

REVIEW

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Cultured meat acceptance for global food security: a systematic literature review and future research directions

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Abstract

Cultured meat is a novel technology-based meat alternative with the potential to complement protein supply for a growing world population. An increasing body of consumer research has investigated personal factors explaining consumers' acceptance of cultured meat. Research on cultural and economic drivers impacting consumer responses across countries, however, is scant. In this light, this article aims to provide a cross-cultural perspective on cultured meat acceptance and guide future empirical research in this domain. First, this article proposes a framework to explain cross-national differences in cultured meat acceptance comprising societal factors (i.e., culture and religion), indicators of the food environment (i.e., meat production and consumption), and economic market parameters (i.e., gross domestic product, carbon dioxide emissions, and population growth). Second, the paper applies a systematic literature review, including 105 empirical consumer studies related to cultured meat. Third, the identified papers are analyzed according to the proposed framework. The findings of this descriptive analysis demonstrate that empirical research to date has predominately been conducted in countries that produce and consume high amounts of meat and are characterized by high gross domestic products per capita. Many of these surveyed countries harbor secular-rational and self-expressional cultural value orientations. Other country types have been less prominently explored, although they represent potentially relevant target markets for cultured meat in the future. Cross-cultural research aiming to explain differences across countries is scarce. To guide future research, the paper develops research propositions relating societal factors, food environment, and market-related factors to consumer acceptance of cultured meat across countries.

Keywords: Cultured meat, Systematic literature review, Culture, Religion, Food environment

Introduction

The global world population is continuously growing and is expected to reach 10.3 billion by 2070 (Roser et al. 2021). Thus, the food industry is challenged to feed an increasing number of people. There are nowadays “[...] three potential pathways to meet the needs of the world’s growing population for protein in a sustainable and healthy way:

alternative proteins; changes to current production systems; and consumer behaviour change” (Godfray 2019, p. 9). This systematic literature review focuses specifically on cultured meat as a particular alternative protein type. Cultured meat shows considerable scaling potential since multiple amounts can be produced with the cells of a single animal (Tomiya et al. 2020). In theory, “[...] 1 billion cultured beef burgers (113 g each) could be produced in 1.5 months from muscle stem cells biopsied from one living cow [...]” (Tomiya et al. 2020, p. 146). Thus, cultured meat might represent a viable approach to feed an increasing number of people worldwide. In contrast to plant-based alternative proteins, cultured meat is an animal cell-based and lab-grown product (Post 2012). Cultured meat as human food was first created in 2013 (Painter et al. 2020) and became commercially available in 2020 in Singapore (Witte et al. 2021). In 2023, cultured meat has been cleared for sale in the USA (The New York Times 2023), after having been approved by the US Food and Drug Administration in 2022 (FDA 2022).

To date, over 150 firms are operating in the cultured food industry (comprising both meat and seafood), which have received investments of approximately USD 2.8 billion (Good Food Institute 2022). Recently, policymakers of different countries (i.e., Israel, China, South Korea) have announced to financially support cultured meat research in the future, whereas other governments (e.g., Italy) have taken action to ban this future food (BBC 2023). Although market forecasts vary substantially, (e.g., CAGR of 52% and 96% between 2022/23 and 2030, see Grand View Research 2022 and Allied Market Research 2021), a positive global market development as suggested by market research companies (Brennan et al. 2021; Witte et al. 2021) appears plausible in case cultured meat gets approved for sale in additional countries.

Turning to the demand side, consumer-oriented cultured meat studies have investigated how consumers make sense of this novel food technology by exploring the underlying associations (e.g., Bekker et al. 2017; Marcu et al. 2015; Verbeke et al. 2015). Research has further examined consumer perceptions regarding the benefits (e.g., ecological and animal welfare, see Weinrich et al. 2020) and barriers (e.g., unnaturalness, see Siegrist et al. 2018) of the production method. A series of experiments has also shown that information provision and framing affect cultured meat acceptance (e.g., Bryant and Dillard 2019; Rolland et al. 2020). In addition, certain individual-level drivers (e.g., innovativeness and universalism, see Lewisch and Riefler 2023) and barriers (e.g., disgust sensitivity and food neophobia, see Wilks et al. 2019) were found to relate to consumers’ acceptance of this novel food technology.

Based on these empirical contributions, a number of literature reviews (e.g., Bryant and Barnett 2018; Pakseresht et al. 2022) have aimed to provide an overview of the general drivers of and barriers to cultured meat consumption at an individual consumer level. They identify ecological sustainability, animal welfare, food security, and health-related aspects as key perceived benefits of cultured meat, while common concerns center around (dis-)trust in science, unnaturalness, and food safety (Bryant and Barnett 2020; Kantono et al. 2022).

While the body on knowledge of individual dispositions impacting cultured meat acceptance is relevant and valuable, evidence from cross-country research clearly indicates that consumer responses strongly vary between nations (e.g., Bryant et al. 2019; Chong et al. 2022; Siegrist and Hartmann 2020a). Furthermore, the relevance of personal

drivers might be contingent upon individuals' cultural and national contexts. For example, empirical research shows distrust in scientists (Lewisch and Riefler 2023; Wilks et al. 2019) and biotechnology (Hwang et al. 2020) to reduce willingness to try cultured meat in some nations (Austria and Korea), while not affecting behavioral intentions in other regions (USA). Since the societal and economic market context as well as the national (food) environment in general impact individual food choice (Stoll-Kleemann and Schmidt 2017), cross-cultural and cross-national differences appear relevant to better understand consumer acceptance of cultured meat as an alternative to conventional meat.

Against this background, this review aims to add to consumer research on technology-based food innovations by providing a complementary perspective that reflects upon selected societal and economic market criteria as well as the national food environment to explain consumers' cultured meat acceptance. Drawing upon Stoll-Kleemann and Schmidt's framework of meat consumption reduction (2017), our paper takes a macro-level perspective and aims to add to the current understanding on how consumer acceptance of cultured meat might be impacted by (i) culture and religion as *societal factors*, (ii) the amounts of conventional meat production and consumption as *indicators of the food environment*, and (iii) gross domestic product (GDP) per capita, national carbon dioxide (CO₂) emissions, and population growth as *economic market factors*.

Using a systematic literature review approach (Snyder 2019), we provide an overview of the extant empirical research regarding the above factors. Based on our descriptive analysis, we illustrate which types of countries have been studied extensively, and which have been neglected. We further develop a theoretical framework and research propositions for future empirical research.

The remainder of this literature review is organized as follows: first, we develop the conceptual model. Next, we elaborate on the methodology used in this review and conduct a descriptive analysis. We then discuss our results and formulate research propositions for empirical studies. Finally, we conclude with implications for practitioners and directions for future research.

Conceptual framework of cultured meat acceptance

For our review, we built upon Stoll-Kleemann and Schmidt's model (2017), which conceptualizes different types of drivers underlying meat-eating behavior that we adapted to cultured meat acceptance (see Fig. 1). The drivers focal to our review comprise societal factors, the food environment, and economic market parameters, in addition to personal factors that have been the emphasis of previous literature reviews (Pakseresht et al. 2022). In the following, we conceptually introduce the focal factors and the indicators we used within these categories.

Societal factors

According to Stoll-Kleemann and Schmidt (2017, p. 1269) „[c]ultural and religious traditions [...] influence and shape people's behaviour towards meat". Building on this insight, we consider a country's culture as well as its predominant religion and level of religiosity as societal variables in our review.

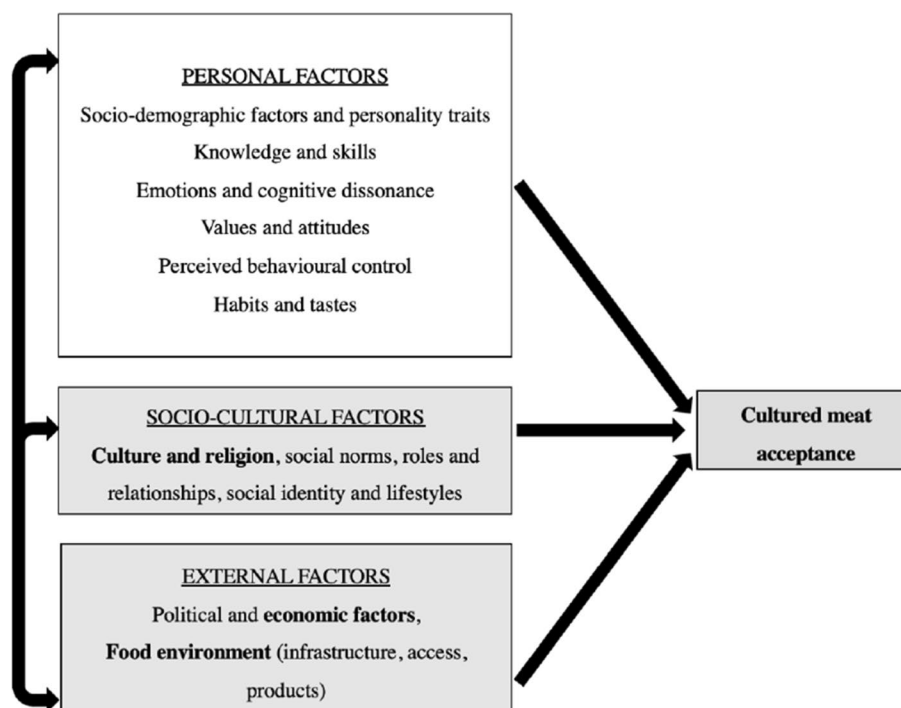


Fig. 1 Cultured meat acceptance framework adapted from Stoll-Kleemann and Schmidt (2017). Components considered are highlighted

Culture

Scholars agree that culture is difficult to define (e.g., Alonso et al. 2018; Wright et al. 2001) and typically understand this term as “[t]he programming of the human mind by which one group of people distinguishes itself from another group [...]” (Hofstede Insights 2022). Thus, culture is deeply embedded in social structures and shapes consumers’ everyday lives in several ways. Apart from cultural influences on behavior in general (for an overview see, e.g., Oyserman 2017), cultural belonging also specifically impacts dietary habits and food preferences (Alonso et al. 2018; Furst et al. 1996; Lee and Lopetcharat 2017; Wright et al. 2001). To this end, cultural influences are particularly eminent regarding meat consumption (Vranken et al. 2014) since “[...] the societal centrality of meat has been ascribed to the power represented by its consumption, demonstrating economic, cultural, and symbolic capital [...]” (Leroy and Praet 2015, p. 205). In the context of cultured meat, the role of cultural influences remains widely unexplored, although this gap has been identified (e.g., Bryant and Barnett 2018). For this reason, researchers have suggested that “[f]uture studies should [...] explain differences between various countries and cultures” (Onwezen et al. 2021, p. 11).

Religion and religiousness

Religion as such “[...] has proven even more difficult to define than culture [...]” (Alonso et al. 2018, p. 114). Although religion and culture are intertwined to some extent, we followed extant conceptualizations as separate constructs for the purpose of our review (Bonney 2004). Religious affiliations do not only affect values, beliefs, community

belonging (Mathras et al. 2016) and consumers' shopping behavior (Mokhlis 2009) but also play a crucial role in shaping dietary habits (Sabaté 2004). To this end, religions frequently restrict alcohol consumption and impose fasting periods. In addition to this general influence on dietary choices, researchers have observed a particularly strong influence on meat consumption habits. Indeed, many religions have created versatile rituals, festive traditions, and strict taboos regarding meat consumption (Leroy and Praet 2015), and they forbid specific types of meat to be eaten (Randers and Thøgersen 2023). In light of these implications, we assume that religious confessions as well as the degree of religiousness in a country affect consumer acceptance of cultured meat as a substitute meat product.

External factors

In the original framework of Stoll-Kleemann and Schmidt (2017), external factors comprise political as well as economic market aspects and reflect upon the prevailing food environment. The authors argue that this dimension is essential because a change in meat consumption habits “[...] requires supportive government policies and practices, new and different business practices and civil society initiatives working in synergy” (p. 1270). In this light, we consider external circumstances to affect cultured meat acceptance in national markets, and we thus include the prevailing food environment as well as selected economic market parameters in our framework.

Food environment

Food environment refers to the “[...] opportunity to obtain food, which includes physical, socio-cultural, economic, and political influences [...]” (Enriquez and Archila-Godinez 2022, p. 3700). In other words, the food environment dictates access to specific types of food in a market economy (Stoll-Kleemann and Schmidt 2017). Thus, a country's food environment depicts a contextual condition for food availability and ultimately food choice. As cultured meat as an animal cell-based future food is not authorized for sale in most parts of the world (i.e., except for Singapore and the USA), conventional meat appears to be the most proximate product currently available in national markets, compared to meat analogues (e.g., tofu) that stem from a different source of protein (e.g., plants). Thus, we include conventional meat production and consumption levels in our framework as indicators of the respective food environment.

National meat consumption levels depict citizens' implicitness for eating animals and indicate the evolutionary centrality of meat as food within a given society (Leroy and Praet 2015). Hence, this measure implies whether meat is consumed as a specialty on festive occasions or as part of an everyday meal. Thus, a country's reliance on conventional meat consumption might have a dual effect on the acceptance of cultured meat. On the one hand, a high dependence on meat in a national cuisine indicates deeply enrooted consumer habits that might be difficult to change, thus resulting in greater resistance to cultured meat. In fact, extant research has shown that a high degree of meat attachment reduces behavioral intentions toward meat alternatives (Van Dijk et al. 2023). On the other hand, a high national demand for meat might result in a substantial market potential for cultured meat as a substitute product. Since countries with high meat consumption levels are typically wealthy (Ritchie et al. 2019), consumers in such

markets might also have a greater likelihood of adopting such novel products because “[...] local governments located in wealthier [...] communities initiate, adopt and implement more innovations” (Damanpour and Schneider 2006, p. 225). To this end, extant empirical research shows that individual consumers’ meat-eating behavior also corresponds to their behavioral intentions toward cultured meat (Bryant et al. 2019; Gousset et al. 2022; Wilks and Phillips 2017), suggesting a link between meat consumption levels and acceptance of cultured meat as a food technology innovation.

In addition to consumption levels, we also consider the amount of conventional meat production at a country level (i.e., the supply side) as it signalizes the relevance of the meat industry within a given market. Combined, meat production and consumption levels further reflect upon the significance of foreign trade in a country’s meat industry. The Food and Agricultural Organization of the United Nations elaborates that “[t]he key to sustainable agricultural growth is more efficient use of land, labour and other inputs through technological progress, social innovation and new business models” (FAO 2017, p. 48). Hence, food technology innovations such as cultured meat could not only disrupt the current practices of the conventional agricultural sector but also provide an opportunity for a seminal development of this industry, thus affecting its diffusion and acceptance.

Economic market factors

Regarding economic market factors, we consider GDP per capita as a general indicator of economic development. We further add national CO₂ emissions and population growth to our framework to reflect specifically upon the ecological and social sustainability of a given market economy. Similar to GDP, these indicators are also known to relate to economic growth (Li et al. 2021; Peterson 2017).

GDP per capita is a key economic measure that reflects upon economic prosperity. GDP is understood as “[...] the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products” (World Bank 2021a). Since economic growth and innovation diffusion are closely related (Maradana et al. 2017; Mohamed et al. 2022), GDP might be an indicator of diffusion and consumer acceptance of cultured meat as an innovative food product. This assumption is supported by the exemplary insight that Singapore and the USA, the only countries in which cultured meat is approved for sale, are also characterized by high levels of GDP per capita (World Bank 2021a). From a different angle, GDP also relates to consumer lifestyles (Saleem and Ali 2019), which might be another prerequisite for the adoption of innovations (Huang et al. 2011; Xie et al. 2022).

From a sustainability perspective, global CO₂ emissions have more than doubled within the past 50 years (Ritchie et al. 2020) and could increase further by 50% until 2050 (OECD 2011). Compared to the conventional meat production industry, which produces approximately 54% of agricultural greenhouse gases (OECD/FAO 2021), cultured meat is estimated to potentially reduce emissions by 78–96% according to early estimations (Tuomisto and Teixeira de Mattos 2011). A more nuanced analysis is provided by a recent lifecycle assessment that finds cultured meat to have less impact on global warming than beef (and also than pork and chicken if sustainable energy is used) (Sinke and Odegard 2021). Considering this potential of lowering greenhouse

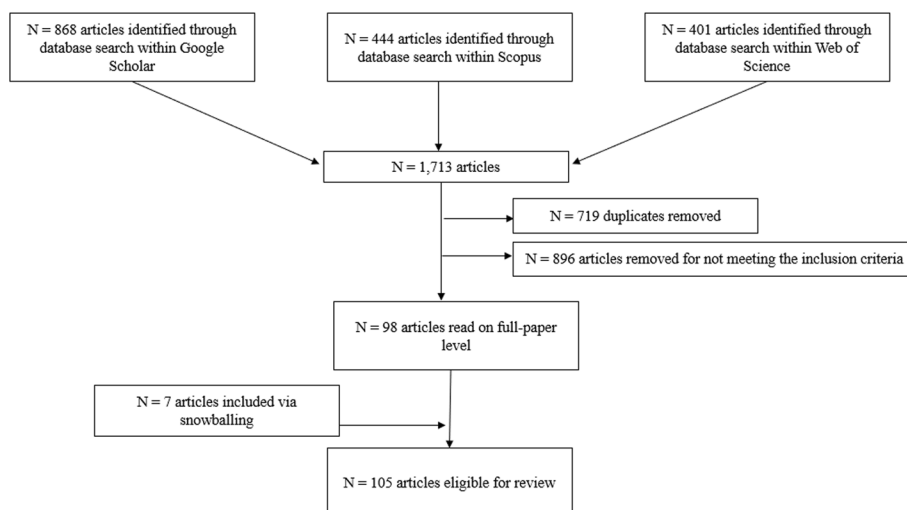


Fig. 2 Information on search procedure

gas emissions compared to conventional beef (Smetana et al. 2023), we expect that a country's current level of CO₂ emissions—and thus, the necessity to take measures of reduction—might relate to the acceptance of cultured meat.

Finally, feeding a continuously growing world population represents one of the key challenges of the twenty-first century (World Resources Institute 2019). Compared with conventional meat, multitude amounts of cultured meat can be produced from the cells of a single animal (Tomiya et al. 2020). Hence, this food technology could ensure a protein supply for future generations, which might be a particularly pressing issue for fast-growing consumer markets. For this reason, we include the population growth rate per country as a relevant indicator of cultured meat acceptance at a national level.

Methodology

Literature search

To provide an overview of the societal and economic setting, as well as the prevailing food environment of extant empirical research in the context of consumers' cultured meat acceptance, we conducted a systematic literature review following the guidelines proposed by Snyder (2019). As such, we first defined the search string, i.e., “cultured meat” OR “* vitro meat” OR “artificial meat” OR “synthetic meat” OR “clean meat” OR “lab * meat” OR “cell * meat” OR “cultivated meat”. We further specified that at least one of these keywords had to appear in the article title. The search was conducted in the Scopus, Web of Science, and Google Scholar databases, covering all articles published in English by June 2023. Additionally, we set the following screening criteria to fit the purpose of our review: first, we only considered publications that are consumer-focused, so that we excluded contributions from other domains. Second, we only included empirical research published in peer-reviewed journals to ensure high-quality standards. Third, only studies that provided clear information on the geographic context of the empirical study were considered in our review.

As shown in Fig. 2, the initial database search yielded 1713 results. After removing 719 duplicates, 994 articles were screened at the abstract level. Ninety-eight articles met all the inclusion criteria and were read on a full-paper level. Based on these articles, we identified seven additional relevant papers using the snowball technique. In summary, the literature search yielded a final sample of 105 peer-reviewed journal articles that built the basis for our systematic literature review.

Measures and analysis

For our descriptive analysis, we assessed culture according to the cultural value map of Inglehart and Welzel (2010), for which recent data were provided by the World Values Survey (2022a). This framework consists of a two-by-two matrix that classifies countries according to their traditional versus secular-rational values on the one hand and based on their survival versus self-expressional orientations on the other hand. While traditional values signalize “the importance of religion [...] and traditional family values”, secular-rational values “have the opposite preferences”. Furthermore, survival values are characterized by “low levels of trust” while self-expression values place “high priority to environmental protection” (World Values Survey 2022b). Based on the potential implications of these insights for cultured meat acceptance, we considered the dimensions of the cultural map of Inglehart and Welzel (2010) relevant to our research context.

We further assessed the predominant religion in each country based on information provided by the site Infoplease (2017) and operationalized the mean level of religiosity in a country according to a report by the Pew Research Center (2018). Regarding the food environment, meat production and consumption were measured according to data from the FAO aggregated by Ritchie and colleagues (2019). These data indicated meat production levels in tons at a country level. To account for differences in population sizes when comparing production levels across national markets, this number was divided by the respective country population (World Bank 2020). Finally, all three economic market measures (GDP per capita, national CO₂ emissions and national population growth) were assessed based on data from the World Bank (2019, 2021a; b).

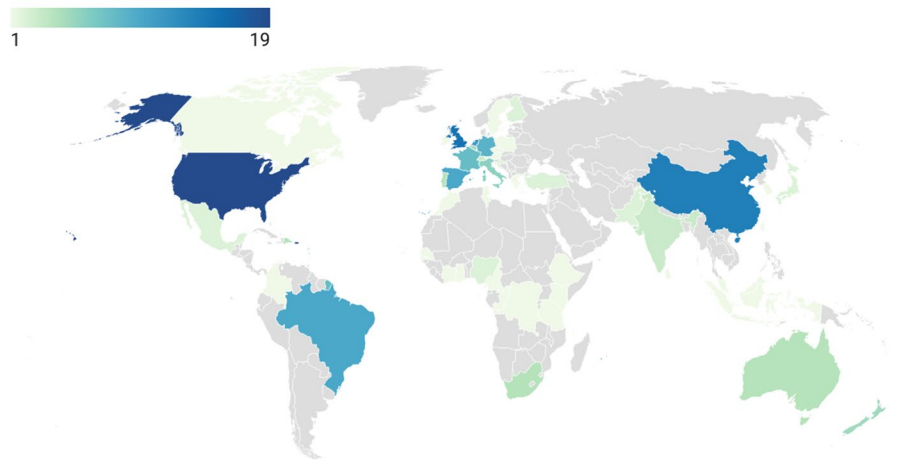
Regarding our procedure for the descriptive analysis, we created a table comprising all relevant studies. We first captured the national background in which the respective data collection took place and then arranged the studies according to their geographic region. Subsequently, we added a column for each of our analysis factors relating to (i) societal background, (ii) food environment, and (iii) economic market characteristics. Subsequently, we gathered data from the respective online sources. As a next step, we performed a descriptive analysis and investigated the societal and economic market context, as well as the prevailing food environment in which the extant studies were conducted. Based on this approach, we were able to detect certain patterns and peculiarities, which we discuss in detail in the next section. An overview of the extant publications and our descriptive analysis can be found as an online resource.

Findings

Geographic study contexts and general remarks

Overall, 49 countries were investigated in 84 single-country and 21 cross-country studies (see Fig. 3). As shown in the Additional file 1 of this review, 54 studies have been

Geographical distribution



Created with Datawrapper

Fig. 3 Information on geographical distribution of extant consumer-focused cultured meat research created with datawrapper.de

conducted in a (predominately) Western European context, covering 17 different countries. Moreover, eleven Asian countries have been explored throughout 27 publications, of which China has been the primary focus. Nineteen publications have further worked with participants from the USA, and one study has focused on Canadian respondents. Regarding the Middle and South American region, Brazil, Colombia, the Dominican Republic, and Mexico have been investigated by a total of 13 studies. Four publications have surveyed Australian participants, and five studies have specifically queried data from New Zealanders. Finally, three South African, one Ethiopian, and one Nigerian studies exist as well as one cross-country study that has conducted research in 12 different African nations (Kombolo Ngah et al. 2023).

Figures 4 and 5 further illustrate the steadily growing number of articles published per year¹ as well as the study distribution per journal.

Assessment of societal factors

Using the Inglehart–Welzel framework (see Fig. 6), most cultured meat acceptance research was conducted in countries classified as secular-rational/self-expressional nations ($n=18$), followed by research in countries that display (i) survival/traditional ($n=12$), (ii) survival/secular-rational ($n=6$), and (iii) self-expressional/traditional cultural value orientations ($n=5$). Hence, although extant studies cover all four cultural

¹ Journals with one publication each are: AGRARIS Journal of Agribusiness and Rural Development Research, Amfiteatru Economic, Animals, ATRS Journal, Brazilian Journal of Marketing, Environmental and Resource Economics, Environmental Science and Pollution Research, Food Control, Food Frontiers, Food Research International, Frontiers in Psychology, International e-Journal of Educational Studies, International Journal of Advertising, International Journal of Environmental Research and Public Health, Journal of Agricultural Economics, Journal of Business Economics, Journal of Cleaner Production, Journal of Environmental Psychology, Journal of Food Products Marketing, Journal of Food Science, Journal of Integrative Agriculture, Journal of International Food & Agribusiness Marketing, Journal of Retailing and Consumer Services, Psychology & Marketing, Public Understanding of Science.

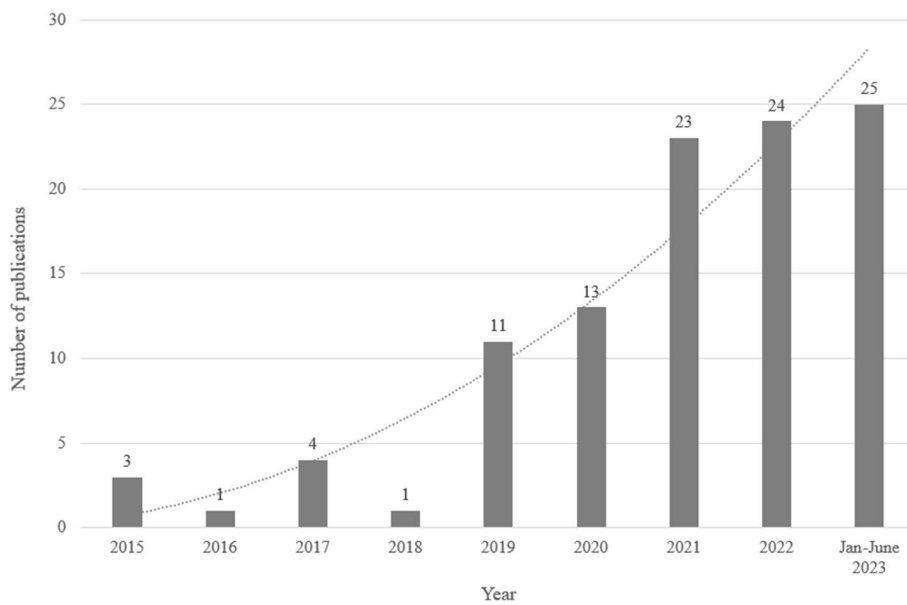


Fig. 4 Number of publications per year

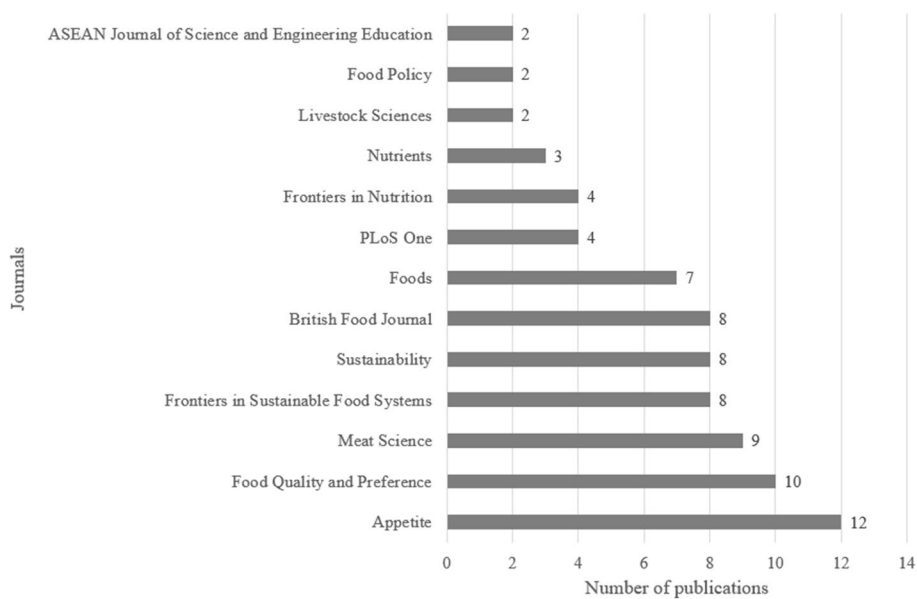


Fig. 5 Journals with more than one consumer-focused cultured meat study

types, we observe an emphasis on countries with secular-rational/self-expressional value dispositions.

Regarding religious contexts, 34 of the 49 national study settings are characterized by a predominance of Christianity. In addition, nine Islamic, three Buddhist, one Shinto as well as one Hindu country have been researched. Thus, compared to other religious confessions, Christian regions are overrepresented in cultured meat research. Since “[o]nly in Christianity, there are no rules related to meat consumption” (Vranken et al. 2014, p. 98), extant research is predominately conducted in a religious context where eating meat

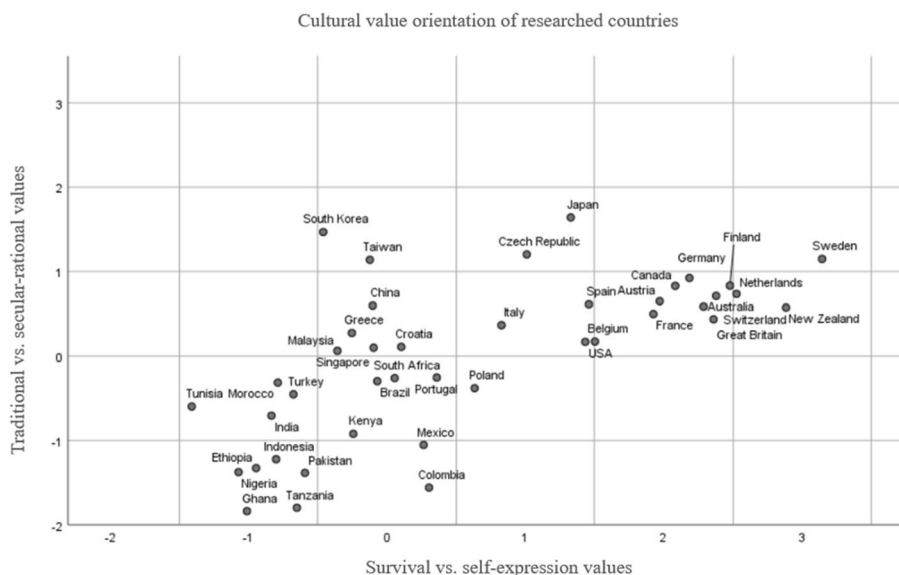


Fig. 6 Cultural context of empirical studies on cultured meat acceptance

as a social practice is accepted rather than stigmatized. In contrast to other religions, the Christian confession does not forbid specific meat types to be eaten in general but still impose certain restrictions around meat consumption, thus “[...] underlining the need for proper contextualization to avoid overgeneralizations” (Leroy and Praet 2015, p. 207). Regarding religiosity, 54% of global consumers say that religion is very important to them (Pew Research Center 2018). As shown in the Additional file 1, this percentage is higher in 20 and lower in 23 of the researched countries, suggesting that prior studies were placed both in religious and profane consumer markets.

Assessment of food environment

Globally, 43 kg of meat are annually produced and consumed per capita (Ritchie et al. 2019). Based on our descriptive analysis, 21 (17) of the researched countries produce (consume) less meat, while 27 (31) nations report production (consumption) levels above the global average. Thus, countries with high meat production and consumption levels have primarily been investigated by extant consumer-focused studies. In contrast, countries with less reliance on conventional meat have been explored to a lesser extent.

Assessment of economic market factors

Regarding the economic market factors, 25 (23) of the examined nations report GDP per capita above (below) the global average of USD 12,262.9 (World Bank 2021a). Similarly, 22 (26) countries depict CO₂ emissions above (below) the global average of 4.4 metric tons (World Bank 2019). In addition, 18 countries grow faster than average (0.9%) while the remaining 30 nations either depict a slower or a regressive population growth rate (World Bank 2021b). Thus, we observe a research focus on countries characterized by high GDPs, low CO₂ emissions per capita, and slow population growth, as shown in the Additional file 1.

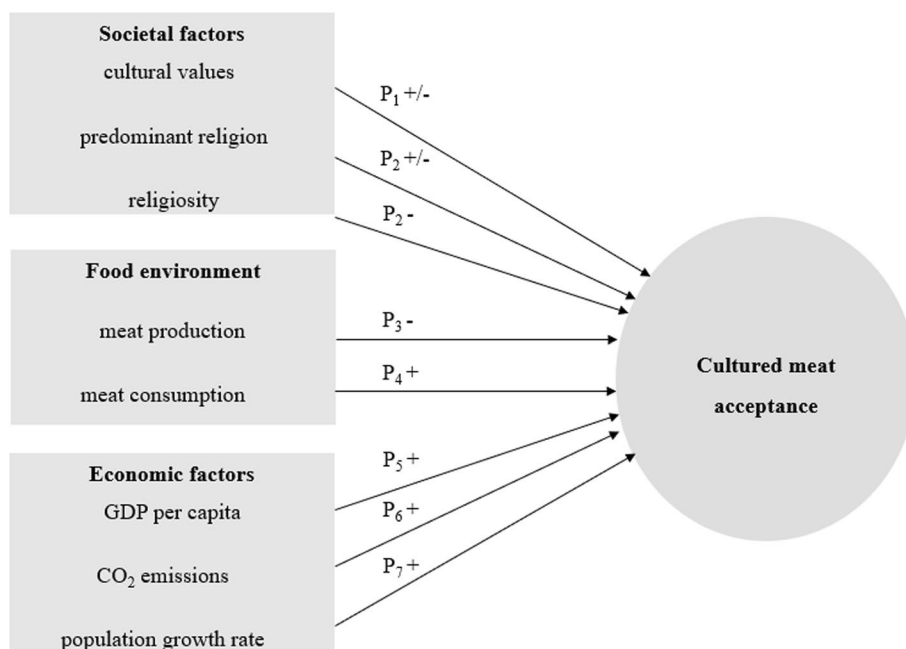


Fig. 7 Research propositions

Discussion and research propositions

We identified and analyzed 105 consumer-focused studies on cultured meat according to the framework depicted in Fig. 1. Our findings show that extant research has covered a wide range of geographical contexts but that certain country types are still over- and underrepresented in terms of societal and economic market factors as well as the prevailing national food environment. In the following section, we highlight the peculiarities and patterns that we have observed. Based on the findings of our descriptive analysis, we further discuss how these factors might relate to cultured meat acceptance and develop research propositions (for a summary, see Fig. 7).

Societal factors

While extant research has worked with consumer samples of distinct cultures, countries with secular-rational/self-expressional values have been most frequently explored. Hence, the extant results might be applicable only to regions characterized by such cultural dispositions. Cross-country contributions find that consumer acceptance varies across nations (e.g., Bryant et al. 2019; Siegrist and Hartmann 2020a). Although these studies have primarily explored cultured meat responses at an individual consumer level, first empirical evidence shows that culture-specific variables (i.e., social image eating motivation) explain the divergent acceptance rates across countries (Chong et al. 2022). This finding further supports the preceding qualitative insight that the understanding and categorization of cultured meat might depend on cultural belonging (Bekker et al. 2017; Hansen et al. 2021). In addition, individual consumers' value dispositions also impact behavioral intentions toward cultured meat (Lewisch and Riefler 2023), suggesting that cultural values at a societal level might also relate to consumer acceptance.

Based on these insights and building on the framework of Inglehart and Welzel (2010), we argue that due to traditionalists' inherent difficulties in accepting change and embracing innovation, a traditional value orientation might constitute a barrier to accept cultured meat as a novel food. Hence, consumers of traditional countries might be less inclined to adopt a new food technology compared to consumers residing in secular-rational contexts. Furthermore, since the perceived importance of ecological welfare impacts behavioral intentions toward cultured meat (Lewisch and Riefler 2023), self-expressional nations characterized by high levels of environmental concern (Inglehart and Welzel 2010) might recognize more societal value in this food innovation than countries characterized by survival value profiles. Since the latter tends to be accompanied by a fear of cultural change (Inglehart and Welzel 2010), this characteristic could also hinder the diffusion of disruptive technology innovations. Thus, we formulate the following proposition:

P_1 Secular-rational and self-expressional values are positively related to cultured meat acceptance, whereas traditional and survival values are negatively related to cultured meat acceptance.

Regarding a country's predominant religion, extant cultured meat research has focused primarily on Christian consumer markets, followed by Islamic countries. However, Hindu and Buddhist regions have been largely neglected, although they represent a community of 1.2 billion and 506 million consumers worldwide (World Population Review 2023a, b). Similarly, no single study focuses on a Jewish consumer sample, despite Israel being the first country to have a cultured meat factory in place (New Atlas 2021). Some initial research results suggest that consumers directly transfer religious dietary restrictions to cultured meat. As such, the numbers of Muslims who eat pork (30.1%) and Hindus who eat beef (18.2%) corresponds to the share of consumers who consider cultured meat appealing (27.5% and 18.9%, respectively) (Bryant 2020). Further, the labelling of cultured meat as halal might be crucial for product acceptance within Muslim communities (Ho et al. 2023; Terano et al. 2023). Thus, religious confessions might determine whether cultured meat is ultimately accepted in a specific market.

In addition to the role of religious confessions in the context of cultured meat, research has rarely assessed individuals' religiousness. The few existing studies show that individuals accepting cultured meat are less religious than other consumer segments (Faletar and Cerjak 2022) and less willing to pay for this food innovation (Kantor and Kantor 2021). In addition to direct effects, we argue that religiousness might also indirectly relate to consumer responses. For example, the perceived unnaturalness of cultured meat is frequently considered a key barrier (Siegrist and Hartmann 2020b). Since "[...] religious values [...] reduce acceptance rates of GM foods [...]" (Alonso et al. 2018, p. 117), we assume religiousness to also moderate the relationship between unnaturalness and consumer acceptance of cultured meat as another scientific food innovation. In light of the above, we expect consumers' religious confession as well as their level of religiousness to affect cultured meat acceptance. Hence, we suggest the following proposition:

P_2 A country's predominant religion affects dispositions toward cultured meat, and religiousness moderates the relationship between religious confessions and cultured meat acceptance.

Food environment

Countries with high meat production levels somewhat dominate cultured meat research, indicating a significant reliance on the meat industry. From a consumer perspective, studies show that individuals perceive cultured meat as a threat to the well-being of farmers (Shaw and Iomaire 2019), although professionals in the meat industry report more positive attitudes toward this food innovation (Bryant et al. 2020). The introduction of cultured meat on a large scale might result in new jobs that differ tremendously in the skill requirements (Bryant 2020). This situation, together with a potential reduction in conventional animal husbandry, might result in conventional meat producers facing increased job insecurity (Bryant 2020). Hence, established value chains could be disrupted, both within and across national markets. Thus, policymakers might undertake certain measures to protect the conventional meat sector (Stoll-Kleemann and Schmidt 2017), as has recently been the case when industry representatives were campaigning against plant-based meat substitutes (The Pig Site 2020). Hence, we expect that such undertakings might impede the diffusion of cultured meat as a future food and consequently aggravate consumer acceptance. Thus, we formally propose the following proposition:

P_3 High levels of conventional per capita meat production in national markets are negatively related to cultured meat acceptance.

Similar to production levels, existing research on cultured meat has focused on countries with high levels of meat consumption. Since cultured meat is expected to have certain advantages over conventional meat in terms of ecological sustainability (Gursel et al. 2022) and animal welfare (Chriki and Hocquette 2020), consumers residing in countries characterized by high meat consumption levels might recognize a particular societal value of this food technology innovation. From a different perspective, a high national demand for conventional meat also indicates a substantial market potential for cultured meat as a substitute. Based on these insights, we formally propose the following relationship between per capita meat consumption and cultured meat acceptance:

P_4 High levels of conventional per capita meat consumption in national markets are positively related to cultured meat acceptance.

Economic market factors

Although economic market factors are known to influence the diffusion of innovations, their impact has not yet been empirically investigated in the context of consumer-oriented cultured meat research. This gap illustrates the current emphasis on explaining individual consumers' perceptions rather than focusing on market-related criteria.

As GDP influences consumer lifestyles (Saleem and Ali 2019), we assume that this economic indicator affects the positioning of cultured meat from a marketing perspective. Because of the relationship between GDP per capita and consumers' purchasing power, GDP is likely to also affect the diffusion speed of cultured meat, as this food innovation is assumed to be sold at a premium when first being introduced to consumer markets (Brennan et al. 2021). In addition, GDP is also positively related to a country's economic freedom (The Heritage Foundation 2022a). Considering that Singapore (i.e., the first country to allow cultured meat for sale) was ranked as the economically freest country in 2022 (The Heritage Foundation 2022b), this criterion might also pave the way for cultured meat as a future food source. Accordingly, we propose the following relationship:

P_5 GDP per capita is positively related to cultured meat acceptance.

Regarding CO₂ emissions, the majority of the examined countries exhibits emissions below the global average, thus classifying as not highly polluting. In light of the severe ecological impact of conventional meat (OECD/FAO 2021), shifting production and consumption toward potentially more sustainable food alternatives could be a viable approach for tackling environmental deterioration. Against this background, we assume that consumers residing in highly polluting countries might perceive greater potential in cultured meat, resulting in a positive relationship with consumer acceptance. Extant findings indeed demonstrate that environmental concern strengthens individuals' behavioral intentions toward cultured meat (Lewisch and Riefler 2023). In addition, countries characterized by high national CO₂ emissions might endorse reduction measures throughout distinct sectors at national and supra-national levels (e.g., Green Deal, see European Commission 2019). Hence, the conversion of conventional meat production facilities to cultured meat laboratories might be institutionally funded. In line with the above, we propose the following:

P_6 High levels of overall CO₂ emissions in national markets are positively related to cultured meat acceptance.

Finally, most consumer research on the acceptance of cultured meat has been conducted in countries with low or negative population growth rates. Thus, areas characterized by fast-growing populations, such as Africa (Saleh 2022), have not yet been explored in detail. Exceptional in this regard is the recent cross-country contribution of Kombolo Ngah and colleagues (2023) that has conducted research in 12 different African countries. We assume that population growth has twofold implications for the acceptance of cultured meat. First, this indicator is related to the challenge of feeding a continuously growing population (World Resources Institute 2019), which makes the need for alternative proteins in fast-growing markets particularly urgent. Given the scaling potential of cultured meat (Tomiyama et al. 2020), this novel food technology could countervail resource scarcity and ensure a global protein supply. Second, population growth might effectuate a shift in demographic patterns. Drawing on the insight that younger consumers are more open to cultured meat than older

citizens (Slade 2018), we assume that this structural change might benefit perceptions of cultured meat. Hence, we expect a positive relationship between a country's population growth rate and cultured meat acceptance:

P_7 A high annual population growth rate in national markets is positively related to cultured meat acceptance.

Conclusion

Cultured meat is an alternative to conventional meat production that is expected to enter an increasing number of national consumer markets (Good Food Institute 2022). From a societal perspective, cultured meat might have the potential to contribute to a global food supply in the future, given its scaling potential in the production process (Tomiyama et al. 2020). Empirical research on consumer acceptance of this innovation has been steadily growing over the past ten years. However, while personal factors driving acceptance have received particular attention in this stream of literature, the relevance of cultural and economic market factors has largely been neglected. This paper aims to provide an impetus for more cross-cultural research considering the influence of these factors on cultured meat acceptance in national consumer markets and the practical significance of this future food for achieving an increased global protein security. This review also provides an overview of extant research settings and proposes a framework with corresponding research propositions relating cultural and economic market factors as well as the national food environment to cultured meat acceptance. In the following, we discuss avenues for future research, before we present the practical implications and limitations of our work.

Avenues for future research

In our review, we have observed that cross-country research represents only a fraction of the empirical body of consumer research on cultured meat acceptance (i.e., 21 of 105 papers). Extant cross-country studies show that cultured meat acceptance varies between countries (e.g., Bryant et al. 2019), demonstrating the practical relevance of such research designs. Thus, we first recommend that future research conducts more such investigations by simultaneously collecting data from respondents of different countries to systematically assess the impact of cultural and economic variables.

Second, we suggest that scholars explore consumer markets that have been neglected at the time of writing. Such investigations could focus on African, South American, and Eastern European consumers. The fact that the African population is the youngest worldwide (Saleh 2022) and that meat production in certain South American countries has almost doubled within the past 20 years (Ritchie et al. 2019) demonstrates the practical need for additional scientific empirical research in these geographic areas. To date, only three studies have worked with Singaporean consumers, although cultured meat has already been approved for sale by policymakers (Witte et al. 2021). Hence, we recommend that future research simulates field experiments in this pioneering country.

Third, extant research has focused primarily on countries that display a self-expressional/secular-rational cultural value orientation. Thus, empirical studies of other cultures would be valuable. In a similar vein, only a few studies have yet empirically

examined the extent to which religious confessions might explain structural differences in consumer acceptance of cultured meat (e.g., Boereboom et al. 2022; Faletar and Cerjak 2022; Ho et al. 2023; Kantor and Kantor 2021); hence, for the purpose of validation, replication studies are needed. To this end, future studies are also required to explore whether personal religiousness moderates the relationship between consumers' confessions and their acceptance of cultured meat.

Fourth, we have observed that in absolute numbers, a substantial amount of consumer samples was drawn from countries where low GDP ($n=23$) and meat consumption levels ($n=17$) prevail. Since these characteristics are often related to malnourishment (Roser and Ritchie 2019) and because cultured meat appears to show considerable scaling potential (Tomiya et al. 2020), future studies could examine whether consumers residing in such markets differ in perceived drivers of and barriers to cultured meat consumption from individuals in saturated markets.

Lastly, we have noted that extant studies typically do not elaborate on the meat type that cultured meat is intended to replace (i.e., with some exceptions, such as the research of Arango et al. 2023). However, this distinction might be crucial for consumers who eat only specific animals, either for religious reasons, taste preferences or individual tolerability. The need for studies differentiating between meat types is further supported by empirical results, suggesting that consumers' behavioral intentions toward cultured meat stem from their conventional meat-eating behavior (e.g., Bryant 2020; Wilks and Phillips 2017).

Practical implications

Based on our systematic literature review, we derive several implications for policymakers and practitioners. As such, our review offers an overview of which countries have been explored by extant articles to provide practitioners with guidance when deciding on strategic focus markets. Considering that research results might be the subject to societal and economic boundaries as well as characteristics of the respective food environment, we further encourage the consideration of such context variables when transferring academic findings to managerial agendas. As different drivers of and barriers to cultured meat consumption might prevail across markets, it will be a key challenge to address the most exigent issues in national marketing campaigns.

In addition, we recommend that practitioners consider specifically the respective economic market conditions relevant to cultured meat commercialization. For example, high levels of meat consumption signalize an increased market potential for cultured meat as a substitute product, whereas slow economic growth might indicate a more reluctant innovation diffusion (Maradana et al. 2017).

Besides these implications, we also acknowledge certain limitations of our review. First, only English papers were considered, resulting in a possible neglect of articles published in local languages. Second, our framework includes a carefully selected set of societal and external factors that is not holistic and might be complemented by future research. Third, in a handful of cases, some data points were not available at a country level and are thus missing (see Additional file 1 as an online resource).

Abbreviations

GDP Gross domestic product
CO₂ Carbon dioxide

Supplementary Information

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Additional file 1. This online resource provides further information about the studies considered in this review.

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Data availability

The dataset supporting the conclusions of this article is included within the article's additional files.

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The authors have no competing interests to declare that are relevant to the content of this article.

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