

Review

# Consumer Acceptance of Cultured Meat: An Updated Review (2018–2020)

Christopher Bryant \*  and Julie Barnett

Department of Psychology, University of Bath, Claverton Down, Bath BA2 7AY, UK

\* Correspondence: C.J.Bryant@bath.ac.uk

Received: 30 June 2020; Accepted: 28 July 2020; Published: 28 July 2020



**Abstract:** Cultured meat is one of a number of alternative proteins which can help to reduce the demand for meat from animals in the future. As cultured meat nears commercialization, research on consumers' perceptions of the technology has proliferated. We build on our 2018 systematic review to identify 26 empirical studies on consumer acceptance of cultured meat published in peer-reviewed journals since then. We find support for many of the findings of our previous review, as well as novel insights into the market for cultured meat. We find evidence of a substantial market for cultured meat in many countries, as well as markets and demographics which are particularly open to the concept. Consumers mostly identified animal- and environment-related benefits, but there is plenty of potential to highlight personal benefits such as health and food safety. The safety of cultured meat and its nutritional qualities are intuitively seen as risks by some consumers, although some recognize potential benefits in these areas. Evidence suggests that acceptance can be increased with positive information, as well as frames which invoke more positive associations. We conclude by arguing that cultured meat will form one part of a varied landscape of future protein sources, each appealing to different groups of consumers to achieve an overall reduction in conventional meat consumption. We acknowledge a range of pro-cultured meat messaging strategies, and suggest that framing cultured meat as a solution to existing food safety problems may be an effective approach to increase acceptance. In the long-term, objections based in neophobia and norm violation will decrease, and widespread acceptance will depend in large part on the price and taste.

**Keywords:** cultured meat; consumer acceptance; consumer psychology; food technology; meat replacement; alternative proteins

---

## 1. Introduction

The way we produce meat today is resource intensive and harmful to the environment [1]. It is also cruel to the animals who suffer on factory farms before going to slaughter [2], and moreover, it is linked to significant public health issues including animal-transmitted pandemics and antibiotic resistance [3,4]. Yet the global demand for meat is forecast to increase rapidly as the world population grows [5]. Evidence suggests that the current system is not sustainable and if we want to mitigate the associated environmental and public health risks without needing to substantially reduce consumption, an alternative means of meat production is required.

Cultured meat grown from animal cells is one proposed way to address these issues, as its production entails far less environmental and public health harm, as well as avoiding animal slaughter [6,7]. This is achieved by isolating stem cells from the muscle biopsy of an animal and proliferating these cells in an environment which provides the energy and nutrients the cells would need to grow inside an animal [8]. Whilst early prototypes have used fetal bovine serum as a culture medium (and therefore still required animal slaughter to produce), contemporary methods use

animal-free growth media. Several companies around the world are currently finessing the technology required to use this process to create real edible meat without animal slaughter [6].

Although it is not yet available to consumers, cultured meat has some distinct advantages over other forms of alternative protein. Unlike plant-based meats which emulate meat using plant proteins, cultured meat is real animal protein and therefore has unique potential to replace animal products directly, addressing concerns that some consumers may have about the ingredients and relative nutrition of plant-based meats. Unlike insects which are also touted as an alternative protein, cultured meat allows consumers to continue eating traditional and familiar meat species and avoid killing animals for food.

Recent years have seen significant shifts in institutions as they prepare for the arrival of cultured meat and related “cellular agriculture” products. While investors and established meat industry players have moved capital to back the new technology, regulators and lobbyists have begun to discuss its regulation [9,10]. The most optimistic cultured meat companies currently estimate that they will be selling products before the end of 2021 [11]. As cultured meat gets closer to reality, research on consumer acceptance has proliferated.

Since our 2018 systematic review of the peer-reviewed empirical research on consumer acceptance of cultured meat [12], investigation in the area has flourished. Our initial systematic review contained 14 studies spanning 2014–2018; since its publication, the number of peer-reviewed empirical studies on the topic has more than doubled, while studies in the grey literature continue to blossom. Their findings support existing literature and also shed light on previously unexplored aspects of consumer psychology with respect to cultured meat.

Our previous review discussed the research in terms of the overall acceptance, common objections, doubts and uncertainty, and positive perceptions [12]. Some of the major themes included demographic predictors of acceptance, the issue of perceived unnaturalness and related food safety issues, speculation about taste and price, discussion of feasibility, ethical status, and regulation, and perceived benefits principally for animals and the environment. More recent studies develop these themes and explore new ones.

In this paper, we provide an updated review of the empirical literature on consumer acceptance of cultured meat published in peer-reviewed journals. It is our intention to synthesize the findings and assess the field to provide a picture of what we know and what is yet to be explored.

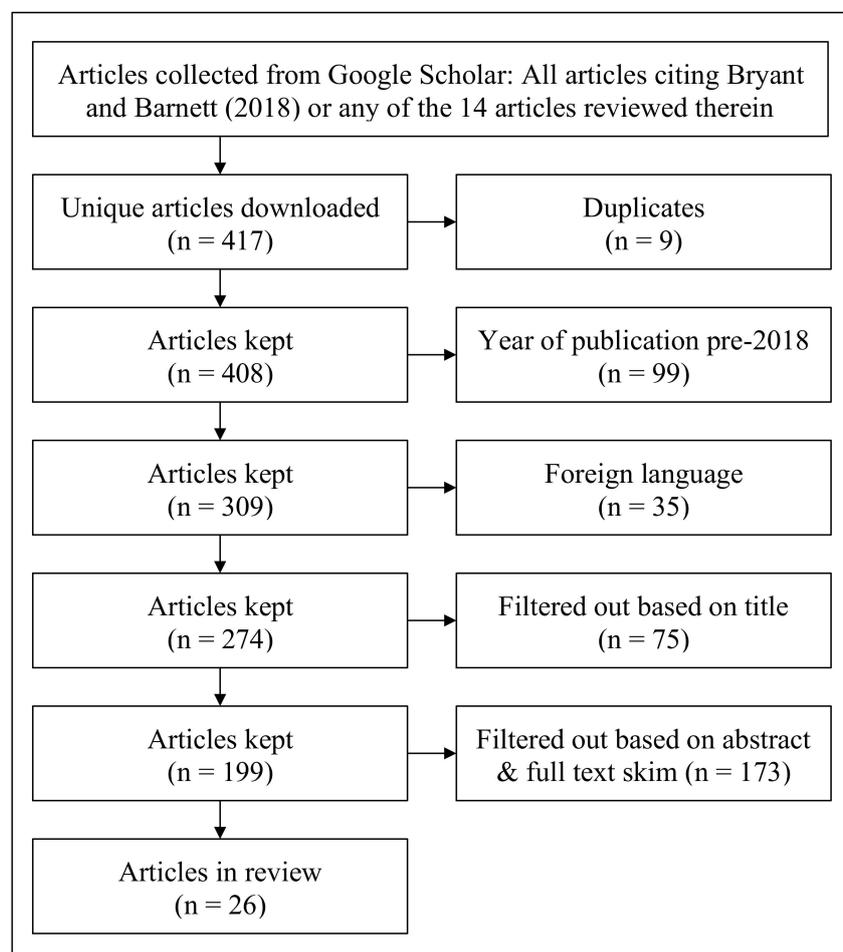
## 2. Methods

In order to identify new empirical studies in the space, we used citation tracking on Google Scholar from our 2018 review and the 14 empirical studies contained therein. We note that it is possible, though unlikely, that studies could exist which do not cite any of the existing literature on the topic—such studies would be missed using this method. We note further that all of the studies contained in this review would have been identified using the same search term as in our 2018 review. Altogether, these 15 papers had 417 unique citations on Google Scholar. We filtered these 417 papers according to the inclusion criteria in Table 1.

**Table 1.** Inclusion and exclusion criteria.

Inclusion Criteria	Exclusion Criteria
1. Focus on consumer perceptions of cultured meat	1. Sources which do not discuss consumer perceptions of cultured meat
2. Presents original empirical data	2. Review articles which do not include original empirical data
3. Published in a peer-reviewed journal	3. Book chapters, conference papers, and unpublished theses and white papers
4. Published since 2018 (inclusive)	4. Articles already reviewed in our previous review [12]
5. English language	

Applying these criteria, we filtered the literature according to the process shown in Figure 1.



**Figure 1.** Process for identifying the relevant literature.

Through this process, we identified 26 studies relevant for inclusion in the review. In the remainder of the paper, we first list the key details of these studies, and then discuss the key themes observed across the literature.

### 3. Studies Reviewed

Table 2 contains the key details of the 26 studies included in this review.

**Table 2.** Key details of the 26 studies included in the review.

Study	Method	Sample	Key Findings
Bryant, Anderson, Asher, Green and Gasteratos (2019) [13]	Experimental	1185 US adults, census balanced	The arguments that cultured meat is natural, and that naturalness should not matter tend not to persuade consumers, and resulted in a lower acceptance than discussing the general benefits without addressing naturalness. Arguing for the unnaturalness of conventional meat was relatively effective, though this argument may not be politically feasible for a co-operative market strategy.
Bryant and Barnett (2019) [14]	Experimental	185 adults recruited online	The name used to describe cultured meat has a significant effect on consumers' attitudes and behavioral intentions, with "clean meat" resulting in significantly more positive attitudes than "lab-grown meat" ("cultured meat" and "animal-free meat" were not significantly different from either of the first two names). This effect was mediated by the positivity of word associations, suggesting that the mechanism is associative.
Bryant and Dillard (2019) [15]	Experimental	480 US adults, generally representative	A frame focused on the high-technology/scientific nature of cultured meat resulted in significantly less positive attitudes and intentions compared to frames focused on the societal benefits of cultured meat, or its similarity to conventional meat.
Geipel, Hadjichristidis and Klesse (2018) [16]	Experimental	161 MTurk participants (mostly female, young) German-speaking	Consumers are more likely to say they would eat cultured meat when asked about it in a foreign language (vs. their native language). The effect was mediated by disgust.
Koch, van Ittersum and Bolderdijk (2018) [17]	Experimental	145 Dutch participants	Cultured meat was perceived to violate norms, which caused moral disgust and subsequent rejection by consumers.
Mancini and Antonioli (2020) [18]	Experimental	525 Italian adults, generally representative	Providing consumers with additional positive information about cultured meat increased their acceptance, including their willingness to buy, but not willingness to try.
Rolland, Markus and Post (2020) [19]	Experimental	193 adults who lived close to Maastricht	Acceptance of cultured meat was increased by the provision of positive information, and by a (simulated) tasting experience. Of three conditions, information about the personal benefits of cultured meat led to a significantly higher improvement in attitudes than information about the quality and taste, though information about the societal benefits produced an improvement in attitudes no different from the other two conditions. All participants ate what they believed was a cultured meat burger, and rated it as better tasting than a conventional burger despite a lack of objective difference.

Table 2. Cont.

Study	Method	Sample	Key Findings
Arora, Brent and Jaenicke (2020) [20]	Survey	394 Mumbai adults	There are distinct groups of consumers who prefer each of four different protein sources: chana (21%), conventional meat (27.5%), plant-based meat (32%) or cultured meat (19.6%). Consumers were willing to pay a small premium for cultured meat compared to conventional meat.
Bryant, Szejda, Parekh, Deshpande and Tse (2019) [21]	Survey	3030 adults in the US, India, and China, generally representative	There are substantial markets for cultured meat (and plant-based meat) in China, India, and the USA, and the acceptance of both is significantly higher in China and India compared to the USA. While some demographic predictors of acceptance, such as being a meat-eater and being left-leaning, predicted cultured meat acceptance across countries, specific attitudinal predictors varied. Disgust predicted cultured meat rejection in the USA only, whilst acceptance in China was driven by a perceived healthiness and safety, and ethical considerations were uniquely predictive of acceptance in India.
Circus and Robison (2019) [22]	Survey	139 UK adults, convenience samples, disproportionately meat reducers	Cultured meat was preferred to insects, but plant-based meat was preferred to cultured meat. Meat attachment was positively related to cultured meat acceptance. People generally held congruent views with respect to societal views of, and personal willingness to eat cultured meat.
Dupont and Fiebelkorn (2020) [23]	Survey	718 German children and adolescents (mean age 13.67, 57% female)	Participants preferred cultured meat burgers to insect burgers, though they broadly found both disgusting. Attitudes towards specific product formats are important for children. Those higher in neophobia and disgust sensitivity were less likely to want to eat cultured meat.
Egolf, Hartmann and Siegrist (2019) [24]	Survey	313 Swiss adults, generally representative	Cultured meat rejection was predicted by disgust. Although cultured meat was considered the most beneficial of the three food technologies included, it was more accepted than GMOs but less accepted than a synthetic food additive.
Gomez-Luciano, de Aguiar, Vriesekoop and Urbano (2019) [25]	Survey	729 adults in the UK, Spain, Brazil, and the Dominican Republic	Meat alternatives were generally more appealing to higher income groups, and cultured meat was more appealing to the European countries than the non-European countries. The perceived healthiness, nutrition, and safety were important predictors of willingness to pay for cultured meat across countries.

Table 2. Cont.

Study	Method	Sample	Key Findings
Gomez-Luciano, Vriesekoop and Urbano (2019) [26]	Survey	401 adults from the Dominican Republic and Spain	Participants generally preferred cultured meat to insects, but preferred plant-based meat to cultured meat. Cultured meat was generally rated worse than alternatives on the perceived healthiness, safety, nutrition, sustainability, and price. Being male and having a higher education were predictors of choosing alternative proteins.
Grasso, Hung, Olthof, Verbeke and Brouwer (2019) [27]	Survey	1825 community-dwelling older adults (65+) in the UK, the Netherlands, Poland, Spain, and Finland	Cultured meat was the least preferred alternative protein, chosen by just 6% of participants compared to plant-based proteins (58%), single-cell proteins (20%) and insect-based proteins (9%). Compared to the UK, participants were in the Netherlands (23%) and Finland (14%) were more likely to eat cultured meat, whilst those in Spain (5%) and Poland (39%) were less likely. The anticipated price and taste were predictors of cultured meat acceptance, as well as food fussiness and green eating behavior.
Gomez-Luciano, de Aguiar, Vriesekoop and Urbano (2019a) [25]	Survey	729 adults in the UK, Spain, Brazil, and the Dominican Republic	Meat alternatives were generally more appealing to higher income groups, and cultured meat was more appealing to the European countries than non-European countries. The perceived healthiness, nutrition, and safety were important predictors of the willingness to pay for cultured meat across countries.
Mancini and Antonioli (2019) [28]	Survey	525 Italian adults, generally representative	The majority (54%) were willing to try cultured meat. People generally agreed with the positive external effects of cultured meat (for animals, the environment, and food security) but gave lower ratings to its intrinsic characteristics (safety, taste, and nutrition). Predictors of acceptance included youth, higher education, higher familiarity, and being a meat-eater.
Michel and Siegrist (2019) [29]	Survey	632 German participants	The subjective importance of naturalness predicted cultured meat acceptance. Those who consider naturalness to be important are less likely to consider cultured meat natural, and are less likely to consume cultured meat.

Table 2. Cont.

Study	Method	Sample	Key Findings
Valente, Fiedler, Heidemann and Molento (2019) [30]	Survey	626 Brazilians Snowball sample from two towns, disproportionately female and well-educated	Many participants perceived problems with conventional meat, principally around animal welfare but also with respect to the environment and human health. Though 81% knew little or nothing about cellular agriculture, 39% said they would eat cultured meat with no conditions and a further 24% said it depends on factors such as taste, healthiness, price, and further information. Just 15% said they would not eat cultured meat (22% said they do not know). The biggest motivators were animal welfare, the environment, health, and trying alternatives, whilst the major concerns were affordability, healthiness, ethics, and a lack of research.
Weinrich, Strack and Neugebauer (2020) [31]	Survey	713 German adults, generally representative	Participants were moderately prepared to accept cultured meat: 57% would try it, 30% would buy regularly. Attitudes were structured in three dimensions: the strongest predictor of acceptance was the perceived ethical benefits, followed by emotional objections, and optimism about global diffusion.
Wilks, Phillips, Fielding and Hornsey (2019) [32]	Survey	1193 US adults, generally representative	Food neophobia, political conservatism, and a distrust of food scientists predicted rejection. Food hygiene sensitivity, food neophobia and conspiratorial ideation predicted absolute rejection. Naturalness sensitivity did not predict either measure of acceptance.
Zhang, Li and Bai (2020) [33]	Survey	1004 urban Chinese consumers	Despite most respondents having a limited knowledge of cultured meat, most do not oppose it. Over 70% are willing to taste or purchase cultured meat, and consumers are willing to pay an average of 2.2% more than for conventional meat. Predictors of cultured meat acceptance included being younger, being male, having a higher level of education, and having a higher trust in the government's regulation of food safety.
Lupton and Turner (2018) [34]	Online focus group discussion	30 Australian adults	Participants recognized the benefits of cultured meat for society, but generally considered it unnatural, not fresh, not nutritious, potentially harmful, and lacking in taste. Cultured meat was considered less natural and less nutritious than insects.

Table 2. Cont.

Study	Method	Sample	Key Findings
Shaw and Mac Con Iomaire (2019) [35]	Focus groups	312 Irish adults Convenience sample, roughly stratified to include young and old rural and urban participants	Participants generally characterized cultured meat as unnatural and had related safety concerns. They expressed trust in Irish meat, and distrust in food companies and food labelling regulations. In particular, they showed concerns about the implications of cultured meat for Irish farmers. Participants generally expected cultured meat to have an inferior taste and texture, and expected it to be cheaper than conventional meat. The environmental benefits were seen as most important, whilst safety was the biggest concern. Characteristics associated with acceptance included being younger, being male, and living in an urban area.
Tucker (2018) [36]	Focus groups	69 New Zealand participants	Generally, participants considered cultured meat unnatural, and not “real meat”, though some acknowledged potential environmental benefits.
Van der Weele and Driessen (2019) [37]	Focus groups	~45 people in the Netherlands, including older and younger groups	Overall, reflecting on cultured meat caused people to reveal deep ambivalence about eating animals. Younger people generally wondered about whether they would eat cultured meat; older people wondered about the transition at a societal and historical level. Generally, the conversations revealed a lot of ambivalence about eating meat.
Specht, Rumble and Buck (2020) [38]	Twitter analysis	2763 Tweets from inside the USA over a 6 month period	Tweets discussing cultured meat generally discussed eight themes: legality and marketing, sustainability, acceptance, business, animal concerns, science and technology, health concerns, and timelines. Influencers discussing this topic included philanthropists, government officials, journalists and writers, and animal advocates. Interested groups included top news and tech influencers, vegan groups, and agricultural interests, as well as media personalities such as Joe Rogan. Discourse was found to be driven by specific events in the media.

The remainder of the paper will discuss the major themes identified in these studies. We will first review the overall acceptance, including representative survey results, comparisons with other alternative proteins, and which countries and demographic groups are the most open to the concept. Next, we will discuss the perceived benefits of cultured meat identified in these studies, including to animals, the environment, health, food safety, and world hunger. We then highlight the key barriers to cultured meat acceptance, including the safety and nutrition concerns related to the perception of unnaturalness, trust, disgust, food neophobia, economic anxieties, and ethical concerns. We also discuss two key uncertainties which will play a large role in determining consumer acceptance in the long-term: price and taste. Finally, we review the growing volume of experimental and intervention research which aims to identify ways of increasing cultured meat acceptance.

#### 4. Consumer Acceptance

In this section, we will review the overall acceptance of cultured meat, including comparisons to other alternative proteins and comparisons across countries and demographic groups.

##### 4.1. Overall Acceptance Rates

Our previous review found that survey data tended to show that most consumers would try cultured meat, but not necessarily use it as a replacement for conventional meat on an ongoing basis [12,39–41]. Surveys are one of the most common methods used in the research on cultured meat acceptance, and as such, six studies provide fresh estimates of the overall acceptance with representative samples. In Table 2, we list all of the reported overall rates of acceptance from studies which had generally representative national samples in terms of gender and age. Studies which primarily used qualitative methods and/or non-representative samples are not included in this table.

As shown in Table 3, most studies find that a majority of consumers would at least try cultured meat, and substantial portions say they would eat it regularly or as a replacement for conventional meat. A number of studies support the view that substantial consumer markets exist for cultured meat across America, Europe, and Asia. Although the question wording varied across studies, these studies tended to follow previous work in giving descriptions of cultured meat followed by a series of Likert scale questions asking about willingness to eat.

Table 3. Representative surveys of cultured meat acceptance.

Study	Sample	Acceptance Rate
Bryant et al. (2019) [13]	1185 adults in the US. Census balanced.	66.4% would try; 48.9% would eat regularly; 55.2% would eat instead of conventional meat
Bryant et al. (2019) [21]	3030 adults in the US, India, and China.	US: 29.8% very or extremely likely to purchase China: 59.3% India: 48.7%
Bryant & Dillard (2019) [15]	480 adults in the US.	64.6% would try; 24.5% would buy regularly; 48.5% would eat instead of conventional meat
Gomez Luciano et al. (2019) [26]	729 adults in the UK, Spain, Brazil, and the Dominican Republic.	Would purchase, UK: 20%; Spain: 42%; Brazil: 11.5%; Dominican Republic: 15%
Mancini & Antonioli (2019) [28]	525 adults in Italy.	54% would try; 44% would buy; 23% would pay a premium
Weinrich, Strack & Neugebauer (2020) [31]	713 adults in Germany.	57% would try; 30% would buy

#### 4.2. Personal and Societal Considerations

One of the major themes identified in the previous literature on cultured meat acceptance is the consideration of costs and benefits to the individual, as well as to society overall. Our previous review found that people typically perceive the benefits of cultured meat as accruing to society, but the risks accruing to themselves [12]. More recent work appears to support this view [34]. Mancini and Antonioli [28] demonstrated that Italian consumers were in agreement with respect to societal benefits, but there was less agreement regarding the personal benefits such as taste, nutrition, and food safety.

The disconnect between societal benefits and perceived personal costs results in some consumers being in favor of cultured meat in principle, but preferring not to eat it themselves. Circus and Robison [22] found this to be the case with cultured meat more than with other alternative proteins, though views on these issues were generally congruent. This may be because consumers are more likely to perceive personal risk from cultured meat compared to other alternative proteins [26]. People with this view may be late adopters, waiting to observe whether and how others adopt the technology (see Rogers [42]).

Interestingly, experimental work has found no significant difference in consumer attitudes between frames which emphasize personal benefits and frames which emphasize societal benefits [15,19]. However, when compared to other frames also used in these studies, we do see some significant differences: in the case of Bryant and Dillard [15], both a frame highlighting societal benefits and a frame highlighting personal benefits led to significantly more positive perceptions than a frame highlighting the technological/scientific aspect of cultured meat. In the case of Rolland et al. [19] the personal benefits frame, but not the societal benefits frame, led to significantly more positive attitudes than a third “meat quality and taste” frame did. This suggests that there could be some advantage of emphasizing personal over societal benefits.

The relative salience of societal vs. personal perspectives may differ for different people. In Dutch focus groups, Van der Weele and Driessen [37] report that younger participants tended to prioritize whether and how they would interact with cultured meat personally, whereas older participants tended to be more reflective on what a societal transition towards cultured meat might look like. Likewise, Bryant et al. [21] found that different attitudes were associated with cultured meat acceptance in different countries—while disgust predicted rejection in the US, a positive ethical evaluation predicted acceptance in India.

#### 4.3. Comparisons to Other Alternative Proteins and Food Technologies

Our previous review found some comparisons with other alternative proteins [12,39], though these were far more common in more recent literature. While cultured meat has garnered attention for its novelty and revolutionary potential, some commentators have worried that a focus on novel technological solutions could cause researchers and resources to overlook other more immediately available alternatives [37,43].

Meanwhile, others have suggested that we learn from other similar food technology innovations such as genetically modified organisms (GMOs; see Mohorčič & Reese [44]). In particular, European advocates should be wary of similarities in the perceptions of cultured meat and GMOs, given the legal status of the latter [12]. Egolf et al. [24] found that cultured meat was more acceptable to their Swiss sample compared to genetically modified food, which is encouraging news for cultured meat companies aiming to sell products in Europe.

Several studies have compared the acceptance of cultured meat to insect protein. Entomophagy, the practice of eating insects, has become a part of the alternative protein conversation for some—however, the evidence broadly suggests that this is less appealing to consumers than cultured meat [22,23,26]. This preference was observed in most studies which made the comparison (with the exception of Grasso et al. [27]) and some authors report that consumers preferred cultured meat over eating insects even though they rated it as less natural and less healthy [23,26].

There are also several comparisons of cultured meat to plant-based meat. These generally find that plant-based meat is acceptable to more consumers at this time [22,26,27]. This may be because plant-based meat is more familiar to consumers [21]—indeed, as it is already available, some will have already eaten it.

However, although there is a preference for plant-based meat on aggregate, other work indicates there is still a role for cultured meat to play. Arora, Brent and Jaenicke [20] classified consumers in their Mumbai sample into one of four categories based on a latent class model of a discrete choice experiment. They found that consumers in this sample were fairly diverse in terms of their preferences for different protein sources: some, who were most likely to be vegetarian, preferred chana (21%); some, who were most likely to be Muslim, preferred conventional meat (27.5%); some preferred plant-based meat (32%), while others preferred cultured meat (19.6%). The fairly-even divide between these groups indicates that there is a role for a variety of alternative proteins catering to different consumers. In particular, Bryant et al. [21] found that, compared to plant-based meat, cultured meat purchase intent was more positively predicted by diet, meat attachment, and meat consumption, thus being more appealing to heavier meat-eaters.

In practice, consumer preferences for cultured meat over other alternative proteins will depend on factors such as price, which may not be salient to respondents in these studies. When asked about the expected price of alternative proteins relative to conventional meat, respondents across countries in Gomez-Luciano et al. [25] indicated that they thought cultured meat would be the most expensive alternative.

#### 4.4. Country Comparisons

In our previous review, we observed that much of the empirical research on this topic focused on the US and Europe with less attention given to other parts of the world, and few surveys being distributed in more than one country, making international comparisons difficult [12]. Since then, research in other parts of the world has flourished [20,33] and several published studies have compared cultured meat acceptance across countries, identifying variations which could be used to optimize a cultured meat marketing approach.

Bryant et al. [21] found that consumers in India and China were significantly more positive about cultured meat than consumers in the US. Whilst these markets are yet to be explored in as much detail as the West, the analysis indicated that different attitudinal drivers could be relevant in different countries. Whilst the purchase intentions in the US were predicted by disgust, consumers in China were mostly driven by the perceived health and nutrition, whereas ethical priorities drove intentions in India. It is especially important to understand Chinese and Indian markets, given the large proportion of the global population (and therefore of future meat consumption) that these countries make up. Large numbers of farm animals, large numbers of consumers, and relatively permissive regulatory frameworks mean that Asia is likely to be the first consumer market for cultured meat [45].

Gomez-Luciano et al. [25] compared consumer responses to cultured meat in four countries. They found the highest acceptance by far in Spain (42%), followed by the UK (20%), the Dominican Republic (15%) and Brazil (11.5%). This is the first study which includes comparable acceptance data from South America, and indicates that these markets may be even more conservative than Europeans with respect to cultured meat (a continental group which data thus far have indicated as being the least accepting of cultured meat [6]).

Grasso et al. [27] examined the acceptance of cultured meat in a sample of older (aged 65+) community-dwelling adults in five European countries. They found the highest acceptance in the Netherlands, a hub of cultured meat research in Europe. There was slightly lower acceptance in Finland, the UK, and Spain, and a far lower acceptance in Poland, the least accepting country in the survey. This may indicate that cultured meat will be more readily adopted in more progressive pragmatic parts of Europe, while countries with more traditional values around food may take longer to adopt the technology.

#### 4.5. Demographic Predictors

The quantitative data in this review provides a more detailed look at the groups to whom cultured meat will be most appealing. Some of these trends have been observed already in our previous review [12], whilst others are new and others are unclear.

*Age.* Previous research has indicated that cultured meat would likely be more appealing to younger people than older people [12,39,41], and new data appears to confirm this [15,28,31,33,35]. Van der Weele and Driessen [37] observed that older people tended to think about cultured meat in terms of the implied societal transition, whereas younger people tended to think about it in terms of their own consumption.

*Gender.* The previous review concluded that men tend to be more accepting of cultured meat than women [12,39,41], and this is confirmed by new data [15,23,26,33,35]. One notable exception to this trend is the Chinese female participants in Bryant et al. [21], who reported a higher purchase intent than their male counterparts. It is possible that this was due to a specific interpretation of the likelihood of purchasing (for example, if women generally purchase food) since other research in China has found the gender trend in China to be the same as elsewhere, with men more likely to want to consume cultured meat [33].

*Diet and meat consumption.* It was observed in our previous review that cultured meat tends to be more appealing to meat-eaters compared to vegetarians [12,41], and this is now well-validated [15,20,28,30]. Moreover, cultured meat seems to be more appealing to those who are higher in meat attachment [21,22], indicating that it may be the future protein of choice for the most committed carnivores.

*Political orientation.* Previous data had indicated that more left-wing/liberal people tended to be more accepting of cultured meat than more right-wing/conservative people [12,41], and again this is reflected in more recent analyses [21,32]. It is likely that this reflects increased concerns on the political left with related issues such as animal welfare and environmental protection. This tends to be related to other predictors of acceptance such as being younger and living in urban centers.

*Urbanness.* Although there was some indication in the previous literature that cultured meat was more appealing to those in urban centers [12,46], this had yet to be tested robustly. Shaw and Mac Con Iomaire [35] set out to test this difference in comparisons of young and old groups from rural or urban areas of Ireland. They found that participants in urban areas were more likely to say they would try cultured meat, and that undermining Irish farming communities was one of the major issues participants were concerned with.

*Education.* Our previous review found one study which identified higher education as a predictor of cultured meat acceptance [12,39]. Recent data has tended to find support for the view that cultured meat is more appealing to more educated consumers [25,28,31,33].

*Socioeconomic status.* There has been some speculation about the impact of cultured meat on consumer inequality [47]. Previous data had indicated that cultured meat could be more appealing to low income consumers in the US [41], although some New Zealand data suggested a different pattern [46]. A more recent study found that cultured meat tends to be more appealing to higher income consumers in India [21], meaning that the balance of data is unclear on this point. Gomez-Luciano et al. [25] observed that meat alternatives were more readily accepted in higher income countries, and speculate that those in lower income countries attach status to meat consumption to a greater extent.

*Familiarity.* Our previous review identified familiarity as a possible predictor of cultured meat acceptance, though we noted that this was yet to be tested statistically [12,41]. Recent studies further fortify this observation [21]. Tucker [36] reports focus group participants commenting that a lack of knowledge about cultured meat was a barrier for them, whilst Weinrich et al. [31] identified prior knowledge about cultured meat as being conducive to positive views about its morality, and found this to be the strongest driver of acceptance. A low overall awareness of cultured meat [30], combined with research which again highlights the importance of food neophobia in cultured meat rejection, [21,23,32]

means that there is plenty of room for educating the public about cultured meat, normalizing the concept, and making it more well-known.

## 5. Perceived Benefits

There are some familiar benefits of cultured meat observed in the literature [12]. Whilst some of these are intrinsic to cultured meat, many consumers framed the appeal of cultured meat in terms of problems with conventional meat.

### 5.1. Problems with Conventional Meat

One of the major focuses of analysis by Van der Weele and Driessen [37] is the deep ambivalence participants reported towards meat from animals. It appears that thinking about cultured meat triggers reflections on existing meat production methods—as the authors noted, many people who appear to accept animal farming are in fact deeply conflicted about the morality of killing animals for food. Although most people eat meat, it is a mistake to believe that there is a consensus on the morality of this even amongst omnivores.

New data from Valente et al. [30] validate these concerns, observing that about half of their Brazilian sample saw problems with conventional meat consumption, and the majority of those were related to animal suffering. Although Gomez-Luciano et al. [25] found that Brazil was the least accepting country surveyed about cultured meat, there is evidence that Brazilians tend to have higher concerns for animal welfare than other nationalities [48]. That said, Valente et al.'s [30] sample was skewed towards urban-dwelling women, a group known to be more likely concerned with animal welfare [49].

Tucker [36] noted that many of their focus group participants spoke about the benefits of eating less meat in terms of saving money, experiencing different tastes, and benefiting their health, but oddly gave the same types of reasons for not wanting to cut down meat (price, taste, and nutrition). This suggests a complex relationship with meat from animals wrought with conflict and dissonance [50].

An experimental study found that messages focused on the problems with conventional meat tended to be more persuasive than those focusing on the benefits of cultured meat [13].

### 5.2. Animals

Ambivalence about the morality of meat consumption was the main theme emerging from Van der Weele and Driessen's [37] focus groups, and avoiding animal suffering and slaughter was one of the major perceived benefits of cultured meat observed in previous research (Bryant and Barnett, 2018). By reflecting on the production methods for producing cultured meat, participants were invited to reflect on the production methods for conventional meat. Participants expressed considerable regret about the animal suffering involved: many wondered why killing animals should be seen as normal and growing cells seen as abnormal. This is a frame discussed by Matti Wilks [51] in her piece titled "*Cultured meat seems gross? It's much better than animal agriculture.*"

Many authors note that avoiding animal suffering and death was considered a key benefit of cultured meat by many consumers [19,22,28,30]. Specht et al. [38] in a study of the Twitter conversation around cultured meat found that animal welfare was one of the most prevalent themes. As well as the poor conditions in animal farming, users mentioned slaughter specifically, indicating that cultured meat is likely seen as morally preferable to any process which involves killing an animal. Several users expressed an interest in feeding cultured meat to pets who cannot follow a vegetarian diet, a topic which has been explored in depth by Ward, Oven and Bethencourt [52].

There is evidence that consumers do care about the animal suffering of meat production; Weinrich et al. [31] found that perceiving cultured meat as an ethical product was the strongest driver of purchase intent in a representative German sample, whilst Bryant et al. [21] report that the ethical evaluation of cultured meat was especially important in India. Mancini and Antonioli [18] found

that extra information improved the perceptions of the animal welfare implications of cultured meat, except for vegetarians.

### 5.3. Environment

Our previous review identified the environmental benefits as one of the major perceived benefits of cultured meat, particularly in terms of reducing greenhouse gas emissions [12,53,54]. More recent literature concurs: environmental benefits are also one of the most commonly perceived benefits of cultured meat for consumers, with some studies finding that this was more important than animal welfare benefits [22,28,30,35]. Such benefits include lower greenhouse gas emissions, and lower water and land use compared to conventional meat [7]. There is also evidence that the positive perceptions of its environmental impact drive cultured meat acceptance [27,31].

There is evidence that some consumers may assume cultured meat is harmful to the environment in virtue of being artificial or processed [38]. Indeed, Tucker [36] notes that while consumers did acknowledge the environmental advantages of cultured meat, these points were generally overrun by a discourse of unnaturalness. Gomez-Luciano et al. [25] found that people tended to rate cultured meat as less sustainable than other alternative proteins, indicating that some intuit that cultured meat could cause environmental harm.

Mancini and Antonioli [18] found that the perceived environmental-friendliness of cultured meat could be increased with an information intervention, indicating that educating consumers about the environmental advantages of cultured meat is likely to be valuable.

### 5.4. Health

Our previous review identified some of the potential health benefits cultured meat consumers discussed, including reducing fat content [12,54,55]. That said, the personal benefits of cultured meat, such as potential health and food safety benefits, tend to be less commonly perceived than societal benefits [28]. Although consumers rarely discussed potential health benefits unprompted, and evidence of the perceived healthiness is limited, there is some evidence that health claims could drive acceptance.

Gomez-Luciano et al. [25] found that, although cultured meat was considered tastier than insects or plant-based meat in some markets, it was generally considered the least healthy, nutritious, and safe alternative across countries. The perceived healthiness and nutrition of cultured meat were amongst the most important factors predicting the willingness to pay for cultured meat across all the countries in their study. They found that the UK generally had the most positive perceptions of the healthiness of cultured meat compared to Spain, Brazil and the Dominican Republic.

Valente et al. [30] report that 24% of their Brazilian participants said that their consumption of cultured meat would be dependent on more information about factors including healthiness. Though some had concerns about the healthiness of conventional meat, animals and the environment were more common factors, motivating a move away from animal meat in this sample, as has been observed in most of the previous research [12].

### 5.5. Food Safety

Our previous review identified some studies which discussed the potential food safety benefits of cultured meat [12,41]. Although it is relatively rarely identified unprompted, some studies suggested that consumers could be open to the potential of cultured meat improving food safety. Gomez-Luciano et al. [25] found that perceived safety was a key predictor of acceptance across countries, yet many people are wary of the safety of cultured meat compared to alternatives [26].

The issue of food safety is particularly salient in China, where the conventional meat supply has regularly been subject to shortages, disease, and scandals [56]; Zhang, Li and Bai [33] highlight perceived food safety as being particularly relevant to cultured meat acceptance in China, finding that trust in the government's safety regulations was a key predictor of cultured meat acceptance.

## 5.6. World Hunger

As in our previous review, recent studies find that some consumers perceive cultured meat as a way to address global hunger [12,46,57]. Mancini and Antonioli [28] noted that participants cited reducing world hunger as one of the three most common benefits of cultured meat, behind avoiding harm to animals and protecting the environment. Weinrich et al. [51] found that optimism about cultured meat's potential to solve global problems, including world hunger and global warming, was one key dimension of attitudes which influenced intentions to consume it. Though it was not as influential as other attitudes (such as beliefs about the ethical advantages, and emotional reactions of disgust to unnaturalness), "global diffusion optimism" was associated with a higher willingness to consume cultured meat.

## 6. Barriers to Acceptance

In this section, we review the major barriers to the acceptance of cultured meat. Many of the major themes are similar to the previously reviewed literature [12], though recent literature provides more detailed findings on a range of factors.

### 6.1. Unnaturalness

The perceived unnaturalness was one of the key themes in our previous review [12,57,58], and was often at the root of disgust and health and safety concerns. Unnaturalness continues to play a central role in consumers' reasons to avoid cultured meat. Indeed, this was a key theme identified in many qualitative studies [22,35,36] and appears to be a more basic objection than other barriers to acceptance, such as perceived safety or ethical problems. For example, Bryant et al. [13] found that messages targeting the perceived unnaturalness failed to persuade consumers that cultured meat was, in fact, natural, or that naturalness should not matter. Weinrich et al. [31] provide some quantitative validation of the importance of naturalness, noting that this was a major component of "emotional objections" which were a major driver of cultured meat rejection.

However, the perception of unnaturalness does not necessarily lead to rejection: Dupont and Feibelkorn [23] observed that their young German sample found cultured meat to be less natural than insects, but preferred it nonetheless. Indeed, Michel and Siegrist [29] demonstrate that the subjective importance of naturalness predicted a lower perceived naturalness of cultured meat, which in turn predicted a lower consumption intention. These findings appear to suggest that those who are especially concerned about naturalness per se are likely to reject cultured meat. We note that the subjective importance of naturalness is different from the perceived unnaturalness; for example, one might agree that cultured meat is unnatural, but not consider this fact important.

There is one notable exception to this trend: Wilks et al. [32] found that, whilst several psychographic factors such as food hygiene sensitivity, food neophobia and political conservatism did predict cultured meat rejection, a naturalness bias did not. They also showed no correlation between a naturalness bias and measures of cultured meat acceptance, indicating that this was not an issue of overfitting. It is notable that the strongest quantitative studies demonstrating that the subjective importance of naturalness is a factor affecting cultured meat acceptance used European samples [29,31], whereas Wilks et al. [32] used an American sample. Given the higher rates of cultured meat acceptance observed in the US compared to Europe [59], it is plausible that naturalness is more of an important issue to Europeans than to Americans.

Lupton and Turner [34] found that, whilst focus group participants greeted both insects and cultured meat with some amount of disgust, insects were considered more natural than cultured meat.

### 6.2. Safety Concerns

As we observed in our previous review, partly due to the perception of cultured meat as unnatural, it is common for consumers to have intuitive questions about its safety [12,53,60]. More recent research

builds on this theme [22,35,36]. In particular, focus group and interview participants expressed anxiety about the uncertainty on the long-term health effects of cultured meat [35], while Tucker [36] notes that such fears appear to be extensions of concerns about unnaturalness. Experts are aware of this intuition, and have highlighted transparency around cultured meat health and safety as paramount to the industry's success [61].

While consumers are generally cautious about the safety of cultured meat [28], this is also one attitude which appears to be particularly malleable given further information. Mancini and Antonioli [18] note that the perceived safety increased significantly when consumers were given additional information about cultured meat, and speculate that perceived safety could be greatly improved if cultured meat received approval from the European Food Safety Authority.

In an experimental setup, Rolland et al. [19] found that a message about the personal benefits of cultured meat (the only message to say that cultured meat is safe, alongside other benefits) led to the largest increase in cultured meat acceptance. The authors also report that food safety was the second most common type of negative remark (behind price) but the fifth most common type of positive remark.

### 6.3. Nutrition Concerns

As observed in our previous review, a common concern reported by consumers in these studies was that cultured meat could be generally unhealthy or nutritionally inferior compared to conventional meat [12,54]. This was also seen in more recent studies [28,34]. Distinct from concerns about food safety, but similarly related to the perceived artificiality, concerns of this type relate to the relative healthiness of cultured meat [34].

Specht et al. [38] report that some Twitter users expressed generic health concerns about cultured meat, which seemed to be associated with its perception as unnatural. However, generally, these were outweighed in the online conversation by the possible health benefits from modifying the nutritional profile of cultured meat. More broadly, it seems that consumers assume cultured meat would not be as healthy as conventional meat [35].

Healthiness may be more or less important to different groups of consumers. Perceived healthiness was amongst the key predictors of the purchase intent in China according to Bryant et al. [21]. However, Dupont and Fiebelkorn [23] found that, interestingly, although their sample of German schoolchildren generally considered cultured meat less healthy than insects, they also tended to prefer it.

### 6.4. Trust

Trust was highlighted as a key issue in three studies, and though this was mentioned in some previous literature, our review did not explore this theme in detail [12]. Shaw and Mac Con Iomaire [35] highlight trust in their focus groups with Irish consumers. Consumers expressed both distrust in food companies and food labelling, as well as an explicit trust in Irish meat and Irish farming. This was particularly prevalent for rural participants, who may have felt a personal connection to the source of the meat, a level of personal assurance it would be hard to emulate in the scale of a large cultured meat company.

Trust in the regulatory bodies responsible for ensuring food safety is also an issue of importance. Zhang, Li and Bai [33] found that consumers who had more trust in food safety government bodies were more accepting of cultured meat, and argue that informing consumers about the benefits of cultured meat via trusted sources can increase acceptance in China in particular.

Finally, Wilks et al. [32] found that a distrust of food scientists predicted the rejection of cultured meat, whilst conspiratorial ideation predicted absolute opposition to cultured meat. This appears to suggest that conspiracy-inclined people who are inclined to distrust science, and perhaps institutions more broadly, are likely to oppose cultured meat.

### 6.5. Disgust

Our previous review identified several studies which mentioned disgust, and this was generally connected to the perceived unnaturalness [12,39,53]. Building on this theme, many recent studies mentioned disgust as a barrier to cultured meat adoption [12,21] [31,34]. Disgust sensitivity and experienced disgust have been shown to predict cultured meat rejection [23,31,32], though interestingly cross-country studies suggest that this may be more influential in Western cultures [21].

Research has indicated that consumers find cultured meat less disgusting than GMOs [24] and eating insects [23,34], but more disgusting than synthetic food additives and similar food technology plant products [24,34]. Interestingly, Dupont and Fiebelkorn [23] found that their sample judged cultured meat to be less disgusting than eating insects, although they judged eating insects to be more natural and more healthy, indicating that a disgust reaction can be independent of evaluations which seem to be related. Similarly, Egolf et al. [24] found that although participants found cultured meat more disgusting than a synthetic food additive, they also judged its benefits to society to be greater. Again, this highlights the emotional nature of the disgust response, and shows how it can occur independently of rational evaluations.

The heuristic associative emotional nature of the disgust responses is neatly illustrated in an experimental study by Geipel et al. [16]. The researchers found that German participants were more willing to try cultured meat when they were asked about it in their non-native English rather than their native German, and that this effect was mediated by evoked disgust. Similarly, Bryant and Barnett [14] find that the positivity of associations was the key factor accounting for differences in the attitudes related to different cultured meat names.

Previous research has linked this disgust to the perceived unnaturalness of food in Western cultures [62], though more recent work contends that it instead stems from norm violation [17]. This is an important distinction, because if we are addressing norm-violating moral disgust rather than food-related disgust, such objections are more likely to be surmountable in the future as cultured meat becomes more familiar. Indeed, this gives credence to the view that consumers objecting to the “unnaturalness” of cultured meat are often objecting in fact to its unfamiliarity.

### 6.6. Neophobia

Whilst studies in our previous review alluded to an aversion to an altogether novel food, this was not discussed in terms of neophobia [12]. Food neophobia [63] has been identified as a key predictor of cultured meat rejection across countries in America, Europe, and Asia [21,23,32]. Grasso et al. [27] identified “food fussiness” as a barrier for cultured meat acceptance amongst older consumers in Europe. This may encompass some concepts of food neophobia alongside strong preferences for food to be prepared and served in a specific familiar way. Indeed, for some consumers, any type of novelty may be unwelcome. One exception of note here is Gomez-Luciano et al. [25], who report that neither food neophobia nor food technology neophobia predicted cultured meat rejection in their international sample, with the exception of food neophobia in Brazil.

### 6.7. Economic Anxieties

Consumers had concerns about the affordability of cultured meat (see Section 7.1) but some also had broader economic anxieties about the impact of the technology on farming and rural communities [22]. Shaw and Mac Con Iomaire [35] identified concern for farmers as a salient issue in their Irish focus groups. In particular, participants were aware of the centrality of beef farming to Ireland’s rural economy, and wondered what impact cultured meat production would have on Irish farmers. Indeed, it is likely that cultured meat could result in fewer agricultural jobs [47]. Some experts and stakeholders have characterized cultured meat as an opportunity to re-evaluate the way we do agriculture [43]. This was mentioned in our previous review, but it is unclear whether such concerns would drive purchasing behavior in practice [12].

### 6.8. Ethical Concerns

As we observed in our previous review, some studies discuss specific ethical concerns, like the possibility that cultured meat could harm animals from whom cells are taken [12,22] or that the industry may end up controlled by agents' whose interests are less noble than those of the pioneers, who are themselves often vegan [37,64]. However, it seems more common that consumers have general moral concerns about cultured meat, which are likely related to the theme of unnaturalness [22].

Koch et al. [17] found that a key mechanism underpinning the rejection of cultured meat was moral disgust, which they demonstrate is linked to norm violation. Relatedly, Bryant et al. [21] found substantially higher levels of acceptance of cultured meat from "normal" food animal species (cows, pigs, chickens, and fish in the West) compared to cultured meat from animals not normally eaten in the culture such as horses and dogs. Whilst there is no difference in principle in the morality of eating cultured meat from a pig or cultured meat from a dog, it is clear that the non-normalness of the latter means it is something that far fewer people would want to do. This finding is important because it suggests that, whilst discussions about cultured meat from unusual species and even "ethical cannibalism" [65] are philosophically interesting, products from non-traditional meat species are unlikely to find a large consumer base, and may arouse or exacerbate moral concerns with cultured meat.

## 7. Key Uncertainties

Research increasingly points to the importance of price and taste in consumer decisions about food [66,67]. These are two key points which will decide the fate of cultured meat to a large extent, and they are well explored in new research.

### 7.1. Price

The importance of cultured meat prices for consumers has been highlighted in several studies, and an anticipated high price was a perceived barrier to buying cultured meat identified by studies in our previous review [12,40,54]. Price was highlighted as the major concern for Brazilian consumers by Valente et al. [30], whilst Gomez-Luciano et al. [26] found that price was a predictor of the purchase intent in three of the four countries in their survey. The authors found that price tended to be more important to consumers than factors such as neophobia [25], commenting that overall, reducing the price of cultured meat will be crucial for mainstream consumers. Interestingly, their data showed that participants in the Dominican Republic were the most likely to expect cultured meat to be cheaper than conventional meat, while Brazilians were the most likely to expect it to be more expensive.

There is mixed evidence on the willingness to pay a premium for cultured meat. Mancini & Antonioli [28] found that roughly equal proportions of their sample were willing to pay a premium (23.2%), were "maybe" willing to pay a premium (20.8%), and were not willing to pay a premium (26.7%; those who indicated they would not try cultured meat did not answer this question). However, Shaw and Mac Con Iomaire [35] found that both rural and urban Irish consumers would expect to pay less money for cultured meat.

Conversely, Rolland et al. [19] found that, with participants who had tasted and broadly liked "cultured meat", 58% were willing to pay a premium, averaging 37% above the price of conventional meat. This reflects a higher willingness to pay than other studies, most likely due to the circumstance of having a sensory experience with what participants believed to be cultured meat. However, the researchers also observed that price was by far the most common form of negative comment, accounting for 36% of negative remarks (not all participants made negative remarks). This suggests that some consumers are likely to be willing to pay a premium, but others certainly are not and will be price sensitive. Mancini and Antonioli [18] found that the willingness to pay a premium was increased with additional information.

## 7.2. Sensory Experience

In our previous review, we found some evidence that consumers tended to expect cultured meat to be worse tasting than conventional meat, and to have an inferior texture and appearance [12,46,53]. More recent evidence suggests that consumers have relatively low expectations for the taste of cultured meat, tending to view it as not fresh, lacking in taste, and worse than conventional meat [34,35]. Moreover, Mancini and Antonioli [28] show that expected taste strongly predicted purchase intent, demonstrating a need to reassure consumers of the sensory experience of cultured meat as a central feature of messaging.

However, some findings can reframe these low consumer expectations as an opportunity. Rolland et al. [19] found that consumers who tried two pieces of the same meat rated a piece marked 'cultured meat' as being tastier than a piece marked 'conventional meat'. It is likely that this occurred due to their prior expectations of the cultured meat tasting worse, and pleasant surprise on finding it did not. Taste was amongst the most common themes in the positive remarks participants made in this study.

It is important to highlight sensory attributes other than taste: indeed, flavor may be less important of an important factor for meat consumers than textural characteristics such as tenderness and juiciness [68]. This is an area where consumers anticipate a particular deficit, often expressing that cultured meat is likely to be mushy or have an otherwise unappealing texture [12].

## 8. Increasing Acceptance

Our previous review included some studies which showed that additional information about cultured meat could influence consumers' views, and that less technical explanations and higher perceived market share were associated with increased acceptance [12,39,40,69]. This section will discuss experimental studies which demonstrated an effect on acceptance of certain interventions.

Several recent studies have demonstrated that cultured meat acceptance can be increased by providing additional positive information. Zhang, Li and Bai [33] found that providing additional information about the environmental benefits of cultured meat increased acceptance amongst urban Chinese consumers. Mancini and Antonioli [18] found that providing additional positive information about cultured meat significantly increased the various measures of acceptance including the willingness to buy, but not the willingness to try.

Rolland et al. [19] found that additional information about the various benefits of cultured meat significantly increased acceptance, and tasting what participants thought to be cultured meat significantly increased acceptance further. The authors tested three types of information (societal benefits, personal benefits, and meat quality and taste). They found that, while all three led to significant increases in acceptance, information about the personal benefits led to a significantly greater increase than the other information conditions. This provides evidence that messages aiming to persuade consumers to adopt cultured meat should focus primarily on the benefits to the consumer (rather than the benefits to society, the environment, or animals). Verbeke et al. [53] noted that the latter tend to be more obvious to participants to begin with.

Nomenclature and terminology are also important. Bryant and Barnett [14] found that different names had a significant effect on the measures of acceptance. We found that "clean meat" led to a significantly higher acceptance than "lab grown meat", with "cultured meat" and "animal-free meat" scoring somewhere in between. Further, we showed that the difference between groups was accounted for by the positivity of associations participants gave. This indicates that the mechanism by which nomenclature affects acceptance is by anchoring to concepts which are more or less appealing in the context. Similarly, Geipel et al. [16] found that German participants reading about cultured meat in their non-native English (vs. their native German) experienced less disgust, and subsequently had a higher willingness to eat it. The authors note that this foreign language effect has been observed in other contexts, appearing to make people behave in a more utilitarian manner [70].

Another issue impacting cultured meat acceptance is framing. Bryant & Dillard [15] found that frames which emphasized the societal benefits of cultured meat or its similarity to conventional meat led to significantly higher measures of acceptance compared to frames which emphasized the cutting-edge science aspect of the technology. We note that, while this frame, including imagery such as test tubes and lab coats, is less conducive to acceptance, it has understandably been one of the major frames used to discuss the topic in the media.

Finally, Bryant et al. [13] found modest differences between experimental groups who read different messages about naturalness. A group who read about the unnaturalness of conventional meat were more persuaded than groups who read about the naturalness of cultured meat, or the irrelevance of naturalness. Manipulation checks indicated that the latter two frames here were ineffective at changing the targeted belief, and they were subsequently less persuasive than a control group, which read about the benefits of cultured meat unrelated to naturalness. This is evidence that drawing comparisons to the existing system is an effective method for dealing with charges of unnaturalness. As other research has noted, reflecting on cultured meat may represent an opportunity to reflect on conventional meat, and realize that existing production methods are far from ideal [37].

## 9. Discussion

The themes and trends observed in this review can inform strategies for increasing the future market share of cultured meat, displacing more of the demand for meat from animals and the harm that its production entails. In particular, there are lessons for cultured meat advocates in terms of market segmentation, message content, and marketing strategy.

First, there is good evidence that different profiles of consumers are likely to prefer different forms of alternative protein. Cultured meat, therefore, will be one of several types of alternative protein competing in the market alongside plant-based meat, insects, and other protein sources. Evidence suggests that cultured meat is likely to be particularly appealing to the heaviest meat-eaters [21, 22], and that it is likely to be particularly unappealing to those high in disgust sensitivity and/or neophobia [21,32]. Acknowledging a wide range in the perceptions of cultured meat, producers should focus initially on those most enthusiastic consumers until the price decreases and the concept becomes more familiar.

Secondly, pro-cultured meat messages may take a variety of approaches. Generally, rather than responding to the criticism that cultured meat is unnatural, advocates should focus on the benefits that the technology can bring [13,44]. Marketers may choose to lean into the moral uncertainty around conventional animal agriculture, bringing attention to an ethical issue which many meat-eaters do not typically think about and framing cultured meat as the transparent and trustworthy option. However, producers should take care when moralizing the issue, since this approach could be off-putting not only to consumers, but also to conventional meat producers, whose investment may be vital to their success [13].

Other messages may highlight the environmental benefits of cultured meat, though some evidence suggests that messages focusing on the personal benefits, such as improvements to product healthiness and safety, are likely to be the most persuasive [19]. Indeed, a focus on the potential safety benefits of cultured meat in terms of avoiding antibiotic resistance and zoonotic pandemics could be especially effective, as it addresses one of the most common concerns about cultured meat (food safety) in a frame which compares it to the current system, which many view as far from ideal [37].

Thirdly, the long-term success of cultured meat will depend on its ability to compete with conventional meat in terms of price and taste. Experts generally agree that cultured meat is unlikely to be price competitive with conventional meat in the near future [43,61]. This is seen as a significant barrier to mainstream adoption, and some have suggested that cultured meat will cater to an elite niche [43] or will need to offer consumers additional health benefits to justify the higher price [61]. As with any technology, it is likely that the price of cultured meat will fall over time as producers compete and production methods become more efficient. Recent public statements from cultured meat

companies have suggested that cultured meat products will indeed have a price premium, though prices being suggested are closer to 10 USD per patty [71] or as low as 10 USD per pound by 2022 [72]. These are far more realistic consumer prices than the 280,000 USD widely reported as the cost of the first cultured meat burger in 2013 [71].

Recent research validates the finding that most consumers anticipate cultured meat to have an inferior taste, texture, and appearance. This pessimism about the quality of cultured meat can be seen as an opportunity—cultured meat companies which can convincingly emulate the taste and texture of a burger patty stand to exceed consumers' expectations. Indeed, the high trialability of cultured meat compared to other technological innovations allows consumers to try the key aspects for themselves with little commitment [42]. Experts in the field view it as paramount to create a product which emulates not only the taste, but the texture and the smell of conventional meat [61].

## 10. Conclusions

Overall, recent research on the consumer acceptance of cultured meat confirms many of the broad findings observed in previous research, and develops these insights further to examine particular ways in which specific attitudes inform consumer opinions, how these may vary, and how they might be malleable to change.

The evidence suggests that, while most people see more societal benefits than personal benefits of eating cultured meat, there is a large potential market for cultured meat products in many countries around the world. Cultured meat is generally seen as more acceptable than other food technologies like GMOs, and more appealing than other alternative proteins like insects. Although it is not as broadly appealing as plant-based proteins, evidence suggests it may be more uniquely positioned to appeal to meat-lovers who are resistant to other alternative proteins, and it is more appealing to certain demographic groups.

Many consumers have mixed feelings about meat from animals, and often recognize the benefits of cultured meat for animals and the environment. The potential safety improvements or nutritional enhancements are currently areas where there could be benefits, but where consumers tend to perceive risks currently due to the perception of unnaturalness and violation of norms. Cultured meat producers and advocates should aim to build trust, facilitate understanding of the technology, and explain how cultured meat could improve outcomes in these areas. Since neophobia and norm violation play an important role in cultured meat rejection, it is likely that this will decrease over time.

Ultimately, the taste and price will be huge determinants of the market success of cultured meat. While some consumers may be willing to pay a premium for cultured meat, most are not, so displacing the serious demand for animal meat requires a price-competitive product. Consumers tend to have low expectations for the taste and texture of cultured meat, which may be a good thing for cultured meat producers. Unlike some other types of innovation, cultured meat is highly trialable [42], meaning that consumers can “try before they buy”. Consumers are much more likely to buy cultured meat if they are able to verify the taste first.

Attitudes towards cultured meat can be improved with information about its benefits, but the message's framing and the associations one provokes with one's language may be more important than the content of the message per se, at least in the short-term. Experts consider that the taste and texture are vitally important, as well as transparency around health and safety. They also project that cultured meat will be expensive at first, perhaps only available to elite consumers and possibly carrying health claims to justify the additional price.

Public perceptions of cultured meat are varied and consider a range of benefits and risks. Opinions are malleable by information and framing, but ultimately product characteristics such as price and taste will play a key role in determining the market success of cultured meat. Advocates should be wary of the associations consumers may form if they perceive cultured meat as unnatural—they may then infer that it is unhealthy or damaging to the environment.

Key issues like the health and safety of the meat supply can become talking points for the cultured meat industry, which currently suffers the intuition that its allegedly unnatural products could be unsafe, but in fact can improve the safety of the food supply. Highlighting ways that cultured meat can help avoid zoonotic disease outbreaks and reduce the use of antibiotics by removing unpredictable and dirty animals from the production process is likely to be an intuitively appealing message which turns a potential barrier into an argument in the technology's favor.

More broadly, developers of alternative proteins should be aware that cultured meat represents a product which is appealing to a certain type of consumer. Those who are concerned about naturalness might prefer to eat insects, while those who are lower in meat attachment or are vegetarian will prefer plant proteins. In the diverse protein landscape of the future, there is room for a variety of solutions.

**Author Contributions:** C.B. designed the protocol, conducted the literature search and review, wrote the first manuscript and conducted corrections after review. J.B. oversaw the protocol and literature review, edited the manuscript and supervised the project. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was part of CB's PhD project funded by the Economic and Social Research Council (Grant no. ES/J50015X/1). The APC was funded by this grant via the University of Bath Library.

**Conflicts of Interest:** C.B. is Director of Social Science for the Cellular Agriculture Society, a nonprofit seeking to advance the commercialization of cellular agriculture technologies including cultured meat, and consults for several companies and non-profits related to cultured meat and reducing animal product consumption. J.B. declares no conflict of interests.

## References

1. IPCC. Global Warming of 1.5° C: An IPCC Special Report on the Impacts of Global Warming of 1.5° C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways. In *the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*; Intergovernmental Panel on Climate Change: Geneva, Switzerland, 2018.
2. Lymbery, P.; Oakeshott, I. *Farmageddon: The True Cost of Cheap Meat*; Bloomsbury Publishing: London, UK, 2014.
3. Mathew, A.G.; Cissell, R.; Liamthong, S. Antibiotic Resistance in Bacteria Associated with Food Animals: A United States Perspective of Livestock Production. *Foodborne Pathog. Dis.* **2007**, *4*, 115–133. [[CrossRef](#)]
4. Oliver, S.; Murinda, S.E.; Jayarao, B.M. Impact of Antibiotic Use in Adult Dairy Cows on Antimicrobial Resistance of Veterinary and Human Pathogens: A Comprehensive Review. *Foodborne Pathog. Dis.* **2011**, *8*, 337–355. [[CrossRef](#)] [[PubMed](#)]
5. OECD/FAO. OECD-FAO Agricultural Outlook 2018–2027. 2018. Available online: <http://www.agri-outlook.org/commodities/Agricultural-Outlook-2018-Meat.pdf> (accessed on 20 June 2020).
6. Post, M.J.; Levenberg, S.; Kaplan, D.; Genovese, N.; Fu, J.; Bryant, C.J.; Negowetti, N.; Verzijden, K.; Moutsatsou, P. Scientific, sustainability and regulatory challenges of cultured meat. *Nat. Food* **2020**, *1*, 403–415. [[CrossRef](#)]
7. Tuomisto, H. The eco-friendly burger: Could cultured meat improve the environmental sustainability of meat products? *EMBO Rep.* **2019**, *20*, e47395. [[CrossRef](#)]
8. Post, M.J. Cultured meat from stem cells: Challenges and prospects. *Meat Sci.* **2012**, *92*, 297–301. [[CrossRef](#)] [[PubMed](#)]
9. Kateman, B. Will Cultured Meat Soon Be A Common Sight In Supermarkets Across The Globe? Available online: <https://www.forbes.com/sites/briankateman/2020/02/17/will-cultured-meat-soon-be-a-common-sight-in-supermarkets-across-the-globe/#651b62917c66> (accessed on 20 June 2020).
10. Purdy, C. *The Billion Dollar Burger*; Hachette: New York, NY, USA, 2020.
11. Foote, N. Cultured meat could be on the EU market 'as early as 2022'. Available online: <https://www.euractiv.com/section/agriculture-food/news/cultured-meat-could-be-on-the-eu-market-as-early-as-2022/> (accessed on 15 January 2020).
12. Bryant, C.; Barnett, J. Consumer acceptance of cultured meat: A systematic review. *Meat Sci.* **2018**, *143*, 8–17. [[CrossRef](#)] [[PubMed](#)]

13. Bryant, C.; Anderson, J.E.; Asher, K.E.; Green, C.; Gasteratos, K. Strategies for overcoming aversion to unnaturalness: The case of clean meat. *Meat Sci.* **2019**, *154*, 37–45. [[CrossRef](#)] [[PubMed](#)]
14. Bryant, C.; Barnett, J. What's in a name? Consumer perceptions of in vitro meat under different names. *Appetite* **2019**, *137*, 104–113. [[CrossRef](#)] [[PubMed](#)]
15. Bryant, C.; Dillard, C. The Impact of Framing on Acceptance of Cultured Meat. *Front. Nutr.* **2019**, *6*. [[CrossRef](#)]
16. Geipel, J.; Hadjichristidis, C.; Klesse, A.-K. Barriers to sustainable consumption attenuated by foreign language use. *Nat. Sustain.* **2018**, *1*, 31–33. [[CrossRef](#)]
17. Koch, J.; van Ittersum, K.; Bolterdijk, W. Disgusting? No, Just Different. Understanding Consumer Skepticism Towards Sustainable Food Innovations. *Adv. Consumer Res. N. Am. Adv.* **2018**, *46*, 1–12.
18. Mancini, M.C.; Antonioli, F. To What Extent Are Consumers' Perception and Acceptance of Alternative Meat Production Systems Affected by Information? The Case of Cultured Meat. *Animals* **2020**, *10*, 656. [[CrossRef](#)]
19. Rolland, N.C.M.; Markus, C.R.; Post, M.J. The effect of information content on acceptance of cultured meat in a tasting context. *PLoS ONE* **2020**, *15*, e0231176. [[CrossRef](#)]
20. Arora, R.S.; Brent, D.A.; Jaenicke, E.C. Is India Ready for Alt-Meat? Preferences and Willingness to Pay for Meat Alternatives. *Sustainability* **2020**, *12*, 4377. [[CrossRef](#)]
21. Bryant, C.; Szejda, K.; Parekh, N.; Desphande, V.; Tse, B. A Survey of Consumer Perceptions of Plant-Based and Clean Meat in the USA, India, and China. *Front. Sustain. Food Syst.* **2019**, *3*. [[CrossRef](#)]
22. Circus, V.E.; Robison, R. Exploring perceptions of sustainable proteins and meat attachment. *Br. Food J.* **2019**, *121*, 533–545. [[CrossRef](#)]
23. Dupont, J.; Fiebelkorn, F. Attitudes and acceptance of young people toward the consumption of insects and cultured meat in Germany. *Food Qual. Prefer.* **2020**, *85*, 103983. [[CrossRef](#)]
24. Egolf, A.; Hartmann, C.; Siegrist, M. When Evolution Works Against the Future: Disgust's Contributions to the Acceptance of New Food Technologies. *Risk Anal.* **2019**, *39*, 1546–1559. [[CrossRef](#)]
25. Gómez-Luciano, C.A.; De Aguiar, L.K.; Vriesekoop, F.; Urbano, B. Consumers' willingness to purchase three alternatives to meat proteins in the United Kingdom, Spain, Brazil and the Dominican Republic. *Food Qual. Prefer.* **2019**, *78*, 103732. [[CrossRef](#)]
26. Gijmez-Luciano, C.A.; Loyola, I.E.D.E.S.; Vriesekoop, F.; Urbano, B. Towards Food Security of Alternative Dietary Proteins: A Comparison between Spain and the Dominican Republic. *Amfiteatru Econ.* **2019**, *21*, 393–407. [[CrossRef](#)]
27. Grasso, A.; Hung, Y.; Olthof, M.R.; Verbeke, W.; Brouwer, I.A. Older Consumers' Readiness to Accept Alternative, More Sustainable Protein Sources in the European Union. *Nutrients* **2019**, *11*, 1904. [[CrossRef](#)] [[PubMed](#)]
28. Mancini, M.C.; Antonioli, F. Exploring consumers' attitude towards cultured meat in Italy. *Meat Sci.* **2019**, *150*, 101–110. [[CrossRef](#)] [[PubMed](#)]
29. Michel, F.; Siegrist, M. How should importance of naturalness be measured? A comparison of different scales. *Appetite* **2019**, *140*, 298–304. [[CrossRef](#)] [[PubMed](#)]
30. Valente, J.D.P.S.; Fiedler, R.A.; Heidemann, M.S.; Molento, C.F.M. First glimpse on attitudes of highly educated consumers towards cell-based meat and related issues in Brazil. *PLoS ONE* **2019**, *14*, e0221129. [[CrossRef](#)]
31. Weinrich, R.; Strack, M.; Neugebauer, F. Consumer acceptance of cultured meat in Germany. *Meat Sci.* **2020**, *162*, 107924. [[CrossRef](#)]
32. Wilks, M.; Phillips, C.; Fielding, K.; Hornsey, M. Testing potential psychological predictors of attitudes towards cultured meat. *Appetite* **2019**, *136*, 137–145. [[CrossRef](#)]
33. Zhang, M.; Li, L.; Bai, J. Consumer acceptance of cultured meat in urban areas of three cities in China. *Food Control.* **2020**, *118*, 107390. [[CrossRef](#)]
34. DLupton, D.; Turner, B. Food of the Future? Consumer Responses to the Idea of 3D-Printed Meat and Insect-Based Foods. *Food Foodways* **2018**, *26*, 269–289. [[CrossRef](#)]
35. Shaw, E.; Iomaire, M.M.C. A comparative analysis of the attitudes of rural and urban consumers towards cultured meat. *Br. Food J.* **2019**, *121*, 1782–1800. [[CrossRef](#)]
36. Tucker, C. Using environmental imperatives to reduce meat consumption: Perspectives from New Zealand. *Kōtuitui New Zealand J. Soc. Sci. Online* **2018**, *13*, 99–110. [[CrossRef](#)]

37. Van der Weele, C.; Driessen, C. How normal meat becomes stranger as cultured meat becomes more normal; Ambivalence and ambiguity below the surface of behaviour. *Front. Sustain. Food Syst.* **2019**, *3*, 69. [CrossRef]
38. Specht, A.R.; Rumble, J.N.; Buck, E.B. "You Call that Meat?" Investigating Social Media Conversations and Influencers Surrounding Cultured Meat. *J. Appl. Commun.* **2020**, *104*, 3. [CrossRef]
39. Slade, P. If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. *Appetite* **2018**, *125*, 428–437. [CrossRef] [PubMed]
40. Verbeke, W.; Sans, P.; Van Loo, E.J. Challenges and prospects for consumer acceptance of cultured meat. *J. Integr. Agric.* **2015**, *14*, 285–294. [CrossRef]
41. Wilks, M.; Phillips, C.J.C. Attitudes to in vitro meat: A survey of potential consumers in the United States. *PLoS ONE* **2017**, *12*, e0171904. [CrossRef] [PubMed]
42. Rogers, E. *Diffusion of Innovations*; Free Press: New York, NY, USA, 2003.
43. Böhm, I.; Ferrari, A.; Woll, S. Visions of In Vitro Meat among Experts and Stakeholders. *NanoEthics* **2018**, *12*, 211–224. [CrossRef]
44. Mohorčič, J.; Reese, J. Cell-cultured meat: Lessons from GMO adoption and resistance. *Appetite* **2019**, *143*, 104408. [CrossRef]
45. Lamb, C. Cultured Meat Will Likely Debut in Asia, Not Silicon Valley, Here's Why. Available online: <https://thespoon.tech/cultured-meat-will-likely-debut-in-asia-not-silicon-valley-heres-why/> (accessed on 19 March 2019).
46. Tucker, C. The significance of sensory appeal for reduced meat consumption. *Appetite* **2014**, *81*, 168–179. [CrossRef]
47. Bryant, C. Culture, Meat, and cultured meat. *J. An. Sci.* **2015**, *109*, 2–12.
48. Anderson, J.; Tyler, L. Attitudes Toward Farmed Animals in the BRIC Countries. Available online: <https://faunalytics.org/wp-content/uploads/2018/09/BRIC-Full-Report.pdf> (accessed on 20 June 2020).
49. Bryant, C. A Guide to Effective Animal Campaigning. Available online: <https://www.vegansociety.com/about-us/research/research-news/project-update-guide-effective-animal-campaigning> (accessed on 20 June 2020).
50. Rothgerber, H. Meat-related cognitive dissonance: A conceptual framework for understanding how meat eaters reduce negative arousal from eating animals. *Appetite* **2020**, *146*, 104511. [CrossRef]
51. Wilks, M. Cultured Meat Seems Gross? It's Much Better than Animal Agriculture. 27 February 2019. Available online: <https://theconversation.com/cultured-meat-seems-gross-its-much-better-than-animal-agriculture-109706> (accessed on 20 June 2020).
52. Ward, E.; Oven, A.; Bethencourt, R. *The Clean Pet Food Revolution*; Lantern Books: Brooklyn, NY, USA, 2019.
53. Verbeke, W.; Marcu, A.; Rutsaert, P.; Gaspar, R.; Seibt, B.; Fletcher, D.; Barnett, J. Would you eat cultured meat?: Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Sci.* **2015**, *102*, 49–58. [CrossRef] [PubMed]
54. I Laestadius, L.; Caldwell, M. Is the future of meat palatable? Perceptions of in vitro meat as evidenced by online news comments. *Public Heal. Nutr.* **2015**, *18*, 2457–2467. [CrossRef] [PubMed]
55. Bekker, G.A.; Tobi, H.; Fischer, A.R. Meet meat: An explorative study on meat and cultured meat as seen by Chinese, Ethiopians and Dutch. *Appetite* **2017**, *114*, 82–92. [CrossRef]
56. Huehnergath, N. China's Food Safety Issues Worse Than You Thought. Available online: <https://www.foodsafetynews.com/2014/07/chinas-food-safety-issues-are-worse-than-you-thought/> (accessed on 11 July 2014).
57. I Laestadius, L. Public Perceptions of the Ethics of In-vitro Meat: Determining an Appropriate Course of Action. *J. Agric. Environ. Ethic.* **2015**, *28*, 991–1009. [CrossRef]
58. Marcu, A.; Gaspar, R.; Rutsaert, P.; Seibt, B.; Fletcher, D.; Verbeke, W.; Barnett, J.; Carvalho, R. Analogies, metaphors, and wondering about the future: Lay sense-making around synthetic meat. *Public Underst. Sci.* **2014**, *24*, 547–562. [CrossRef]
59. Surveygoo. Nearly one in Three Consumers Willing to Eat Lab-Grown Meat, According to New Research. 2018. Available online: <https://www.datasmoothie.com/@surveygoo/nearly-one-in-three-consumers-willing-to-eat-lab-g/> (accessed on 20 June 2020).
60. Siegrist, M.; Sütterlin, B. Importance of perceived naturalness for acceptance of food additives and cultured meat. *Appetite* **2017**, *113*, 320–326. [CrossRef] [PubMed]

61. Tiberius, V.; Borning, J.; Seeler, S. Setting the table for meat consumers: An international Delphi study on in vitro meat. *NPJ Sci. Food* **2019**, *3*, 10. [[CrossRef](#)]
62. MSiegrist, M.; Sütterlin, B.; Hartmann, C. Perceived naturalness and evoked disgust influence acceptance of cultured meat. *Meat Sci.* **2018**, *139*, 213–219. [[CrossRef](#)]
63. Pliner, P.; Hobden, K. Development of a scale to measure the trait of food neophobia in humans. *Appetite* **1992**, *19*, 105–120. [[CrossRef](#)]
64. Stephens, N.; Di Silvio, L.; Dunsford, I.; Ellis, M.; Glencross, A.; Sexton, A. Bringing cultured meat to market: Technical, socio-political, and regulatory challenges in cellular agriculture. *Trends Food Sci. Technol.* **2018**, *78*, 155–166. [[CrossRef](#)]
65. Milburn, J. Chewing Over In Vitro Meat: Animal Ethics, Cannibalism and Social Progress. *Res. Publica* **2016**, *22*, 249–265. [[CrossRef](#)]
66. Fotopoulos, C.; Krystallis, A.; Vassallo, M.; Pagiaslis, A. Food Choice Questionnaire (FCQ) revisited. Suggestions for the development of an enhanced general food motivation model. *Appetite* **2009**, *52*, 199–208. [[CrossRef](#)] [[PubMed](#)]
67. Januszewska, R.; Pieniak, Z.; Verbeke, W. Food choice questionnaire revisited in four countries. Does it still measure the same? *Appetite* **2011**, *57*, 94–98. [[CrossRef](#)]
68. Ramalingam, V.; Song, Z.; Hwang, I.; Zhen, S. The potential role of secondary metabolites in modulating the flavor and taste of the meat. *Food Res. Int.* **2019**, *122*, 174–182. [[CrossRef](#)] [[PubMed](#)]
69. Bekker, G.A.; Fischer, A.R.H.; Tobi, H.; Van Trijp, H.C. Explicit and implicit attitude toward an emerging food technology: The case of cultured meat. *Appetite* **2017**, *108*, 245–254. [[CrossRef](#)]
70. Costa, A.; Foucart, A.; Hayakawa, S.; Aparici, M.; Apesteguia, J.; Heafner, J.; Keysar, B. Your Morals Depend on Language. *PLoS ONE* **2014**, *9*, e94842. [[CrossRef](#)]
71. González, A.; Koltowitz, S. The \$280,000 Lab-Grown Burger Could be a More Palatable \$10 in two Years. Available online: <https://uk.reuters.com/article/us-food-tech-labmeat/the-280000-lab-grown-burger-could-be-a-more-palatable-10-in-two-years-idUKKCN1U41W8> (accessed on 9 July 2019).
72. Lucas, A. Lab-Grown Meat Start-up Raises \$14 Million to Build Production Plant. Available online: <https://www.cnn.com/2019/10/10/future-meat-technologies-a-lab-grown-meat-start-up-raises-14-million-dollars.html> (accessed on 10 October 2019).



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).