



This document is a postprint version of an article published in Meat Science© Elsevier after peer review. To access the final edited and published work see <https://doi.org/10.1016/j.meatsci.2022.108941>

Document downloaded from:



1 **Understanding the future meat consumers**

2 Maria Font-i-Furnols* & Luis Guerrero

3 IRTA-Food Quality and Technology, Finca Camps i Armet, 17121 Monells (Girona), Spain

4 *Corresponding author: maria.font@irta.cat

5

6 **Abstract**

7 Revered, desired, hated and even persecuted, meat leaves almost no one indifferent. It is a
8 fundamental element of our culture and traditions, and gives rise to numerous controversies,
9 trends and social movements. Currently, there are many dilemmas raised by its production and
10 consumption, from ethical and moral to environmental, economic and health. This paper
11 focuses on examining and analysing some of these dilemmas, related to ethical and socio-
12 cultural issues, animal welfare, sustainability and meat alternatives, from a consumer
13 perspective and their impact on current and future meat consumption. In the coming years,
14 the meat sector will have to face many challenges to ensure its survival, particularly in terms of
15 the ethical aspects of meat consumption and the environmental impact of meat production.
16 Listening to society's demands, adapting to them, and communicating progress in a truthful
17 and transparent manner are probably the keys to success and to the future of meat.

18 **Keywords:** socio-anthropological, pleasure, sustainability, animal welfare, cultured meat, meat
19 analogues

20

21 **1. Introduction**

22 Meat is probably the most controversial food today and is subject to the greatest number of
23 ethical and moral, health, environmental and even economic dilemmas (Macdiarmid et al.,
24 2016). Thus, we eat meat, but at the same time we care about animals and their welfare

25 (Bastian et al., 2012); it provides us with essential nutrients, although certain types of meat,
26 consumed in excess, seem to increase the risk of suffering from certain diseases (Godfray et
27 al., 2018); it generates sensory pleasure, identity, status (Piazza et al., 2015) and is closely
28 linked to numerous traditions (Leroy & Praet, 2015), but its high consumption is
29 environmentally unsustainable if advances in technology do not take place and/or if livestock
30 practices do not change (Hedenus et al., 2014) which is unlikely since efforts are focussed on
31 this issue (FAO, 2018; HLPE, 2016); finally, the global demand for meat generates economic
32 and social benefits to communities worldwide, but uncontrolled production comes at a high
33 cost to the planet (Capper, 2013). High quality animal-source food comes from livestock.
34 Moreover, livestock has social, economic, and environmental benefits because it provides
35 fertilizers, livelihood, rural and societal development, food and nutrition security,
36 environmental resilience, wealth storage, conservation and use of diversity, among others
37 (Capper, 2013; Dumont et al., 2019; FAO, 2018; Leroy et al., 2022). Consequently, a high
38 reduction of livestock or even abolishment of it, due to sustainable concerns or
39 implementation of veganism, would have important health, nutritional, social, economic and
40 environmental consequences (Leroy et al., 2020; 2022).

41 Attitudes and beliefs evolve throughout one's life influenced by the experiences, inclinations
42 and knowledge acquired (Font-i-Furnols & Guerrero, 2014). Aspects such as healthiness and
43 sustainability are becoming more and more important, thus shaping meat consumption habits.
44 Accordingly, consumer demand for a more sustainable and more ethical meat production is
45 increasing (European Commission, 2020). The livestock and meat processing sectors have
46 made efforts to adapt to the societal demands regarding climate change, environmental
47 impact, animal welfare, ethical issues, food security, safety and overall quality but still have
48 challenges to face in terms of global sustainability (Broom, 2021; Capper, 2013; Simões et al.,
49 2021).

50 Many consumers, have reduced or intend to reduce their meat consumption, either for health,
51 sustainability or ethical reasons (Hartmann & Siegrist, 2017; Sanchez-Sabate & Sabaté, 2019),
52 but the benefits of consuming meat cannot be forgotten (Leroy et al., 2022). Although this
53 reduction has taken place mainly in developed countries, where the meat consumption per
54 capita is higher, an increase of meat consumption is expected in developing countries, thus,
55 the global demand for meat will increase in the following decades. According to the FAO
56 (Alexandratos & Bruinsma, 2012), global agricultural production will need to increase 1.1% per
57 year until 2050 due to population growth and dietary changes. Similarly, livestock production
58 will need to increase, either by increasing the number of animals or increasing productivity.
59 However, it is essential to consider and control the possible harmful effects on the
60 environment and the impact on animal welfare. Other possibilities are the use of alternative
61 proteins, such as plant-based proteins, insects, mushrooms, pulses algae or cultured 'meat'
62 (Anusha Siddiqui et al., 2022; Onwezen et al., 2021; Zhang et al., 2022) but not forgetting that
63 meat is not only a source of protein but of other minerals, energy, fatty acids, vitamins and
64 essential amino acids which plants do not provide or have low bioavailability (Leroy et al.,
65 2022; Leroy & Barnard, 2020; Wood, 2017). In all cases, it is essential to explore consumer
66 attitudes towards these new protein sources and to consider how best to inform consumers
67 about the sustainability, safety and quality of the products that can be derived from them.
68 Scientific publications are usually a reflection of topics of potential interest or concern to the
69 population. To identify these, a brief literature review of recently published articles relating to
70 meat and consumers has been carried out. Figure 1 shows the most frequent words appearing
71 in the titles of reviews including the words "Meat" and "Consumer" from 1 January 2015 to 3
72 April 2022 in Web of Science (1173 articles in total). It is interesting to note that, of the total
73 number of review papers found using these search criteria since 1942 (2219), 53% (1173) have
74 been published in the last 7 years. These data indicate the importance that the perception of
75 meat has acquired in the last decade which has focused mainly on aspects relating to health,

76 sustainability in general and the environment in particular, animal welfare, meat analogues
77 and other potential meat substitutes (Figure 1). Except for those health-related issues, this
78 paper focuses on all these topics as well as including the ethical and socio-cultural aspects
79 associated with meat consumption.

80 **2. The origin**

81 Meat is a key element of our evolutionary heritage (Smil, 2013) that is rooted in many cultural
82 and social aspects today (Bulliet, 2005; deFrance, 2009; Leroy & Praet, 2015). It is difficult to
83 understand the role of meat in our cultures if we do not first analyse its origin and evolution in
84 human history. Many studies have shown the physiological and dietary importance of meat in
85 the sustainability and development of our ancestors (Smil, 2002). Thus, the consumption of
86 high-quality foods of animal origin may have facilitated the necessary bioenergetic
87 transformations that allowed the development of the human brain, energetically favoured by
88 the relative reduction of a metabolically costly intestinal system (Leroy & Praet, 2015).

89 Notably, young children, with their rapidly expanding brains and high metabolic and nutritional
90 demands relative to adults, would have benefitted from volumetrically concentrated, high-
91 quality foods such as meat (Siekmann et al., 2003). According to these authors, using animal
92 foods primarily to meet essential nutrient needs other than energy, and using plant sources
93 primarily for energy, is a dietary strategy compatible with human gut anatomy and digestive
94 kinetics.

95 From a more social perspective, it is worth highlighting the role of different strategies for meat
96 provisioning, which inevitably led to hunting in groups, turning humans into obliged
97 collaborators (Tomasello et al., 2012). Likewise, the perishable nature of meat may have
98 stimulated various socialisation behaviours. Due to the unpredictability of hunting, being able
99 to share meat decreased risks of shortage and provided less variation in its availability
100 (Hawkes, 1991). As a result, the social interactions of exchanging goods and services and

101 establishing long-term relationships could have originated from a set of commodities
102 exchangeable for meat, including sex, childcare, tool production and even support and
103 protection between groups or tribes (Gomes & Boesch, 2011). Thus, social activities, originally
104 aimed at stabilising the supply of meat, eventually led to more complex networks and
105 collective activities. It is curious to think that the sharing of food, and meat in particular,
106 served as a bonding mechanism (Bellasco, 2008), as well as an effective system of
107 communication, the formation of shared values and the development of feelings of affiliation,
108 hospitality, gratification and affection (Fiddes, 1991).

109 Apart of the hunting society there are also the domestic and post-domestic societies (Bulliet,
110 2005; Leroy, 2019; Leroy & Praet, 2017). In the domestic societies, meat consumption is
111 sporadic and related to special occasions. However, in the post-domestic societies, there is an
112 abundant meat consumption though production is purchased or subcontracted to
113 slaughterplants, and it is performed out of the cities and avoiding references to the live animal
114 (Leroy & Praet, 2017). In this post-domestic society, aspects such as animal welfare,
115 sustainability and meat alternatives, relative to meat consumption, become important, and
116 tendencies to reduce or avoid meat seem to become fashion in some societies. It is also
117 important to be aware of the proliferation of fake news relative to meat production and
118 consumption consequences, that can confuse consumers and damage the different
119 stakeholders of the meat sector.

120

121 **3. Ethical and socio-cultural role of meat**

122 Nowadays, unlike other foods, the procurement of meat and its preparation continue to have
123 a markedly masculine character, especially on special occasions (Fiddes, 1991), where,
124 curiously, cooking tends to be public and outdoors with the use of fire (Sobal, 2005). According
125 to Graça et al. (2014), meat consumption continues to affirm a sense of belonging, enhancing

126 gastronomic traditions and collective identity. Meat remains a central part of various religious
127 celebrations as well as local festivals (Smil, 2013). Indeed, the central place of meat in
128 contemporary Western diets is thought to be largely due to its connotations of success and
129 power (Bellasco, 2008) and, also, because it provides essential and high quality nutrients. Not
130 surprisingly, many people do not consider a meal to be complete without the presence of
131 animal protein (Sobal, 2005). Cultural predispositions and prescriptions will continue to be
132 important factors in defining future meat consumption trends, although it is difficult to know
133 whether meat will maintain its central role in Western diets as different attitudes and moral
134 stances develop (Holm & Møhl, 2000), especially in certain population groups such as women
135 and young people (Sanchez-Sabate & Sabaté, 2019). It is also difficult to know if meat will
136 become part of the meal in societies where today it is not present, either for cultural or
137 economic reasons.

138 People's relationships with animals are very complex. Thus, although many people enjoy
139 animals and spend large amounts of money each year on the care and maintenance of their
140 pets, the majority of the population continues to consume animals (Herzog, 2010). People
141 employ a range of strategies to overcome this apparent attitudinal and behavioural
142 contradiction to deal with the 'meat paradox' (Herzog, 2010; Loughnan et al., 2014). Not
143 wanting to harm animals and, at the same time, enjoying meat as a dietary staple causes an
144 internal conflict or cognitive dissonance (Cooper, 2007), of which the magnitude depends on
145 the number and relevance of the cognitions (Harmon-Jones & Mills, 2019). The resolution of
146 this conflict can take two different routes: rejecting meat consumption and aligning behaviour
147 with moral ideals; or aligning individual beliefs and attitudes with behaviour through various
148 psychological mechanisms or changes in the organization of the society. The fact that most of
149 the world's population continues to consume meat indicates that the latter pathway is the one
150 more widely adopted. However, it is important to take into account that in the post-domestic
151 societies, some activists and advocates of meat alternatives talk about the abolishment of

152 livestock and this could have important consequences from health, sustainability and ethical
153 points of view (Leroy et al., 2022). One of the psychological mechanisms of self-protection is
154 rationalisation, i.e. offering defensible reasons and arguments for one's actions when they are
155 questioned or criticised (Kunda, 1990). This process is an essential part of human socialisation,
156 as we normally live in close-knit social groups where it is very important to manage and defend
157 one's actions to others (Ingram et al., 2009). Within these arguments, avoiding the
158 humanisation of animals and denying that they have mental capacities such as the possibility
159 of suffering or experiencing pleasure is a fairly common strategy (Rothgerber, 2014). This is in
160 line with Descartes' theory about animals' being conscious automata and not being 'self-
161 conscious' as humans (Smith, 1998). Harming animals is only problematic if animals are
162 thought to have moral rights. Denying animals emotions is a subtle way of excluding them
163 from moral concern. Classifying animals into different categories (e.g. food or pets) can have
164 wide consequences for their treatment (Herzog, 2010). Simply considering an animal as food
165 serves to suppress its moral rights (Loughnan et al., 2012). According to Piazza et al. (2015) the
166 4Ns (natural, normal, necessary, and nice) are a tool frequently used by consumers to dilute
167 the sense of guilt experienced when consuming animal products. Of these, beliefs about the
168 need to eat meat, and the pleasure derived from it, seem to be the least justifiable, while
169 beliefs about the naturalness of eating meat are the most persistent and difficult to neutralise.
170 According to these authors, people who use the 4Ns as a justification for their meat
171 consumption are usually less concerned about ethical and moral issues related to animals or
172 the environment. According to Rothgerber (2014), the three basic coping mechanisms for
173 cognitive dissonance, applied to reduce the discomfort of eating animals, are: (1) hiding or
174 avoiding the harm, possibly by making the victim invisible (*i.e.* avoidance of unpleasant
175 thoughts, dissociation between animal and food, and perceived behavioural change); (2)
176 denying one's own role or responsibility in causing the harm (*i.e.* denial animal pain, denial
177 animal mind and pro-meat justifications); and (3) denigrating the victim (*i.e.* reduction of

178 perceived choice and pro-meat justifications related to meat taste, animals hierarchy or
179 religious justification). In this regard it is worth noting that most consumers do not think about
180 the suffering of animals when they buy meat (Font-i-Furnols & Guerrero, 2014; Guerrero et al.,
181 2013; Mayfield et al., 2007). This meat-animal dissociation strategy could explain why the
182 more meat resembles the real animal (e.g. the redder, bloodier and fattier it is), the more
183 repulsive it is to individuals (Kubberød et al., 2002). Exposure to live animals, their death or
184 their carcasses are strong triggers of cognitive dissonance (Dowsett et al., 2018). Interestingly,
185 dissociation can also be observed at the linguistic level, demonstrating its cultural
186 embeddedness. For example, in English, animals that are consumed are referred to by
187 different terms such as pork (not pig), beef (not cow) and veal (not calf) (Benningstad & Kunst,
188 2020).

189 Introducing changes in consumer behaviour aimed at a more reasonable and sustainable
190 consumption of meat does not seem a simple task as changing such deep-rooted and ancestral
191 beliefs, habits and traditions requires well-planned and properly executed actions. As stated by
192 Graça et al. (2015), there is a strong positive emotional attachment to meat that constitutes an
193 important motivational barrier to its reduction in the diet. Many consumers find it difficult to
194 control their meat intake when the majority of their family and friends consume meat,
195 highlighting the role of the social pressure (Biermann & Rau, 2020). Also, as De Backer et al.
196 (2020) state, eating practices based on male stereotypes do not help to reduce meat
197 consumption. It should not be forgotten that the pleasure of eating meat, together with the
198 belief that it contains important nutrients that cannot be substituted, are two additional
199 barriers that also hinder a more reasonable consumption of meat (Corrin & Papadopoulos,
200 2017). In this regard, Michel et al. (2021) found that the most frequent association with meat
201 was "delicious", highlighting its sensory value as an element of indulgence (Jahn et al., 2021).
202 The process of cooking and eating is often deeply connected to social norms and rituals, and
203 the underlying legacy of "meat traditions" provides a strong barrier to its reduction. For

204 centuries, human society and meat have developed in parallel, giving rise to deep-rooted
205 traditions and rituals around hunting, slaughtering, cooking and eating meat (Leroy & Praet,
206 2015). As Rothgerber (2014) mentions, negative campaigning about meat is often
207 counterproductive, as it can ultimately increase cognitive dissonance, which is reduced by
208 creating justifications that further stimulate meat consumption. However, other actions such
209 as exposure to friendly animal characters (either companion, farm or wild animals) in movies,
210 television, books, as well as through toys, stuffed animals, etc. (Figure 2), play a central role in
211 children's early experiences (Melson, 2005) and, especially those related to farm animals, may
212 have a positive effect in the medium to long term on the regulation of meat consumption. The
213 study by Rothgerber and Mican (2014) showed that pet ownership in childhood increased the
214 perception of human-animal similarities. When the humanization of animals are emphasised,
215 our moral concern for their rights increases and our willingness to eat them decreases
216 (Loughnan et al., 2012).

217 **4. (Un)Sustainable meat**

218 Sustainable healthy diets are defined as *'dietary patterns that promote all dimensions of*
219 *individuals' health and wellbeing; have low environmental pressure and impact; are accessible,*
220 *affordable, safe and equitable, and culturally acceptable"* (FAO & WHO, 2019). Traditionally,
221 sustainability has been addressed from a tripartite approach, integrating environmental
222 protection, social equity in terms of closing the gap between industrialised and developing
223 countries, and economic viability (United Nations, 2005). Hanss and Böhm (2012) go a step
224 further by defining five dimensions of sustainability: (i) an environmental dimension
225 (preservation of natural resources); (ii) a social dimension (improvement of living conditions
226 and equal opportunities for all); (iii) an economic dimension (economic viability and economic
227 growth that guarantees human well-being); (iv) a temporal dimension considering the needs of
228 current and future generations; and (v) a development dimension that allows sustainability to
229 be achieved. According to these authors, these five dimensions play a fundamental role in

230 consumers' understanding of the concept of sustainability, albeit at different levels. However,
231 it is worthwhile stating that, although most of the consumers have heard about sustainability,
232 it is a very broad term that has many aspects often unknown to most of the consumers. In
233 general, most people have a limited or biased knowledge of this concept, and mainly associate
234 it with environmental issues and, to a lesser extent, with ethical or economic issues (Blanco-
235 Penedo et al., 2021; Grunert et al., 2014; Hanss & Böhm, 2012).

236 It is evident that the growth of the world population and the increase in income has favoured
237 meat consumption (de Boer et al., 2014; Godfray et al., 2018). However, health, social and
238 environmental issues associated with high levels of animal-based food consumption have
239 increased concerns and brought about calls for a reduction in the amount of meat we eat
240 (Apostolidis & McLeay, 2016), despite the fact that many consumers consider meat products
241 to be an important source of nutrients and an indispensable traditional component of their
242 diet (Verbeke et al., 2010). According to Hallström et al. (2014) meat products have an
243 inefficient conversion rate (amount of feed vs. amount of protein obtained), generate high
244 greenhouse gas emissions, promote deforestation, cause biodiversity loss and may even pose
245 risks to food security. Even though all these negative effects depend on the characteristics of
246 each production system and metric used to calculate them (van Eenennaam & Werth, 2021).
247 However, as discussed above, reducing the amount of meat we consume requires a profound
248 social transition (Apostolidis & McLeay, 2016) as meat has a fundamental socio-cultural role
249 and is one of the most popular food products, valued not only for the pleasure of eating it but
250 also because it is generally perceived as a healthy food (Font-i-Furnols & Guerrero, 2014).
251 Additionally, consumers' preferences, behaviour and attitude towards sustainability are
252 influenced by socio-demographic characteristics, culture and tradition, life values and a food
253 related lifestyle (Grunert et al., 2014; Janssen et al., 2016; Verain et al., 2012). Other social
254 aspects to be taken into consideration when talking about perception of sustainability by
255 consumers are related to values and attitudes linked to human protection, preservation of

256 cultural differences, and aspects related to bias in distribution of natural resources and goods,
257 social welfare and fair trade (Hanss & Böhm, 2012). Some of these can also be linked to a
258 perception of sustainability relating to meat production and consumption.

259 Although sustainability and environmental concerns have been around for many years, their
260 impact on consumer decision-making regarding meat consumption has had very little influence
261 (Jahn et al., 2021). One of the reasons for this, is the low awareness of the negative
262 environmental impact associated with the production and excessive consumption of meat
263 (Hartmann & Siegrist, 2017; Lentz et al., 2018), although in some countries this perception
264 seems more important (Hocquette et al., 2022). Moreover, coupled with this lack of
265 awareness, the perception that personal meat consumption plays a minimal role in the overall
266 context of climate change, and resistance to the idea of reducing personal meat consumption,
267 explains why meat consumption is not noticeably decreasing in some developed countries
268 (Macdiarmid et al., 2016; Tonsor & Lusk, 2022; Dagevos & Verbeke, 2022). However, in other
269 countries the decrease in meat consumption seems more important (Font-i-Furnols &
270 Guerrero, 2022; Ngapo, 2022; Dagevos & Verbeke, 2022) or there have been changes in the
271 type of meat consumed mainly due to price and health reasons (Realini et al., 2022; Hötzel &
272 Vandresen, 2022). According to Macdiarmid et al. (2016), even consumers who are more or
273 less aware of the relationship between meat consumption and environmental impact are
274 rather sceptical about the existing scientific evidence, considering that changing non-food
275 related behaviours are more acceptable and take priority in mitigating climate change. This
276 sceptical position might have changed during the last years, at least for consumers who have
277 increased their awareness of this relationship.

278 Assessing the real environmental impact of meat production compared to the production of
279 other types of food is not easy, as it depends on the production system, whether or not it
280 competes for resources that could be used in the production of other foods, and how the
281 damage to the environment is measured (Godfray et al., 2018). According to Capper (2013),

282 the future of the meat sector necessarily involves the implementation of production
283 improvements that reduce resource use and emissions, improve economic viability and
284 maintain an affordable supply of animal-based foods for the consumer. Finally, regarding
285 economic sustainability, we must not forget all the jobs that are involved in the production of
286 food of animal origin, its economic weight in many regions of the planet and its role in
287 maintaining rural life.

288 **5. Welfare friendly meat**

289 There are several definitions of animal welfare (AW) and the majority take into account animal
290 suffering and satisfaction. Animal welfare is one of the pillars of sustainability which, in meat
291 production and consumption, is very important for consumers and society (European
292 Commission, 2018; Grandin, 2014; Sonoda et al., 2018; Taylor & Signal, 2009). Different
293 regulations and standards have been launched on this topic, although not all the countries
294 have these nor do they cover the same aspects (Hild, 2019). Furthermore, AW is considered as
295 a cross-cutting sustainable challenge for livestock in agricultural development (HLPE, 2016).

296 Consumers concerns and awareness about animal well-being and welfare have increased
297 considerably in the last years (European Commission, 2007, 2016; McKendree et al., 2014) and
298 AW issues have been widely investigated. However, there is a regional bias in these scientific
299 studies, since most of them have been performed in Europe, some in North and Central
300 America and Oceania, a few in South America and Asia and almost none in Africa. Animal
301 welfare, animal well-being, welfare friendly production or products, or similar, are concepts
302 quite often used when discussing livestock and meat. Most of the concepts are related to
303 societal concerns such as the suffering and stress of the animals, their natural state, the
304 human-animal relation, and they vary within and between countries (Carnovale et al., 2021;
305 Estévez-Moreno et al., 2021; European Commission, 2016; Prickett, 2010; Vargas-Bello-Pérez
306 et al., 2021). Apart from the individual differences, results also depend on how the research
307 was carried out (i.e. if information was previously provided and type of information provided)

308 and by whom (i.e. research institution, animal protectionist organization), the characteristics
309 of the population sampled (i.e. region, age, studies, income), recent interventions or public
310 information shown in the mass media (i.e. if there have been recent campaigns enhancing AW,
311 viral videos, sometimes biased and out of context, showing the mistreatment of animals), etc.
312 Consumer attitudes towards AW depend on socio-demographic variables (Kendall et al., 2006;
313 Musto et al., 2014; Sonoda et al., 2018), on the previous individual experience or knowledge
314 (Kendall et al., 2006) and the type of husbandry practice (Janssen et al., 2016). Furthermore,
315 interventions appealing to AW seem effective (Mathur et al., 2021) and can shape consumers'
316 attitudes and beliefs. Thus, it seems relevant to focus on more effective tools to inform
317 consumers and to be more transparent (Grandin, 2014) to allow them to know about current
318 practices rather than imagining them, enhancing positive aspects and sending realistic and
319 beneficial messages. In the same vein, it is crucial to inform consumers about the practices and
320 the actions carried out to improve livestock welfare in order to increase their overall
321 understanding and to provide them with the appropriate tools to create a referenced and
322 informed opinion on this topic and to identify and disregard possible fake news.

323 From the economic perspective, applying EU welfare standards (regulations) leads to higher
324 costs for livestock producers, which are around 2% of the value of the overall livestock sector
325 output (DG-SANCO, 2010), although this percentage depends on the country and each
326 particular case (Broom, 2021; CWF, 2014). Part of the cost can be offset by increasing
327 productive benefits, higher quality and food safety, and greater profitability during processing
328 (Belk et al., 2002). Thus, it would be important to economically motivate farmers to produce
329 according to high welfare standards in order to prevent losses and, if possible, to gain benefits
330 (Thorslund et al., 2017). When the cost of production increases, it is important to know
331 whether consumers would be willing to pay a premium for products that were welfare friendly
332 or welfare certified. The willingness to pay is normally higher in pro-welfare consumers
333 (Cornish et al., 2020) and those concerned about AW (Miranda-de la Lama et al., 2019),

334 although it depends on the species, the region, the socio-demographic characteristics, type of
335 populations, the methodology used to carry out the study (Clark et al., 2017), the information
336 provided to the consumer (Cornish et al., 2020) and the level of welfare compared with the
337 standard (Denver et al., 2017).

338 Animal welfare is one of the reasons for reducing or avoiding meat consumption, together
339 with environmental and health issues (Bryant & Sanctorum, 2021; Janssen et al., 2016; Mancini
340 & Antonioli, 2019). Concerns towards AW can be related to the welfare of the animals during
341 their life and at slaughtering. In this sense, the most important husbandry practices related to
342 AW were outdoor access, stocking density and floor type (Janssen et al., 2016). Other practices
343 have also been studied from the consumers point of view such as those related to animal
344 husbandry practices (i.e. teeth clipping, castration, dehorning, beak and toe trimming, tail
345 docking), gestation crates, early weaning, etc. (Heleski et al., 2004; McKendree et al., 2014).

346 Religious slaughtering cannot be forgotten since it has generated concerns due to its impact on
347 AW and many studies have been performed to try to find out a compromise between religious
348 demands and AW (Aghwan et al., 2016; Farouk, 2013; Jalil et al., 2018; Velarde et al., 2014).

349 Furthermore, AW concerns are also related to the right or not to kill animals to eat them due
350 to moral reasons. Leroy and Praet (2017) review the different theories that explain the moral
351 attitudes associated to this practice such as anthropomorphic, cognitive ethology, capacities
352 perspective, anthropocentric and essentialist. In general, the higher the concern about AW,
353 the higher the reduction of meat in the diet (De Backer & Hudders, 2015). Interventions that
354 focus on social norms, that take advantage of the identification of the victim or that provide
355 specific suggestions for meat reduction also seem to be effective (Mathur et al., 2021). The
356 relationship between AW and meat quality is also relevant from the economic point of view,
357 especially for consumers interested in quality products. In this sense, different aspects of
358 quality can be considered, two of which - ethical and sensory properties - are of greater
359 importance to the consumer. When talking about ethical quality, reference is made to the

360 quality due to the production aspects of the meat, independent of the perceived quality when
361 eating or processing this meat. Nevertheless, some consumers link higher welfare to higher
362 sensory quality (European Commission, 2007; Lai et al., 2018), and, depending on the welfare
363 aspect considered, this can be true or false (Thorslund et al., 2017).

364 The relationship between AW and environmental issues is quite complex and some studies
365 show that they are not always going in the same direction, i.e. production systems with high
366 AW are not always good from the environmental point of view (Siegford et al., 2008) and,
367 moreover, strategies to improve sustainability can be good or bad for AW (Llonch et al., 2017).
368 In all cases, it is important to know the impact that strategies to improve AW have on the
369 environment and sustainability, or the impact that strategies to improve sustainability have on
370 AW. This would allow the consumers to understand the environmental cost of AW or the
371 ethical cost of a well preserved environment, to have informed attitudes and beliefs and to
372 add value to the welfare-friendly products, what, at the same time, could be a limitation for
373 population with low purchasing ability.

374 **6. Meat alternatives emphasizing on cultured 'meat'**

375 Despite the previously mentioned importance of meat, meat alternatives such as cultured
376 'meat' (CM), plant-based products, and products with insects or sea-weed as a source of
377 protein, are having more and more resonance. The promotion of meat alternatives has been
378 based on 5 different types of promises: (1) healthier than animal-based products, (2) a way to
379 secure food for the world, (3) more animal-friendly and environmentally-friendly, (4) better
380 control of production, and (5) they taste like animal products (Sexton et al., 2019). But these
381 statements need to be further analysed and verified (Munteanu et al., 2021) because
382 improvements in technologies for their processing are still required (Lee et al., 2020) and the
383 properties of the final product from the nutritional, health, safety, sustainability, structure,
384 texture and sensory point of view still need to be explored (Chriki & Hocquette, 2020; Fraeye

385 et al., 2020; Munteanu et al., 2021). Moreover, encouraging the avoidance of meat
386 consumption in order to improve sustainability and health might be harmful and dangerous
387 because of the positive role of animal husbandry (*e.g.* food security, livelihoods, manure for
388 fertilization, etc.), the nutritional value of meat in the diet, and as a distraction from what
389 really needs to be considered in order to solve the problems of climate change, food security
390 and malnutrition (Leroy et al., 2022; Leroy & Hite, 2020).

391 Cultured ‘meat’ is also known, among others, as cell, synthetic, artificial, in vitro, laboratory-
392 grown, factory-grown, clean and animal-free ‘meat’ (Bryant & Barnett, 2019; Chriki et al.,
393 2020; Verbeke, Marcu, et al., 2015). A critical point is if the term ‘meat’ can be used for this
394 product, since CM is muscle cells grown in a bioreactor, but meat includes also other tissues
395 such as adipocytes, connective and vascular tissue (Warner, 2019) as well as other compounds
396 of the muscles that come from animal feed components transformed by animal organs, which
397 influence in the sensory and nutritional properties of the meat (Ong et al., 2020). It is also a
398 point of discussion if ‘meat product’ or another (new) term would be more acceptable (Chriki
399 et al., 2022; Ong et al., 2020). Moreover, the term used to name it varies depending on the
400 interest of the users (*i.e.* advocates, CM companies, meat producers or consumers; Ong et al.,
401 2020), influences CM acceptability by the consumer (Bryant & Barnett, 2019), and it can have
402 legal and social implications *e.g.* by using the term ‘clean meat’ there is the risk of considering
403 animal-based meat as a ‘dirty’ meat (Sexton et al., 2019). Likewise, the term chosen by
404 consumers to designate this product could also indicate the perception of the consumers
405 towards the product, *e.g.* low choice of the term ‘cell meat’ could indicate a low perception of
406 CM as environmentally friendly in opposition of what it is claimed by its defenders (Hocquette
407 et al., 2022). Cultured ‘meat’ is a new product that, except in Singapore, it is not yet available
408 on the market. Probably because of this, consumers’ knowledge of CM is low, with a high
409 number of consumers who have never heard about it or are not familiar with it (Figure 3).
410 However, as can be seen in Figure 3, the most recent studies seem to show a tendency of a

411 reduction of the number of citizens that have never heard about CM, at least in some
412 countries. This might be explained by the most frequent appearance of information in the
413 press media. There are several steps in the production of CM as detailed in the review of
414 Warner (2019). In brief, (stem) cell selection, followed by the proliferation, differentiation, and
415 maturation of the cells in a growth media aided with biomechanical, biophysical and electrical
416 stimulation. Then there is the scaling up to industrial production by finally harvesting and
417 manufacturing meat products. Moreover, this production needs to be highly controlled,
418 economically feasible, sustainable, with a high production rate in order to ensure food
419 security, healthiness, and acceptability to consumers.

420 A key point regarding the social view of CM and meat analogues is try to answer the question:
421 why do these alternative products need to mimic meat or meat products? Firstly, because they
422 are considered as meat substitutes. Furthermore, since visual appearance is a very important
423 factor in consumer choice (Font-i-Furnols & Guerrero, 2014), the imitation should be good
424 enough as to be accepted at first sight. Meat products belong to human culture, and the
425 alternatives need to meet consumer demands (Leroy et al., 2022) and, moreover, the
426 importance of meat consumption at social events (Smil, 2013; Sobal, 2005) could create the
427 need to give the impression of eating meat when eating these alternatives. Furthermore, the
428 term meat is convenient for the supporters of 'cultured meat' because it allows them to
429 remove the negative aspects of meat keeping the positive ones and reinforcing this confusion
430 (Chriki et al., 2022). Another option would be that these alternatives do not mimic meat,
431 neither by appearance nor by taste or name, showing the novelty of the product and trying to
432 include it in the diet as another source of protein.

433 Socio-demographic characteristics influence acceptance of CM, these being, in general, that
434 men, young and low-income consumers are more positive towards it as reviewed by Bryant &
435 Barnett (2018). Nevertheless, different results were obtained in more recent works, which can
436 be explained by the interaction between several characteristics such as gender, age, studies or

437 relation with animal production (Heidemann et al., 2020; Hocquette et al., 2022), or by the
438 characteristics of the consumers included in the study (Heidemann et al., 2020). In fact,
439 differences in studies regarding the characteristics of the sample evaluated, the description of
440 CM provided, the familiarity with the concepts, cultural issues and meat consumption
441 practices might be relevant (Bekker et al., 2017; Bryant & Barnett, 2018; Bryant & Dillard,
442 2019; Mancini & Antonioli, 2019; SmartProtein, 2021; Wilks et al., 2021). The perception of
443 naturalness is very pertinent for CM (Hocquette et al., 2022) and meat analogues, since the
444 higher the perception of this product as being unnatural, the lower its acceptability (Siegrist &
445 Hartmann, 2020; SmartProtein, 2021; Weinrich et al., 2020; Wilks et al., 2021) and willingness
446 to try (Hocquette et al., 2022). Naturalness has also been related to healthiness (Siegrist &
447 Sütterlin, 2017), disgust (Rosenfeld & Tomiyama, 2022; Siegrist & Hartmann, 2020), and
448 probably to the perception of inauthenticity of this meat alternative (Bryant & Sanctorem,
449 2021). Cultured 'meat' perception of healthiness and safety is influenced by the type of
450 information provided (Bryant & Dillard, 2019) and care has to be taken not to believe the fake
451 news that are spread through the mass media related to CM and other meat analogues, that
452 normally shows their benefits without providing the real facts.

453 Eating meat is a pleasure, and the sensory properties have a lot to do with this. Therefore, the
454 major reasons why meat alternatives did not meet consumer needs were the fact that
455 substitutes were perceived as not being tasty and did not have the same taste and texture as
456 meat (Bryant & Sanctorem, 2021; Verbeke, Marcu, et al., 2015). In the case of CM, there are
457 still a lot of challenges that need to be reached to have similar sensorial and nutritional
458 properties as meat without compromising consumers' acceptability (Fraeye et al., 2020). There
459 are other societal concerns with CM, such as its effect at social events where a meat dish is
460 important, the loss of farm and livestock traditions and its effect on the biodiversity and
461 countryside (see review from Bryant and Barnett (2019)). A recent study reports that negative
462 impact of CM on territories and rural life and on local farmers jobs were important barriers to

463 the willingness to try CM, although the expectation that CM would reduce the farming was low
464 (Hocquette et al., 2022).

465 Considering the economic perspective, cost of production is important and today could be a
466 barrier if the price of CM is not competitive enough compared with the price of conventional
467 meat (Bryant & Sanctorem, 2021; Weinrich et al., 2020). The cost of scale-up CM production
468 considering capital cost, production cost and fixed cost, analysed and discussed by Humbird
469 (2021), are high and could be a limitation in its production.

470 Information and images provided to consumers influence their attitudes and beliefs towards
471 CM. Providing information about the benefits of CM in addition to basic information about the
472 technology (Verbeke, Sans, et al., 2015) or using less technical wording in its definition (Bryant
473 & Dillard, 2019; Siegrist et al., 2018; Verbeke, Sans, et al., 2015) increases willingness to try,
474 purchase or pay. This is probably related to neophobia of novel technologies and products
475 (Siegrist & Hartmann, 2020; Wilks et al., 2019). Bryant (2020) reviewed the economic impact of
476 CM and also considered its effect on agricultural employment, on the fact that food production
477 could be consolidated into a smaller number of actors who would dominate the market and,
478 finally, on the possible inequality between consumers depending on their socio-economic
479 status, either if CM were more expensive or cheaper than conventional meat.

480 From the environmental point of view, a review by Munteanu et al. (2021) concludes that CM
481 production could be related mainly to 4 Sustainable Development Goals (SDG), SDG 2 (zero
482 hunger), 3 (good health and wellbeing), 13 (climate action) and 15 (life on land). And in fact,
483 consumers perceived CM as a meat that prevents animal suffering, as being better for the
484 environment, as a solution for the world food problem, and as having less risk of diseases and
485 with fewer additives (Bryant & Sanctorem, 2021). Considering meat alternatives in general,
486 they were also perceived as good for AW and for the environmental impact (Bryant &
487 Sanctorem, 2021) although, on the other hand, some consumers were concerned about the

488 environmental impact of CM production due to energy requirements (Verbeke, Marcu, et al.,
489 2015). In fact, in a recent study, environmental footprint would be one of the barriers to try
490 CM but, also, less environmental footprint would be one of the expectations of CM and the
491 consideration of CM as an eco-friendly product, was one of the reasons consumers wanted to
492 try it (Hocquette et al., 2022). Care for the environment is one of the reasons why some
493 consumers avoid or reduce meat consumption, although following a vegan, vegetarian or
494 flexitarian diet, allows only a reduction in the total footprint of 6%, 4% and 2%, respectively
495 (Leroy et al., 2022).

496 One of the main messages of CM is that it is environmentally friendly. Results of different
497 studies show different outcomes regarding the environmental impact of CM due to the
498 operational parameters considered for the calculation, the system boundaries or materials and
499 processes included or not considered in the calculations, or the parameters of environmental
500 impacts considered (Rodríguez Escobar et al., 2021; Van Eenennaam & Werth, 2021). Because
501 of that, Rodríguez Escobar et al. (2021) proposed a process for life cycle assessment of CM.
502 Considering the different published works, the review of Van Eenennaam and Werth (2021)
503 show that CM has, on average, similar greenhouse gas emissions, land, water and energy use,
504 eutrophication and acidification potential, to plant-based and insect-based 'meat', and that
505 most of the animal source food protein except a specific type of ruminant meat, that has
506 greater impact. Sinke and Odegard (2021) collected information for CM companies in the
507 supply chain and concluded that CM has the potential to be highly sustainable meat product,
508 only if there is a switch to sustainable energy. Furthermore, since there is still not enough
509 knowledge about the effects of large-scale production of CM on the environment (and safety),
510 the benefits need to be further analysed to be able to ensure that it is a more environmentally
511 sustainable (and safe) alternative.

512 **6. Final remarks and conclusion**

513 Meat and its production have a marked social impact, so it is essential for the meat sector to
514 be aware of and exploit advances in research and technology in order to meet society's
515 demands. The sector must also take advantage of this knowledge to establish the best
516 production strategy that will enable the sustainability of the entire value chain to be increased
517 and to improve the communication strategy that will allow the actions being taken to be
518 publicized and the value of the results obtained enhanced. The type of information provided
519 and the way in which it is communicated are key aspects in the development of attitudes and
520 preferences. Thus, it is essential to define the best way to provide a story using truthful and
521 reliable information on sustainability, nutritional aspects, animal welfare, as well as on meat
522 alternatives, while promoting a more rational meat consumption. The livestock and meat
523 sector must develop a marketing strategy that emphasizes the benefits of meat, fighting
524 against the fake news that circulates with great impunity on social networks, and playing with
525 the tradition-progress binomial. The message should highlight the progress made in improving
526 the sustainability of meat production and meat quality, highlighting the importance and
527 attributes of traditional products, while admitting that there is still much to be done and that
528 great efforts are being made to achieve this goal. Furthermore, these messages and the
529 marketing strategy must reach the consumer, especially the younger and future generations,
530 so in addition to the traditional channels, actions to be done must be adapted to the current
531 and most popular communication channels.

532

533 **7. Author's contribution**

534 Maria Font i Furnols & Luis Guerrero : Conceptualization, Writing - Original Draft, Writing -
535 Review & Editing.

536

537 **8. Ethical statement**

538 Not applicable.

539

540 **9. Declaration of competing interest**

541 The authors declare no conflict of interest associated with this research.

542

543 **10. Acknowledgements**

544 This research did not receive any specific grant from funding agencies in the public,
545 commercial, or not-for-profit sectors. CERCA from the Generalitat de Catalunya is
546 acknowledged. The authors would like to thank the reviewers for their comments and
547 suggestions that have been very useful to improve the manuscript.

548

549 **11. Literature review**

550 Aghwan, Z. A., Bello, A. U., Abubakar, A. A., Imlan, J. C., & Sazili, A. Q. (2016). Efficient halal
551 bleeding, animal handling, and welfare: A holistic approach for meat quality. *Meat Science*,
552 *121*, 420-428. [https://doi.org/https://doi.org/10.1016/j.meatsci.2016.06.028](https://doi.org/10.1016/j.meatsci.2016.06.028)

553 Alexandratos, N., & Bruinsma, J. (2012). *World agriculture towards 2030/2050: the 2012*
554 *revision*.

555 Anusha Siddiqui, S., Bahmid, N. A., Mahmud, C. M. M., Boukid, F., Lamri, M., & Gagaoua, M.
556 (2022). Consumer acceptability of plant-, seaweed-, and insect-based foods as alternatives
557 to meat: a critical compilation of a decade of research. *Critical Reviews in Food Science and*
558 *Nutrition*, 1-22. <https://doi.org/10.1080/10408398.2022.2036096>

559 Apostolidis, C., & McLeay, F. (2016). Should we stop meating like this? Reducing meat
560 consumption through substitution. *Food Policy*, *65*, 74-89.

561 <https://doi.org/10.1016/j.foodpol.2016.11.002>

562 Bastian, B., Loughnan, S., Haslam, N., & Radke, H. R. (2012). Don't mind meat? The denial of
563 mind to animals used for human consumption. *Personality and Social Psychology Bulletin*,
564 38(2), 247-256. <https://doi.org/10.1177/0146167211424291>

565 Bekker, G. A., Tobi, H., & Fischer, A. R. H. (2017). Meet meat: An explorative study on meat and
566 cultured meat as seen by Chinese, Ethiopians and Dutch. *Appetite*, 114, 82-92.
567 <https://doi.org/10.1016/j.appet.2017.03.009>

568 Belk, K. E., Scanga, J. A., Smith, G. C., & T., G. (2002). The Relationship Between Good Handling
569 / Stunning and Meat Quality in Beef, Pork, and Lamb. AMIF Annual Animal Handling and
570 Stunning Conference, Kansas City, USA.

571 Bellasco, W. (2008). *Food. The key concepts*. Berg.

572 Benningstad, N. C. G., & Kunst, J. R. (2020). Dissociating meat from its animal origins: A
573 systematic literature review. *Appetite*, 147, 104554.
574 <https://doi.org/10.1016/j.appet.2019.104554>

575 Biermann, G., & Rau, H. (2020). The meaning of meat: (Un)sustainable eating practices at
576 home and out of home. *Appetite*, 153, 104730.
577 <https://doi.org/10.1016/j.appet.2020.104730>

578 Blanco-Penedo, I., García-Gudiño, J., Angón, E., Perea, J. M., Escribano, A. J., & Font-i-Furnols,
579 M. (2021). Exploring Sustainable Food Choices Factors and Purchasing Behavior in the
580 Sustainable Development Goals Era in Spain. *Sustainability*, 13(13), 7397.
581 <https://www.mdpi.com/2071-1050/13/13/7397>

582 Broom, D. M. (2021). A method for assessing sustainability, with beef production as an
583 example. *Biological Reviews of the Cambridge Philosophical Society*, 96(5), 1836-1853.
584 <https://doi.org/10.1111/brv.12726>

585 Bryant, C., & Barnett, J. (2018). Consumer acceptance of cultured meat: A systematic review.
586 *Meat Science*, 143, 8-17. <https://doi.org/10.1016/j.meatsci.2018.04.008>

587 Bryant, C., & Dillard, C. (2019). The Impact of Framing on Acceptance of Cultured Meat
588 [Original Research]. *Frontiers in Nutrition*, 6(103). <https://doi.org/10.3389/fnut.2019.00103>

589 Bryant, C., & Sanctorem, H. (2021). Alternative proteins, evolving attitudes: Comparing
590 consumer attitudes to plant-based and cultured meat in Belgium in two consecutive years.
591 *Appetite*, 161, 105161. <https://doi.org/10.1016/j.appet.2021.105161>

592 Bryant, C., Szejda, K., Parekh, N., Deshpande, V., & Tse, B. (2019). A Survey of Consumer
593 Perceptions of Plant-Based and Clean Meat in the USA, India, and China. *Frontiers in*
594 *Sustainable Food Systems*, 3(11). <https://doi.org/10.3389/fsufs.2019.00011>

595 Bryant, C. J. (2020). Culture, meat, and cultured meat. *Journal of Animal Science*, 98(8), 1-7.
596 <https://doi.org/10.1093/jas/skaa172>

597 Bryant, C. J., & Barnett, J. C. (2019). What's in a name? Consumer perceptions of in vitro meat
598 under different names. *Appetite*, 137, 104-113.
599 <https://doi.org/10.1016/j.appet.2019.02.021>

600 Bulliet, R. W. (2005). *Hunters, herders, and hamburgers. The past and future of human-animal*
601 *relationships*. Columbia University Press

602 Capper, J. L. (2013). Should we reject animal source foods to save the planet? A review of the
603 sustainability of global livestock production. *South African Journal of Animal Science*, 43(3),
604 233-246. <https://doi.org/http://dx.doi.org/10.4314/sajas.v43i3.1>

605 Carnovale, F., Jin, X., Arney, D., Descovich, K., Guo, W., Shi, B., & Phillips, C. J. C. (2021).
606 Chinese Public Attitudes towards, and Knowledge of, Animal Welfare. *Animals*, 11(3).
607 <https://doi.org/10.3390/ani11030855>

608 Chriki, S., Ellies-Oury, M.-P., Fournier, D., Liu, J., & Hocquette, J.-F. (2020). Analysis of Scientific
609 and Press Articles Related to Cultured Meat for a Better Understanding of Its Perception
610 [Systematic Review]. *Frontiers in Psychology*, 11. <https://doi.org/10.3389/fpsyg.2020.01845>

611 Chriki, S., Ellies-Oury, M. P., & Hocquette, J. F. (2022). Is "cultured meat" a viable alternative to
612 slaughtering animals and a good compromise between animal welfare and human
613 expectations? *Anim Front*, 12(1), 35-42. <https://doi.org/10.1093/af/vfac002>

614 Chriki, S., & Hocquette, J.-F. (2020). The Myth of Cultured Meat: A Review [Review]. *Frontiers*
615 *in Nutrition*, 7. <https://doi.org/10.3389/fnut.2020.00007>

616 Chriki, S., Payet, V., Pflanzner, S. B., Ellies-Oury, M.-P., Liu, J., Hocquette, É., . . . Hocquette, J.-F.
617 (2021). Brazilian Consumers' Attitudes towards So-Called "Cell-Based Meat". *Foods*, 10(11),
618 2588. <https://doi.org/10.3390/foods10112588>

619 Clark, B., Stewart, G. B., Panzone, L. A., Kyriazakis, I., & Frewer, L. J. (2017). Citizens,
620 consumers and farm animal welfare: A meta-analysis of willingness-to-pay studies. *Food*
621 *Policy*, 68, 112-127. <https://doi.org/10.1016/j.foodpol.2017.01.006>

622 Cooper, J. (2007). *Cognitive dissonance. Fifty years of a classic theory*. SAGE Publications Ltd.

623 Cornish, A. R., Briley, D., Wilson, B. J., Raubenheimer, D., Schlosberg, D., & McGreevy, P. D.
624 (2020). The price of good welfare: Does informing consumers about what on-package labels
625 mean for animal welfare influence their purchase intentions? *Appetite*, 148, 104577.
626 <https://doi.org/10.1016/j.appet.2019.104577>

627 Corrin, T., & Papadopoulos, A. (2017). Understanding the attitudes and perceptions of
628 vegetarian and plant-based diets to shape future health promotion programs. *Appetite*,
629 109, 40-47. <https://doi.org/10.1016/j.appet.2016.11.018>

630 CWF. (2014). *Economic implications of moving to improved standards of animal welfare*.
631 Compassion in World Farming. CIWF reports. Retrieved December 2021 from
632 [https://www.ciwf.org.uk/media/5885638/economic-implications-of-moving-to-improved-](https://www.ciwf.org.uk/media/5885638/economic-implications-of-moving-to-improved-standards-of-animal-welfare-2014.pdf)
633 [standards-of-animal-welfare-2014.pdf](https://www.ciwf.org.uk/media/5885638/economic-implications-of-moving-to-improved-standards-of-animal-welfare-2014.pdf)

634 Dagevos, H., & Verbeke, W. (2022). Meat consumption and flexitarianism in the Low
635 Countries. *Meat Science*, 192, 108894.
636 <https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108894>

637 De Backer, C., Erreygers, S., De Cort, C., Vandermoere, F., Dhoest, A., Vrinten, J., & Van Bauwel,
638 S. (2020). Meat and masculinities. Can differences in masculinity predict meat consumption,
639 intentions to reduce meat and attitudes towards vegetarians? *Appetite*, 147, 104559.
640 <https://doi.org/10.1016/j.appet.2019.104559>

641 De Backer, C. J., & Hudders, L. (2015). Meat morals: relationship between meat consumption
642 consumer attitudes towards human and animal welfare and moral behavior. *Meat Science*,
643 99, 68-74. <https://doi.org/10.1016/j.meatsci.2014.08.011>

644 de Boer, J., Schösler, H., & Aiking, H. (2014). "Meatless days" or "less but better"? Exploring
645 strategies to adapt Western meat consumption to health and sustainability challenges.
646 *Appetite*, 76, 120-128. <https://doi.org/10.1016/j.appet.2014.02.002>

647 deFrance, S. D. (2009). Zooarchaeology in Complex Societies: Political Economy, Status, and
648 Ideology. *Journal of Archaeological Research*, 17(2), 105-168.
649 <http://www.jstor.org/stable/41053260>

650 Denver, S., Sandøe, P., & Christensen, T. (2017). Consumer preferences for pig welfare – Can
651 the market accommodate more than one level of welfare pork? *Meat Science*, 129, 140-
652 146. <https://doi.org/10.1016/j.meatsci.2017.02.018>

653 DG-SANCO. (2010). *Final Report: Evaluation of the EU Policy on Animal Welfare & Possible*
654 *Options for the Future*. [https://ec.europa.eu/food/system/files/2021-
655 07/aw_eu_strategy_eupaw-eval_report_201012.pdf](https://ec.europa.eu/food/system/files/2021-07/aw_eu_strategy_eupaw-eval_report_201012.pdf)

656 Dowsett, E., Semmler, C., Bray, H., Ankeny, R. A., & Chur-Hansen, A. (2018). Neutralising the
657 meat paradox: Cognitive dissonance, gender, and eating animals. *Appetite*, 123, 280-288.
658 <https://doi.org/10.1016/j.appet.2018.01.005>

659 Dumont, B., Ryschawy, J., Duru, M., Benoit, M., Chatellier, V., Delaby, L., . . . Sabatier, R. (2019).
660 Review: Associations among goods, impacts and ecosystem services provided by livestock
661 farming. *Animal*, 13(8), 1773-1784. <https://doi.org/10.1017/S1751731118002586>

662 Estévez-Moreno, L. X., María, G. A., Sepúlveda, W. S., Villarroel, M., & Miranda-de la Lama, G.
663 C. (2021). Attitudes of meat consumers in Mexico and Spain about farm animal welfare: A
664 cross-cultural study. *Meat Science*, 173, 108377.
665 <https://doi.org/10.1016/j.meatsci.2020.108377>

666 European Commission, E. C. (2007). *Attitudes of EU citizens towards animal welfare : report.*
667 *Special Eurobarometer 270*. European Commission.
668 <https://europa.eu/eurobarometer/surveys/detail/470>

669 European Commission, E. C. (2016). *Attitudes of Europeans towards animal welfare : report.*
670 *Special Eurobarometer 442*. European Commission. <https://doi.org/doi:10.2875/884639>

671 European Commission, E. C. (2018). *Special Report: Animal welfare in the EU: closing the gap*
672 *between ambitious goals and practical implementation*. European Commission.
673 https://www.eca.europa.eu/Lists/ECADocuments/SR18_31/SR_ANIMAL_WELFARE_EN.pdf

674 European Commission, E. C. (2020). *Europeans, Agriculture and the CAP. Special*
675 *Eurobarometer 504*. European Commission. <https://doi.org/10.2762/621294>

676 FAO. (2018). *Livestock and Agroecology. How they Can Support the Transition Towards*
677 *Sustainable Food and Agriculture*. Retrieved June 2022 from
678 <https://www.fao.org/3/i8926EN/i8926en.pdf>

679 FAO, & WHO. (2019). *Sustainable healthy diets - Guiding principles*. I. Rome.
680 <https://www.fao.org/3/ca6640en/ca6640en.pdf>

681 Farouk, M. M. (2013). Advances in the industrial production of halal and kosher red meat.
682 *Meat Sci*, 95(4), 805-820. <https://doi.org/10.1016/j.meatsci.2013.04.028>

683 Fiddes, N. (1991). *Meat: A Natural Symbol*. Taylor & Francis.

684 Font-i-Furnols, M., & Guerrero, L. (2014). Consumer preference, behavior and perception
685 about meat and meat products: An overview. *Meat Science*, 98(3), 361-371.
686 <https://doi.org/10.1016/j.meatsci.2014.06.025>

687 Font-i-Furnols, M., & Guerrero, L. (2022). Spanish perspective on meat consumption and
688 consumer attitudes. *Meat Science*, 191, 108874.
689 <https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108874>

690 Fraeye, I., Kratka, M., Vandeburgh, H., & Thorrez, L. (2020). Sensorial and Nutritional Aspects
691 of Cultured Meat in Comparison to Traditional Meat: Much to Be Inferred [Conceptual
692 Analysis]. *Frontiers in Nutrition*, 7. <https://doi.org/10.3389/fnut.2020.00035>

693 Franceković, P., García-Torralba, L., Sakoulogeorga, E., Vučković, T., & Perez-Cueto, F. J. A.
694 (2021). How Do Consumers Perceive Cultured Meat in Croatia, Greece, and Spain?
695 *Nutrients*, 13(4), 1284. <https://www.mdpi.com/2072-6643/13/4/1284>

696 Godfray, H. C. J., Aveyard, P., Garnett, T., Hall, J. W., Key, T. J., Lorimer, J., . . . Jebb, S. A. (2018).
697 Meat consumption, health, and the environment. *Science*, 361(6399).
698 <https://doi.org/10.1126/science.aam5324>

699 Gomes, C. M., & Boesch, C. (2011). Reciprocity and trades in wild West African chimpanzees.
700 *Behavioral Ecology and Sociobiology*, 65(11), 2183. [https://doi.org/10.1007/s00265-011-](https://doi.org/10.1007/s00265-011-1227-x)
701 [1227-x](https://doi.org/10.1007/s00265-011-1227-x)

702 Gousset, C., Gregorio, E., Marais, B., Rusalen, A., Chriki, S., Hocquette, J.-F., & Ellies-Oury, M.-P.
703 (2022). Perception of cultured “meat” by French consumers according to their diet.
704 *Livestock Science*, 260, 104909.
705 <https://doi.org/https://doi.org/10.1016/j.livsci.2022.104909>

706 Graça, J., Calheiros, M. M., & Oliveira, A. (2014). Moral Disengagement in Harmful but
707 Cherished Food Practices? An Exploration into the Case of Meat. *Journal of Agricultural and*
708 *Environmental Ethics*, 27(5), 749-765. <https://doi.org/10.1007/s10806-014-9488-9>

709 Graça, J., Calheiros, M. M., & Oliveira, A. (2015). Attached to meat? (Un)Willingness and
710 intentions to adopt a more plant-based diet. *Appetite*, 95, 113-125.
711 <https://doi.org/10.1016/j.appet.2015.06.024>

712 Grandin, T. (2014). Animal welfare and society concerns finding the missing link. *Meat Science*,
713 98(3), 461-469. <https://doi.org/10.1016/j.meatsci.2014.05.011>

714 Grunert, K. G., Hieke, S., & Wills, J. (2014). Sustainability labels on food products: Consumer
715 motivation, understanding and use. *Food Policy*, 44, 177-189.
716 <https://doi.org/10.1016/j.foodpol.2013.12.001>

717 Guerrero, L., Claret, A., Rodriguez, P., Hernández, F., & Dalmau, A. (2013, 28–31 May). *Actitud,*
718 *creencias y expectativas de los consumidores españoles frente a la castración (quirúrgica e*
719 *inmunocastración) y el bienestar animal porcino* VII World Congress of Dry-Dured Ham,
720 Ourique, Portugal.

721 Hallström, E., Röö, E., & Börjesson, P. (2014). Sustainable meat consumption: A quantitative
722 analysis of nutritional intake, greenhouse gas emissions and land use from a Swedish
723 perspective. *Food Policy*, 47, 81-90. <https://doi.org/10.1016/j.foodpol.2014.04.002>

724 Hanss, D., & Böhm, G. (2012). Sustainability seen from the perspective of consumers.
725 *International Journal of Consumer Studies*, 36(6), 678-687. [https://doi.org/10.1111/j.1470-](https://doi.org/10.1111/j.1470-6431.2011.01045.x)
726 [6431.2011.01045.x](https://doi.org/10.1111/j.1470-6431.2011.01045.x)

727 Harmon-Jones, E., & Mills, J. (2019). An introduction to cognitive dissonance theory and an
728 overview of current perspectives on the theory. In E. Harmon-jones (Ed.), *Cognitive*
729 *Dissonance. Reexamining a pivotal theory in psychology (2nd Edition)* (pp. 3-24). American
730 Psychological Association (APA). <https://doi.org/https://doi.org/10.1037/0000135-001>

731 Hartmann, C., & Siegrist, M. (2017). Consumer perception and behaviour regarding sustainable
732 protein consumption: A systematic review. *Trends in Food Science & Technology*, 61, 11-25.
733 <https://doi.org/10.1016/j.tifs.2016.12.006>

734 Hawkes, K. (1991). Showing off: Tests of an hypothesis about men's foraging goals. *Ethology*
735 *and Sociobiology*, 12(1), 29-54. [https://doi.org/10.1016/0162-3095\(91\)90011-E](https://doi.org/10.1016/0162-3095(91)90011-E)

736 Hedenus, F., Wirsenius, S., & Johansson, D. J. A. (2014). The importance of reduced meat and
737 dairy consumption for meeting stringent climate change targets. *Climatic Change*, 124(1),
738 79-91. <https://doi.org/10.1007/s10584-014-1104-5>

739 Heidemann, M. S., Taconeli, C. A., Reis, G. G., Parisi, G., & Molento, C. F. M. (2020). Critical
740 Perspective of Animal Production Specialists on Cell-Based Meat in Brazil: From Bottleneck
741 to Best Scenarios. *Animals (Basel)*, 10(9). <https://doi.org/10.3390/ani10091678>

742 Heleski, C. R., Mertig, A. G., & Zanella, A. J. (2004). Assessing attitudes toward farm animal
743 welfare: a national survey of animal science faculty members. *J Anim Sci*, 82(9), 2806-2814.
744 <https://doi.org/10.2527/2004.8292806x>

745 Herzog, H. (2010). *Some we love, some we hate, some we eat. Why it's so hard to think straight*
746 Harper Perennial.

747 Hild, S. (2019). Introduction. *Animal Welfare: from Science to Law*, Paris, France.

748 HLPE (2016). *Sustainable agricultural development for food security and nutrition: what roles*
749 *for livestock?* . High Level Panel of Experts on Food Security and Nutrition of the Committee
750 on World Food Security. Retrieved December 2021 from
751 <https://www.fao.org/3/i5795e/i5795e.pdf>

752 Holm, L., & Møhl, M. (2000). The role of meat in everyday food culture: an analysis of an
753 interview study in Copenhagen. *Appetite*, 34(3), 277-283.
754 <https://doi.org/10.1006/appe.2000.0324>

755 Hocquette, É., Liu, J., Ellies-Oury, M. P., Chriki, S., & Hocquette, J. F. (2022). Does the future of
756 meat in France depend on cultured muscle cells? Answers from different consumer
757 segments. *Meat Sci*, 188, 108776. <https://doi.org/10.1016/j.meatsci.2022.108776>

758 Hötzel, M. J., & Vandresen, B. (2022). Brazilians' attitudes to meat consumption and
759 production: Present and future challenges to the sustainability of the meat industry. *Meat*
760 *Science*, 192, 108893. <https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108893>

761 Humbird, D. (2021). Scale-up economics for cultured meat. *Biotechnol Bioeng*, 118(8), 3239-
762 3250. <https://doi.org/10.1002/bit.27848>

763 Ingram, G. P. D., Piazza, J. R., & Bering, J. M. (2009). The adaptive problem of absent third-
764 party punishment. In J. T. H. Høgh-Olesen, & P. Bertelsen (Ed.), *Human characteristics.*
765 *Evolutionary perspectives on human mind and kind* (pp. 205–229). Cambridge Scholars
766 Publishing.

767 Jahn, S., Furchheim, P., & Strässner, A.-M. (2021). Plant-Based Meat Alternatives: Motivational
768 Adoption Barriers and Solutions. *Sustainability*, 13(23), 13271.
769 <https://www.mdpi.com/2071-1050/13/23/13271>

770 Jalil, N. S. A., Tawde, A. V., Zito, S., Sinclair, M., Fryer, C., Idrus, Z., & Phillips, C. J. C. (2018).
771 Attitudes of the public towards halal food and associated animal welfare issues in two
772 countries with predominantly Muslim and non-Muslim populations. *PLoS One*, 13(10),
773 e0204094. <https://doi.org/10.1371/journal.pone.0204094>

774 Janssen, M., Rödiger, M., & Hamm, U. (2016). Labels for Animal Husbandry Systems Meet
775 Consumer Preferences: Results from a Meta-analysis of Consumer Studies. *Journal of*
776 *Agricultural and Environmental Ethics*, 29(6), 1071-1100. [https://doi.org/10.1007/s10806-](https://doi.org/10.1007/s10806-016-9647-2)
777 [016-9647-2](https://doi.org/10.1007/s10806-016-9647-2)

778 Kendall, H. A., Lobao, L. M., & Sharp, J. S. (2006). Public Concern with Animal Well-Being: Place,
779 Social Structural Location, and Individual Experience. *Rural Sociology*, 71, 399-428.

780 Kubberød, E., Ueland, Ø., Tronstad, Å., & Risvik, E. (2002). Attitudes towards meat and meat-
781 eating among adolescents in Norway: a qualitative study. *Appetite*, 38(1), 53-62.
782 <https://doi.org/10.1006/appe.2002.0458>

783 Lai, J., Wang, H. H., Ortega, D. L., & Olynk Widmar, N. J. (2018). Factoring Chinese consumers'
784 risk perceptions into their willingness to pay for pork safety, environmental stewardship,
785 and animal welfare. *Food Control*, 85, 423-431.
786 <https://doi.org/10.1016/j.foodcont.2017.09.032>

787 Lee, H. J., Yong, H. I., Kim, M., Choi, Y.-S., & Jo, C. (2020). Status of meat alternatives and their
788 potential role in the future meat market - A review. *Asian-Australasian journal of animal*
789 *sciences*, 33(10), 1533-1543. <https://doi.org/10.5713/ajas.20.0419>

790 Lentz, G., Connelly, S., Miroso, M., & Jowett, T. (2018). Gauging attitudes and behaviours: Meat
791 consumption and potential reduction. *Appetite*, 127, 230-241.
792 <https://doi.org/10.1016/j.appet.2018.04.015>

793 Leroy, F. (2019). Chapter Eight - Meat as a Pharmakon: An Exploration of the Biosocial
794 Complexities of Meat Consumption. In F. Toldrá (Ed.), *Advances in Food and Nutrition*
795 *Research* (Vol. 87, pp. 409-446). Academic Press.
796 <https://doi.org/https://doi.org/10.1016/bs.afnr.2018.07.002>

797 Leroy, F., Abraini, F., Beal, T., Dominguez-Salas, P., Gregorini, P., Manzano, P., . . . van Vliet, S.
798 (2022). Animal board invited review: Animal source foods in healthy, sustainable, and
799 ethical diets – An argument against drastic limitation of livestock in the food system.
800 *Animal*, 16(3), 100457. <https://doi.org/https://doi.org/10.1016/j.animal.2022.100457>

801 Leroy, F., & Barnard, N. D. (2020). Children and adults should avoid consuming animal products
802 to reduce risk for chronic disease: NO. *The American Journal of Clinical Nutrition*, 112(4),
803 931-936. <https://doi.org/10.1093/ajcn/nqaa236>

804 Leroy, F., & Hite, A. H. (2020). The place of meat in dietary policy: an exploration of the
805 animal/plant divide. *Meat and Muscle Biology*, 4(2), 1-11.
806 <https://doi.org/https://doi.org/10.22175/mmb.9456>

807 Leroy, F., Hite, A. H., & Gregorini, P. (2020). Livestock in Evolving Foodscapes and
808 Thoughtscapes [Hypothesis and Theory]. *Frontiers in Sustainable Food Systems*, 4.
809 <https://doi.org/10.3389/fsufs.2020.00105>

810 Leroy, F., & Praet, I. (2015). Meat traditions. The co-evolution of humans and meat. *Appetite*,
811 90, 200-211. <https://doi.org/https://doi.org/10.1016/j.appet.2015.03.014>

812 Leroy, F., & Praet, I. (2017). Animal Killing and Postdomestic Meat Production. *Journal of*
813 *Agricultural and Environmental Ethics*, 30(1), 67-86. [https://doi.org/10.1007/s10806-017-](https://doi.org/10.1007/s10806-017-9654-y)
814 [9654-y](https://doi.org/10.1007/s10806-017-9654-y)

815 Liu, J., Hocquette, É., Ellies-Oury, M. P., Chriki, S., & Hocquette, J. F. (2021). Chinese
816 Consumers' Attitudes and Potential Acceptance toward Artificial Meat. *Foods*, 10(2).
817 <https://doi.org/10.3390/foods10020353>

818 Llonch, P., Haskell, M. J., Dewhurst, R. J., & Turner, S. P. (2017). Current available strategies to
819 mitigate greenhouse gas emissions in livestock systems: an animal welfare perspective.
820 *Animal*, 11(2), 274-284. <https://doi.org/10.1017/S1751731116001440>

821 Loughnan, S., Bastian, B., & Haslam, N. (2014). The Psychology of Eating Animals. *Current*
822 *Directions in Psychological Science*, 23(2), 104-108.
823 <https://doi.org/10.1177/0963721414525781>

824 Loughnan, S., Bratanova, B., & Puvia, E. (2012). The meat paradox: how are we able to love
825 animals and love eating animals. *Mind*, 1, 15-18. [http://it.in-](http://it.in-mind.org/uploads/Italia/Issues/1/Loughnan%20et%20al_Eng.pdf)
826 [mind.org/uploads/Italia/Issues/1/Loughnan%20et%20al_Eng.pdf](http://it.in-mind.org/uploads/Italia/Issues/1/Loughnan%20et%20al_Eng.pdf)

827 Macdiarmid, J. I., Douglas, F., & Campbell, J. (2016). Eating like there's no tomorrow: Public
828 awareness of the environmental impact of food and reluctance to eat less meat as part of a
829 sustainable diet. *Appetite*, 96, 487-493. <https://doi.org/10.1016/j.appet.2015.10.011>

830 Mancini, M. C., & Antonioli, F. (2019). Exploring consumers' attitude towards cultured meat in
831 Italy. *Meat Science*, 150, 101-110. <https://doi.org/10.1016/j.meatsci.2018.12.014>

832 Mathur, M. B., Peacock, J., Reichling, D. B., Nadler, J., Bain, P. A., Gardner, C. D., & Robinson, T.
833 N. (2021). Interventions to reduce meat consumption by appealing to animal welfare:
834 Meta-analysis and evidence-based recommendations. *Appetite*, 164, 105277.
835 <https://doi.org/10.1016/j.appet.2021.105277>

836 Mayfield, L. E., Bennett, R. M., Tranter, R. B., & Wooldridge, M. J. (2007). Consumption of
837 welfare-friendly food products in Great Britain, Italy and Sweden, and how it maybe

838 influenced by consumer attitudes to, and behaviour towards, animal welfare attributes.
839 *International Journal of Sociology of Food and Agriculture*, 15(3), 59-73.
840 <https://doi.org/10.48416/ijisaf.v15i3.284>

841 McKendree, M. G., Croney, C. C., & Widmar, N. J. (2014). Effects of demographic factors and
842 information sources on United States consumer perceptions of animal welfare. *J Anim Sci*,
843 92(7), 3161-3173. <https://doi.org/10.2527/jas.2014-6874>

844 Melson, G. F. (2005). *Why the Wild Things Are: Animals in the Lives of Children*. Harvard
845 University Press.

846 Michel, F., Hartmann, C., & Siegrist, M. (2021). Consumers' associations, perceptions and
847 acceptance of meat and plant-based meat alternatives. *Food Quality and Preference*, 87,
848 104063. <https://doi.org/10.1016/j.foodqual.2020.104063>

849 Miranda-de la Lama, G. C., Estévez-Moreno, L. X., Villarroel, M., Rayas-Amor, A. A., María, G.
850 A., & Sepúlveda, W. S. (2019). Consumer Attitudes Toward Animal Welfare-Friendly
851 Products and Willingness to Pay: Exploration of Mexican Market Segments. *J Appl Anim*
852 *Welf Sci*, 22(1), 13-25. <https://doi.org/10.1080/10888705.2018.1456925>

853 Munteanu, C., Mireşan, V., Răducu, C., Ihuţ, A., Uiuu, P., Pop, D., . . . Groza, I. (2021). Can
854 Cultured Meat Be an Alternative to Farm Animal Production for a Sustainable and Healthier
855 Lifestyle? *Frontiers in Nutrition*, 8, 749298. <https://doi.org/10.3389/fnut.2021.749298>

856 Musto, M., Faraone, D., & Cellini, F. (2014). The role of cognitive styles and sociodemographic
857 characteristics in consumer perceptions and attitudes toward nonhuman animal welfare.
858 *Journal of Applied Animal Welfare Science*, 17(3), 198-215.
859 <https://doi.org/10.1080/10888705.2014.899911>

860 Ngapo, T. M. (2022). Meat analogues, the Canadian Meat Industry and the Canadian
861 consumer. *Meat Science*, 191, 108846.
862 <https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108846>

863 Ong, S., Choudhury, D., & Naing, M. W. (2020). Cell-based meat: Current ambiguities with
864 nomenclature. *Trends in Food Science & Technology*, *102*, 223-231.
865 <https://doi.org/https://doi.org/10.1016/j.tifs.2020.02.010>

866 Onwezen, M. C., Bouwman, E. P., Reinders, M. J., & Dagevos, H. (2021). A systematic review on
867 consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat
868 alternatives, and cultured meat. *Appetite*, *159*, 105058.
869 <https://doi.org/https://doi.org/10.1016/j.appet.2020.105058>

870 Piazza, J., Ruby, M. B., Loughnan, S., Luong, M., Kulik, J., Watkins, H. M., & Seigerman, M.
871 (2015). Rationalizing meat consumption. The 4Ns. *Appetite*, *91*, 114-128.
872 <https://doi.org/10.1016/j.appet.2015.04.011>

873 Prickett, R. W. (2010). Consumer preferences for farm animal welfare: results from a
874 telephone survey of US households. *Animal Welfare*, *19*, 335-347.

875 Realini, C. E., Ares, G., Antúnez, L., Brito, G., Luzardo, S., del Campo, M., . . . Montossi, F. M.
876 (2022). Meat insights: Uruguayan consumers' mental associations and motives underlying
877 consumption changes. *Meat Science*, *192*, 108901.
878 <https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108901>

879 Rodríguez Escobar, M. I., Cadena, E., Nhu, T. T., Cooreman-Algoed, M., De Smet, S., & Dewulf,
880 J. (2021). Analysis of the Cultured Meat Production System in Function of Its Environmental
881 Footprint: Current Status, Gaps and Recommendations. *Foods*, *10*(12), 2941.
882 <https://www.mdpi.com/2304-8158/10/12/2941>

883 Rolland, N. C. M., Markus, C. R., & Post, M. J. (2020). The effect of information content on
884 acceptance of cultured meat in a tasting context. *PLoS One*, *15*(4), e0231176.
885 <https://doi.org/10.1371/journal.pone.0231176>

886 Rosenfeld, D. L., & Tomiyama, A. J. (2022). Would you eat a burger made in a petri dish? Why
887 people feel disgusted by cultured meat. *Journal of Environmental Psychology*, *80*, 101758.
888 <https://doi.org/10.1016/j.jenvp.2022.101758>

889 Rothgerber, H. (2014). Efforts to overcome vegetarian-induced dissonance among meat eaters.
890 *Appetite*, 79, 32-41. <https://doi.org/10.1016/j.appet.2014.04.003>

891 Rothgerber, H., & Mican, F. (2014). Childhood pet ownership, attachment to pets, and
892 subsequent meat avoidance. The mediating role of empathy toward animals. *Appetite*, 79,
893 11-17. <https://doi.org/10.1016/j.appet.2014.03.032>

894 Sanchez-Sabate, R., & Sabaté, J. (2019). Consumer Attitudes Towards Environmental Concerns
895 of Meat Consumption: A Systematic Review. *International journal of environmental*
896 *research and public health*, 16(7), 1220. <https://www.mdpi.com/1660-4601/16/7/1220>

897 Sexton, A. E., Garnett, T., & Lorimer, J. (2019). Framing the future of food: The contested
898 promises of alternative proteins. *Environment and Planning. Nature and Space. E*, 2(1), 47-
899 72. <https://doi.org/10.1177/2514848619827009>

900 Siegford, J. M., Powers, W., & Grimes-Casey, H. G. (2008). Environmental aspects of ethical
901 animal production. *Poultry Science*, 87(2), 380-386. <https://doi.org/10.3382/ps.2007-00351>

902 Siegrist, M., & Hartmann, C. (2020). Perceived naturalness, disgust, trust and food neophobia
903 as predictors of cultured meat acceptance in ten countries. *Appetite*, 155, 104814.
904 <https://doi.org/10.1016/j.appet.2020.104814>

905 Siegrist, M., & Sütterlin, B. (2017). Importance of perceived naturalness for acceptance of food
906 additives and cultured meat. *Appetite*, 113, 320-326.
907 <https://doi.org/10.1016/j.appet.2017.03.019>

908 Siegrist, M., Sütterlin, B., & Hartmann, C. (2018). Perceived naturalness and evoked disgust
909 influence acceptance of cultured meat. *Meat Science*, 139, 213-219.
910 <https://doi.org/10.1016/j.meatsci.2018.02.007>

911 Siekmann, J. H., Allen, L. H., Bwibo, N. O., Demment, M. W., Murphy, S. P., & Neumann, C. G.
912 (2003). Animal source foods to improve micronutrient nutrition and human function in
913 developing countries. *Journal of Nutrition*, 133, 3972S-3980S.

914 Simões, J., Moran, D., Edwards, S., Bonnet, C., Lopez-Sebastian, A., & Chemineau, P. (2021).
915 Editorial: Sustainable livestock systems for high-producing animals. *Animal*, 15, 100371.
916 <https://doi.org/10.1016/j.animal.2021.100371>

917 Sinke, P., & Odegard, I. (2021). *LCA of Cultivated Meat Future Projections for Different*
918 *Scenarios*. [https://cedelft.eu/wp-](https://cedelft.eu/wp-content/uploads/sites/2/2021/04/CE_Delft_190107_LCA_of_cultivated_meat_Def.pdf)
919 [content/uploads/sites/2/2021/04/CE_Delft_190107_LCA_of_cultivated_meat_Def.pdf](https://cedelft.eu/wp-content/uploads/sites/2/2021/04/CE_Delft_190107_LCA_of_cultivated_meat_Def.pdf)

920 SmartProtein (2021). *What consumers want: A survey on European consumer attitudes*
921 *towards plant-based foods with a focus on flexitarians*. European Union's Horizon 2020
922 research and innovation programme (No. 862957). <https://smartproteinproject.eu/>

923 Smil, V. (2002). Eating Meat: Evolution, Patterns, and Consequences. *Population and*
924 *Development Review*, 28(4), 599-639. <https://doi.org/10.1111/j.1728-4457.2002.00599.x>

925 Smil, V. (2013). *Should we eat meat? Evolution and consequences of modern carnivory*. Wiley-
926 Blackwell. <https://doi.org/http://doi.org/10.1002/9781118278710>

927 Smith, C. U. (1998). Descartes' pineal neuropsychology. *Brain Cogn*, 36(1), 57-72.
928 <https://doi.org/10.1006/brcg.1997.0954>

929 Sobal, J. (2005). Men, meat, and marriage: models of masculinity. *Food and Foodways*, 13(1-2),
930 135-158. <https://doi.org/10.1080/07409710590915409>

931 Sonoda, Y., Oishi, K., Chomei, Y., & Hirooka, H. (2018). How do human values influence the
932 beef preferences of consumer segments regarding animal welfare and environmentally
933 friendly production? *Meat Science*, 146, 75-86.
934 <https://doi.org/10.1016/j.meatsci.2018.07.030>

935 Taylor, N., & Signal, T. D. (2009). Willingness to pay: Australian consumers and "on the farm"
936 welfare. *Journal of Applied Animal Welfare Science*, 12(4), 345-359.
937 <https://doi.org/10.1080/10888700903163658>

938 Thorslund, C. A., Aaslyng, M. D., & Lassen, J. (2017). Perceived importance and responsibility
939 for market-driven pig welfare: Literature review. *Meat Science*, 125, 37-45.
940 <https://doi.org/10.1016/j.meatsci.2016.11.008>

941 Tomasello, M., Melis, A. P., Tennie, C., Wyman, E., & Herrmann, E. (2012). Two Key Steps in the
942 Evolution of Human Cooperation: The Interdependence Hypothesis. *Current Anthropology*,
943 53(6), 673-692. <https://doi.org/10.1086/668207>

944 Tonsor, G. T., & Lusk, J. L. (2022). U.S. perspective: Meat demand outdoes meat avoidance.
945 *Meat Science*, 190, 108843. <https://doi.org/https://doi.org/10.1016/j.meatsci.2022.108843>

946 United Nations (2005). Resolution adopted by the General Assembly. 60/1. 2005 World
947 Summit outcome. 1-38. <http://www.un.org/womenwatch/ods/A-RES-60-1-E.pdf>

948 Van Eenennaam, A. L., & Werth, S. J. (2021). Animal board invited review: Animal agriculture
949 and alternative meats – learning from past science communication failures. *Animal*, 15(10),
950 100360. <https://doi.org/10.1016/j.animal.2021.100360>

951 Vargas-Bello-Pérez, E., Obermöller-Bustamante, C., Faber, I., Tadich, T., & Toro-Mujica, P.
952 (2021). Knowledge and Perception on Animal Welfare in Chilean Undergraduate Students
953 with Emphasis on Dairy Cattle. *Animals*, 11(7). <https://doi.org/10.3390/ani11071921>

954 Velarde, A., Rodriguez, P., Dalmau, A., Fuentes, C., Llonch, P., von Holleben, K. V., . . . Cenci-
955 Goga, B. T. (2014). Religious slaughter: evaluation of current practices in selected countries.
956 *Meat Sci*, 96(1), 278-287. <https://doi.org/10.1016/j.meatsci.2013.07.013>

957 Verain, M. C. D., Bartels, J., Dagevos, H., Sijtsema, S. J., Onwezen, M. C., & Antonides, G.
958 (2012). Segments of sustainable food consumers: a literature review. *International Journal*
959 *of Consumer Studies*, 36(2), 123-132. <https://doi.org/10.1111/j.1470-6431.2011.01082.x>

960 Verbeke, W., Marcu, A., Rutsaert, P., Gaspar, R., Seibt, B., Fletcher, D., & Barnett, J. (2015).
961 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium,
962 Portugal and the United Kingdom. *Meat Science*, 102, 49-58.
963 <https://doi.org/10.1016/j.meatsci.2014.11.013>

964 Verbeke, W., Pérez-Cueto, F. J., Barcellos, M. D., Krystallis, A., & Grunert, K. G. (2010).
965 European citizen and consumer attitudes and preferences regarding beef and pork. *Meat*
966 *Science*, 84(2), 284-292. <https://doi.org/10.1016/j.meatsci.2009.05.001>

967 Verbeke, W., Sans, P., & Van Loo, E. J. (2015). Challenges and prospects for consumer
968 acceptance of cultured meat. *Journal of Integrative Agriculture*, 14(2), 285-294.
969 [https://doi.org/10.1016/S2095-3119\(14\)60884-4](https://doi.org/10.1016/S2095-3119(14)60884-4)

970 Warner, R. D. (2019). Review: Analysis of the process and drivers for cellular meat production.
971 *Animal*, 13(12), 3041-3058. <https://doi.org/10.1017/S1751731119001897>

972 Weinrich, R., Strack, M., & Neugebauer, F. (2020). Consumer acceptance of cultured meat in
973 Germany. *Meat Science*, 162, 107924. <https://doi.org/10.1016/j.meatsci.2019.107924>

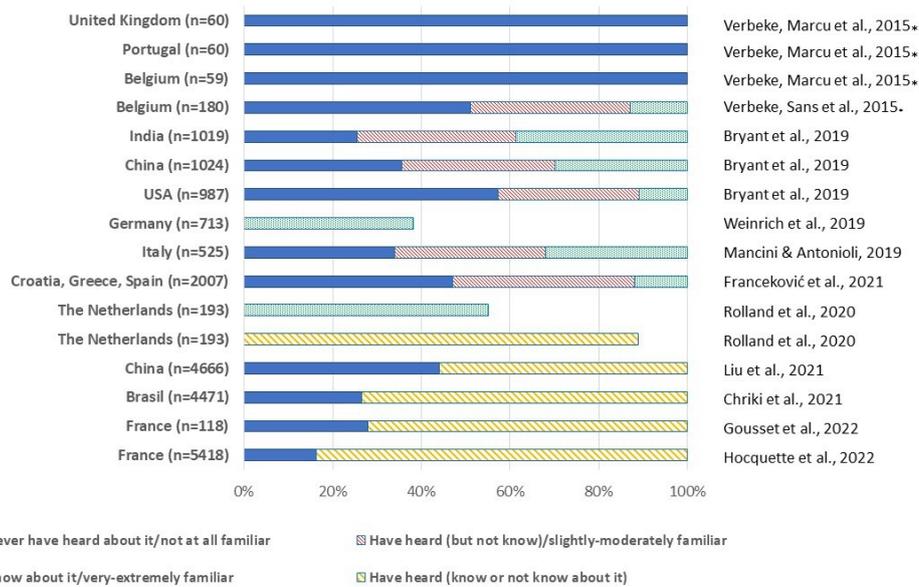
974 Wilks, M., Hornsey, M., & Bloom, P. (2021). What does it mean to say that cultured meat is
975 unnatural? *Appetite*, 156, 104960. <https://doi.org/10.1016/j.appet.2020.104960>

976 Wilks, M., Phillips, C. J. C., Fielding, K., & Hornsey, M. J. (2019). Testing potential psychological
977 predictors of attitudes towards cultured meat. *Appetite*, 136, 137-145.
978 <https://doi.org/10.1016/j.appet.2019.01.027>

979 Wood, J. D. (2017). Meat Composition and Nutritional Value. In F. Toldrá (Ed.), *Lawrie's Meat*
980 *Science* (pp. 635-659). Woodhead Publishing.

981 Zhang, C., Guan, X., Yu, S., Zhou, J., & Chen, J. (2022). Production of meat alternatives using live
982 cells, cultures and plant proteins. *Current Opinion in Food Science*, 43, 43-52.
983 <https://doi.org/https://doi.org/10.1016/j.cofs.2021.11.002>

984



991

992 Figure 3. Familiarity of cultured meat in several studies. * carried out before August 2012 when
 993 the first *in vitro* hamburger was presented by Mark Post.

994

995 **Highlights**

- 996 - To deal with the contradiction between protecting animals and enjoying meat
- 997 - Sustainability is a broad term with many aspects, some of which are unknown
- 998 - Consumers concern about animal welfare depend on many factors
- 999 - Many gaps remain on sustainability, safety and the nutritional and sensory quality of
- 1000 cultured meat
- 1001 - Communication by the meat sector needs to be transparent and reach out to society