cultured meat.

518 In summary, the data suggests that the objections most likely to drive rejection of cultured
519 meat in practice are safety concerns, taste, and price. Whilst taste and price can be verified
520 through experience, safety concerns are not only more difficult to address, but may be a
521 barrier willingness to try cultured meat (Verbeke, Marcu, et al., 2015). Cultured meat
522 advocates, therefore, should prioritise addressing safety concerns (and to the extent that they
523 are related, perceptions of unnaturalness (Siegrist & Sütterlin, 2017)), and secondarily,
524 concerns about taste and price.

525 ***4.3 Perceived benefits***

526 The most commonly perceived benefit of cultured meat was in terms of animal welfare.
527 Whilst many also perceived benefits for the environment and food security, relatively few
528 discussed the potential for cultured meat to have health/safety benefits to individual
529 consumers. The personal benefits, which appear to be the least obvious to consumers, are also
530 those which are likely to be those most important for motivating consumption of cultured
531 meat (Bruhn, 2007). However, whilst The Grocer (2017) addresses this question, there is
532 currently no data in the peer-reviewed literature assessing the relative value of health,
533 environmental, and animal welfare benefits, or the efficacy of persuasive messages based on
534 these.

535 **5. Conclusion**

536 The variation in survey findings points to the importance of framing. We hope that the issues
537 identified in this review might form the basis of attempts to formulate a standard description
538 and set of measures which can be used in future studies to enable more comparable and
539 comprehensive data.

540 Furthermore, framing itself could be an important variable to consider in future research on
541 this topic. Research could build on existing studies to investigate how different descriptions
542 of cultured meat affect consumer acceptance, as well as the different names used. In
543 particular, studies should investigate the most effective ways of addressing concerns around
544 naturalness, given the centrality of naturalness to perceived safety and the acceptance of food
545 technologies in general.

546 Moreover, the paucity of studies investigating the most important benefits to highlight to
547 consumers is somewhat surprising, given the importance of such evidence in formulating
548 information and marketing campaigns in the future. Current evidence suggests that, whilst
549 consumers most readily perceive benefits to animal welfare and the environment, these issues
550 are unlikely to be central to their buying decisions. Future research should therefore test the
551 effect of highlighting these different benefits on consumer acceptance experimentally.

552 Overall, the research reviewed in this paper is geographically focused in Europe and the
553 USA. Research investigating consumer acceptance of cultured meat elsewhere in the world,
554 particularly China and India, is warranted, given that most of the forecast increase in demand
555 for meat will be driven by those in developing countries. Moreover, some evidence suggests
556 that the character of consumer acceptance in different cultures is likely to be significantly
557 different from that observed in the west. Cross-cultural studies of consumer acceptance could
558 be vital in informing future marketing or regulatory strategies.

559 It is likely that the picture of consumer acceptance of cultured meat will continue to change
560 over the coming years as the concept nears commercialisation. Increased familiarity,
561 increased perceived feasibility, regulation, commercial availability, media coverage, and the
562 ability to try cultured meat are all factors which are likely to drive consumer acceptance in
563 the future. Longitudinal studies which allow us to observe how, if at all, attitudes shift over
564 time are likely to be vital going forward.

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