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Halal or not? Exploring Muslim perceptions of cultured meat in Singapore

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Singapore was the first country to approve cultured meat for public consumption. However, it remains unclear whether Muslims, who adhere to religious dietary restrictions and constitute a significant proportion of Singapore's population, are willing to consume cultured meat. Informed by the cognitive miser model, this study explores how Muslims make sense of cultured meat through their religious beliefs, trust in different stakeholders, as well as their risk or benefit perceptions of cultured meat. The findings from online focus group discussions showed that Muslim participants would only consider consuming cultured meat if it is certified halal (i.e., compliant with Islamic laws) and they also voiced religious concerns about cultured meat. Muslims have strong trust in food regulatory authorities in providing information about the safety and halal status of cultured meat. In addition to religious concerns, Muslims had similar risk and benefit perceptions of cultured meat compared to those of the non-Muslims. Theoretical and practical implications were discussed.

KEYWORDS

cultured meat, Muslims, cognitive miser model, halal, focus group (FG)

Introduction

The global population is projected to increase by 2 billion to an estimated 10 billion people by 2050 (United Nations, 2019), leading to greater demand for food and increased strain on agricultural production and environmental resources (Food and Agriculture Organization of the United Nations, 2017). Cultured meat, or meat made from stem cells grown outside of animals, has the potential to alleviate future pressure on global food production (Post et al., 2020). The process of making cultured meat involves the removal of stem cells from an animal before the cells are grown in a suitable medium with the right environmental conditions and mature into muscle cells that are biologically similar to animal products from livestock agriculture (Bhat et al., 2015; Stephens et al., 2018).

The cultured meat industry has developed quickly since the first cultured hamburger patty was introduced to the public in 2013 (BBC, 2013; Good Food Institute, 2021). However, regulatory agencies around the world have been slow in approving the sale of cultured meat (Neslen, 2020; Kateman, 2021). To date, Singapore is the only country that has approved cultured meat for sale and public consumption. Specifically, the Singapore Food Agency (SFA) has approved the sale of cultured chicken nuggets and chicken breasts produced by the American company Eat Just (Tan and Tay, 2021).

Despite some advances in the regulatory approval of cultured meat, cultured meat is still an emerging food technology which is unfamiliar to the public. As the future potential of novel food technology is dependent on how the public perceives it, it

is imperative to understand public attitudes toward novel food (Siegrist and Hartmann, 2020a). Existing studies have broadly revolved around public acceptance of cultured meat while narrowing in on myriad barriers to and determinants of acceptance (Bryant and Barnett, 2020; Pakseresht et al., 2022). One understudied consideration for cultured meat in extant studies is the role of religion, despite its importance in relation to meat consumption (Bryant, 2020). Religion is pertinent to cultured meat as specific beliefs may prescribe restrictions on meat consumption, leading to uncertainties on whether cultured meat can adhere to religious requirements (Einhorn et al., 2022). While scholars have analyzed potential issues and concerns in Islam (Hamdan et al., 2018) and Judaism (Kenigsberg and Zivotofsky, 2020), few empirical studies have examined the perceptions of cultured meat among the religious public.

Islam presents an interesting case study to better understand religious nuances on public perceptions toward cultured meat as 15.6% of the population in Singapore identify themselves as Muslim (Department of Statistics Singapore, 2021). The key consideration for Muslims is whether cultured meat is halal (Hamdan et al., 2018). According to Islamic beliefs, food classified as halal, which means *lawful* in Arabic, is permissible for consumption while food classified as Haram, which means *unlawful*, is not allowed for consumption (MUIS, 2020b). For meat to be certified halal, animals have to be slaughtered in accordance with Islamic law, while prominent examples of Haram food include pork (Chaudry and Riaz, 2014). Scholars have argued that cultured meat can be halal if stem cells are obtained from animals which are slaughtered according to Islamic requirements and if no blood is used in the production process (Hamdan et al., 2018).

Existing work on Muslim perceptions of cultured meat is limited, with only one quantitative study in the UK focusing on their acceptance rate of and willingness to purchase cultured meat (Boereboom et al., 2022). While consumer preferences provide a baseline for understanding general metrics like the acceptance rate of cultured meat, a deeper understanding of Muslim considerations through an in-depth, qualitative approach is lacking. Different from the quantitative approach employed in the study by Boereboom et al. (2022), the qualitative approach (i.e., focus group discussion) used by this study is ideal for investigating Muslim groups' insights on cultured meat and their reasons for accepting or not accepting cultured meat, which helps to understand the motivators or barriers behind different cultural groups' acceptance of novel foods. Moreover, focus group discussion can produce insightful self-disclosure that may remain hidden in an one-to-one interview and therefore is "well poised for learning how certain groups react to a similar issue or shared experience" (Tracy, 2019, p. 169). Hence, by employing such a qualitative method as a focus group study, it would be easier to capture Muslim groups' collective reactions toward cultured meat and the underlying reasons for for accepting or rejecting the novel food. Moreover, the multi-religious context of Singapore may result in diverse food choices across different religious groups. To better convey cultured meat to different cultural groups in Singapore, it is important to employ a qualitative approach (i.e., focus group discussions) to explore how some religious groups, such as Muslims, perceive cultured meat. As such, this study aims to fill the existing research gap in the literature

by employing focus group discussions to understand how Muslims perceive cultured meat in Singapore.

By using the cognitive miser model, this study aims to gain a nuanced understanding of how Muslims in Singapore perceive cultured meat. The cognitive miser model posits that when people lack knowledge of scientific topics and have little incentive to seek knowledge, they rely on heuristics to make decisions (Fiske and Taylor, 1991). As cultured meat is an emerging food technology, the public may lack knowledge or experience about the topic. This makes the cognitive miser model a suitable theoretical framework for understanding public perceptions of cultured meat. Specifically, this study seeks to examine how Muslims rely on their religious beliefs, trust in different information providers relevant to cultured meat, and their risk or benefit perceptions to perceive cultured meat. Theoretically, this study is the first to apply the cognitive miser model to understand how Muslims perceive cultured meat in Singapore, thus contributing to the existing literature on cultured meat in an understudied cultural context. Practically, the findings can aid policymakers and relevant stakeholders to better understand Muslims' concerns about cultured meat and thus, enabling them to develop effective strategies for enhancing Muslims' comprehension of cultured meat.

Literature review

Cognitive miser model

This study uses the cognitive miser model to understand Muslims' perceptions of cultured meat. The cognitive miser model posits that individuals tend to acquire as little information as they require to make a decision about a topic (Fiske and Taylor, 1991). Consequently, individuals' finite time and attention propels them to turn to cognitive shortcuts, or heuristics, to help them to make sense of complex topics that would otherwise demand too much effort to understand (Popkin, 1991). The cognitive miser model (Fiske and Taylor, 1991) has been used to examine public perceptions of emerging and contentious novel food technologies such as nanotechnology (Ho et al., 2010) and genetically-modified food (Raza et al., 2021). Salient heuristics such as religiosity (Ho et al., 2008), trust (Siegrist et al., 2007) as well as risk (Raza et al., 2021) and benefit perceptions (Brossard et al., 2009) have been found to play a key role in shaping public perceptions of emerging technologies.

In the context of novel food technologies, heuristics serve important functions for individuals with little knowledge (i.e., laypersons) to make sense of emerging technologies and make decisions in relation to them (Siegrist and Hartmann, 2020a). While existing studies on cultured meat in Singapore have examined the acceptance rate of cultured meat among Singaporeans in relation to social image motivations (Chong et al., 2022), there is still scarce knowledge of how a specific cultural group, Muslims, makes sense of cultured meat based on various heuristics. Additionally, though previous studies found that religiosity served as a heuristic cue that influences layperson's attitudes toward novel food technologies (e.g., nano-enabled food; Cummings et al., 2018), it is unclear how Muslims, who are also laypersons to cultured meat, perceive

this novel food technology by relying on different heuristics (e.g., religiosity). Hence, to identify the various heuristic cues that Muslims tend to use for understanding cultured meat, we employed the cognitive miser model as the theoretical framework for this study.

Religious beliefs

Religious beliefs help individuals make sense of science and technology broadly (Scheufele et al., 2009). These beliefs may contradict scientific principles, particularly for controversial technologies like nanotechnology (Brossard et al., 2009) and stem cell research (Ho et al., 2008). These studies found a negative relationship between religious beliefs and public perceptions of contentious science topics, underscoring the incompatibility of specific religious beliefs with science.

Currently, Muslim perceptions of cultured meat are understudied, especially for exploratory studies using qualitative research. To the best of our knowledge, there are two quantitative studies that provided empirical evidence on Muslim perceptions of cultured meat. Bryant (2020) found that in a sample of 193 Muslims, more than half of them would eat cultured beef and lamb or goat meat while 49% would eat cultured chicken. Another study examined the perceptions of British Muslims and compared their considerations to British non-Muslims (Boereboom et al., 2022). The researchers found that Muslims in Britain have a greater willingness to purchase and pay extra for cultured meat compared to non-Muslims. In both populations, the healthiness, safety, and nutritional values of cultured meat are the main factors that affect their willingness to purchase it.

In Singapore, Muslim perceptions of cultured meat are currently unknown. As Muslims represent a relatively large proportion of the population in Singapore, examining how they perceive cultured meat in relation to their religious beliefs would inform communication practitioners on the engagement strategies that can be used to help Muslims to understand cultured meat. Thus, we pose the following research question:

RQ1: How do Muslims in Singapore perceive cultured meat in relation to their religious beliefs?

Trust

In the absence of knowledge about emerging technologies, trust allows people to rely on the opinions of other people or institutions (Siegrist and Cvetkovich, 2000; Siegrist and Hartmann, 2020a) to make decisions. This is especially important in the context of emerging food technology when people lack the knowledge to make sense of such technologies and are, therefore, unable to assess its risks and benefits (Siegrist, 2021). Thus, institutions like the government may play a key role in providing information to laypeople. Existing studies have found a positive association between trust in the government and attitudes toward novel food technologies such as nano-enabled food (Yue et al., 2015) and genetically-modified food (Chen and Li, 2007; Prati et al., 2012).

Studies on cultured meat focused on the roles of stakeholders in the food industry, another source of information for laypeople, showing how trust in food industry stakeholders affects public perceptions of cultured meat. The results of a study that involved focus group discussions revealed that a lack of trust in businesses which produced cultured meat was based on prior negative experiences of food labeling (Shaw and Iomaire, 2019). One survey found that a lack of trust in food scientists was a predictor of negative perceptions of cultured meat (Wilks et al., 2019) while another survey revealed that respondents with higher levels of trust in the food industry were more likely to perceive cultured meat as natural (Siegrist and Hartmann, 2020b). Similar to trust in government, these studies show that trust in food industry stakeholders is linked to positive perceptions while a lack of trust shapes negative perceptions of cultured meat.

Given that cultured meat is still a nascent food technology, it is important to consider how trust in different stakeholders is a consideration for Muslims in understanding cultured meat. Hence, we pose the following research question:

RQ2: How do Muslims perceive trust toward different stakeholders, such as the government or industrial players, in providing information about cultured meat?

Risk perceptions

Risk perceptions refer to people's assessments of potential negative outcomes (Slovic, 1987). People usually rely on their own experiences or values to form their risk perceptions (Paek and Hove, 2017; Siegrist and Hartmann, 2020a). On an individual level, people are concerned about the unknown and potentially negative effects of cultured meat on personal health (Verbeke et al., 2015). An experimental study contrasted people's risk acceptability toward natural beef with cultured beef and found that participants had higher risk perceptions of cultured beef than real beef, even if they were told that eating both types of beef had the same health risks (Siegrist and Sütterlin, 2017). These findings showed that a key factor influencing individuals' risk perceptions toward cultured meat is its unnaturalness, which in turn, increases individuals' uncertainty about it (Verbeke et al., 2015; Siegrist and Sütterlin, 2017). The perceived unnaturalness and safety concerns regarding cultured meat are among the most commonly mentioned barriers to consuming cultured meat (Bryant and Barnett, 2020), which may subsequently shape Muslims' acceptance or rejection of cultured meat. Thus, it is important to understand the risk perceptions of cultured meat among Muslims. Hence, we pose the following research question:

RQ3: How do Muslims perceive the risks of cultured meat?

Benefit perceptions

Benefit perceptions refer to people's assessments of potential positive outcomes (Chuah et al., 2018). Existing studies found that participants acknowledge the positive effects of cultured meat on

a societal level, citing reasons such as reducing animal suffering and carbon dioxide emitted from livestock agriculture (Verbeke et al., 2015; Wilks and Phillips, 2017). While animal welfare and environmental benefits are the most common benefits of cultured meat (Bryant and Barnett, 2018), researchers also found that respondents perceived cultured meat as a solution to alleviate hunger problems globally (Verbeke et al., 2015). Lastly, studies found that people tended to have more positive attitudes toward the benefits of cultured meat on a societal level, in comparison to individual benefits (Verbeke et al., 2015; Mancini and Antonoli, 2019). The perceived societal benefits of cultured may account for Muslims' acceptance or rejection of cultured meat. Thus, it is important to understand the benefit perceptions of cultured meat among Muslims. Hence, we pose the following research question:

RQ4: How do Muslims perceive the benefits of cultured meat?

Methods

This study aims to offer an in-depth understanding of perceptions of cultured meat among Muslims in Singapore. This study used focus group discussions, a qualitative method to answer our research questions. Given the intimate ties between our participants and religion, using focus group discussions will allow for deep and diverse insights into the nuances of Muslim perceptions of cultured meat and the beliefs that underpin these perceptions (Liamputtong, 2011). This choice of method was further strengthened by existing studies which have documented the use of focus group discussions across various countries to explore public perceptions of cultured meat (Verbeke et al., 2015; Stephens et al., 2018; van der Weele and Driessen, 2019). Data collection was conducted until data saturation, where little or no new information was elicited from participants (Guest et al., 2006; Saunders et al., 2018). Data saturation provided the confidence that we have established a comprehensive set of perspectives from focus group participants on their perceptions of cultured meat.

Sampling and recruitment

We conducted three online focus group discussions between March and July of 2022 in Singapore. After gaining approval from the university's Institutional Review Board, our research team members used purposive and convenience sampling to recruit participants. The recruitment process involved distributing posters online through social media and messaging apps, as well as offline distribution of posters at food centers. The minimum age for participants was 21, in accordance with Singapore's legal voting age.

We recruited a total of 24 participants, whose ages ranged from 22 to 69 years ($M = 47.63$, $SD = 14.76$). All participants were Singaporean and identified as Muslim. Participants were selected to ensure an equal distribution of gender, with males constituting 50% and females constituting 50% of the sample. To achieve a sample with similar characteristics (Krueger and Casey, 2015), each focus group was segmented by age, according to Pew Research Centre's definition of the age range for Millennials, Generation X, and Baby Boomers (Per Research Center, 2019). In relation to ethnicity, 71%

TABLE 1 Details of online focus group participants.

Focus group	Participants (number and gender)	Age	Generations
FGD1	8 (4 males, 4 females)	22–38 ($M = 30.13$; $SD = 5.64$)	Millennial
FGD2	7 (4 males, 3 females)	42–55 ($M = 47.85$; $SD = 4.22$)	Generation X
FGD3	9 (4 males, 5 females)	58–68 ($M = 63.00$; $SD = 3.64$)	Baby Boomer

of the sample were identified as Malay, 25% were identified as Indian, and 4% were identified as Javanese. Table 1 displays the details of Muslim participants in each focus group. Participants in each group were engaged in the focus group discussion only once.

Participants were asked to partake in the focus group discussions after they provided their consent on an online consent form. The duration of each focus group discussion was approximately 2 h. At the conclusion of each focus group, participants were given an incentive of S\$50.

Moderation

The focus group discussions with Millennial and Generation X respondents were conducted in English, while the focus group with Baby Boomers was conducted in Malay. The change in language was necessary as we encountered difficulties in recruiting older Muslims. Shifting to Malay ensured that we had access to a wider pool of potential Muslim participants. Members of the research team moderated the focus group discussions in English while an undergraduate who was fluent in Malay moderated the focus group discussion in Malay. To ensure consistency across all focus groups, the research team trained the Malay moderator on standard focus group discussion procedures and used the same moderators' guide, which was translated from English to Malay. The moderators' guide comprised a list of questions and prompts generated from the cognitive miser model and research questions. During the focus group discussions, the moderator asked questions from the moderators' guide and prompted participants to answer or elaborate on their responses.

Analysis

The video recording of each focus group discussion was transcribed verbatim by student assistants from a local university. The focus group discussion conducted in Malay was transcribed and translated into English. In addition, the translated transcript of the Malay focus group discussion was checked against the video recording to ensure accuracy. All names and identifying information were removed from the final transcript to protect the confidentiality of participants. Names were replaced with alphanumeric codes during data analysis. Examples of these codes from each focus group discussion are "MP1," "XP1," and "BP1."

These codes refer to the first participant from the Millennial, Generation X, and Baby Boomer focus groups.

Two coders from the research team coded and analyzed the data. Inductive coding was first employed to generate the initial codes to alleviate any potential preconceptions of the data (Thomas, 2006). In this step, the two coders first independently generated initial codes by reading the text line-by-line. After the first round of coding, the two coders categorized the codes generated in the first step into larger conceptual bins, and then compared their codes and conceptual bins through discussion. Finally, the researchers and coders identified the larger themes that were relevant to the research questions proposed in this study.

Results

This section is organized around the research questions. The data analysis results reflected four considerations from Muslim participants that relate to their perceptions of cultured meat: religious beliefs, trust in various stakeholders to provide information, as well as risk and benefit perceptions of cultured meat.

Religious beliefs

Halal Status of cultured meat

The most important consideration for participants was that cultured meat must be halal before it is consumed. Without being prompted, older participants tended to question whether cultured meat was halal in the early stages of the focus group discussion. Participants were unanimous about the importance of aligning cultured meat with their religious beliefs. XP4 captured the overall sentiment with this quotation: “I think for Muslims, generally, we need it to be halal and preferably halal-certified.” Many participants were open to trying cultured meat, but some participants were adamant about not trying cultured meat, even if it was halal.

Participants pondered whether cultured meat or its production process could be halal. They raised concerns about the potential presence of pork in cultured meat, especially if production facilities were in close proximity to other facilities producing cultured pork or other types of meat that were not produced in the Islamic manner. The participants emphasized that the halal status of cultured meat should be established by the religious authorities. For instance, MP8 commented that he would wait for religious authorities, such as Majlis Ugama Islam Singapura (MUIS), to decide on the halal status of cultured meat before trying it himself. Majlis Ugama Islam Singapura (MUIS) is a government statutory board that oversees Muslim affairs in Singapore (MUIS, 2021).

Trust in MUIS

Participants were unanimous in expressing trust in MUIS to determine the halal status of cultured meat. The main reason for trusting MUIS was its authority. This point was stressed by XP5 who stated that Muslims need to trust authorities (e.g., MUIS) as “they are doing the right thing as a Muslim authority and speaking on behalf of all Muslims in Singapore.” Other reasons cited

included rigor, familiarity, and credibility. Participants believed that MUIS’s process of halal certification was comprehensive. For example, MP7 explained that MUIS would go through a thorough checking process, including checking on the ingredients of cultured meat and investigating whether these ingredients meet the criteria for food safety.

Another reason for trusting MUIS was the organization’s credibility. Participants contrasted Singapore’s stringent regulations with the relatively looser requirements overseas. For instance, MP3 mentioned that some countries may not review regulations for halal certification regularly; in contrast, the regulations for halal certification in Singapore are regularly reviewed and updated. He stated that “[If Singapore] set a rule last year, it doesn’t mean that rule will exist this year.” This sentiment was also similarly expressed by MP6, saying that “In Singapore, some food may have been labelled as halal last year, [but it] may not be labelled as halal this year.” As most participants concurred that MUIS would regularly review the regulation of halal certification, they trust MUIS in determining the halal status of cultured meat.

Another reason for participants’ trust in MUIS is their familiarity with the institution. Most participants believed that MUIS is one of the most authoritative institutions that regulate Muslim affairs in Singapore. Therefore, Muslims are highly cognizant of the organization’s societal functions, with MP3 stating that “MUIS is like a brand.” Therefore, when it comes to Islamic-related problems, such as the halal status of cultured meat, most Muslims in Singapore would turn to MUIS. Although MUIS was predominantly the focus of discussion, there is also a minority of participants who mentioned they would trust other entities in deciding if cultured meat can be halal. For example, XP5 said they would trust equivalent organizations to MUIS in neighboring countries because they have “profound knowledge” while BP5 would trust religious teachers, who are accredited by MUIS in Singapore (MUIS, 2020a).

Trust in stakeholders

Trust in government

Many participants expressed strong trust in the government to provide information about cultured meat. Participants indicated that they sought information on whether cultured meat was safe to consume and whether it was halal certified. As detailed in the earlier section, participants rely on MUIS, a government statutory board, to determine the halal status of cultured meat. Beyond religious considerations, participants were also concerned about the safety of cultured meat. As MP3 highlighted, this necessitated a multi-institutional approach. First, they trusted the food regulators from the government to inform the public about cultured meat and to ensure that it complied with safety standards. After the safety of cultured meat has been established by the government, participants would then turn to MUIS for guidance on the religious permissibility of consuming cultured meat. Participants trusted the government to provide information because it was credible. As MP7 summarized, “I believe our government will do a good job in handling such matters [as cultured meat].”

Trust in other stakeholders

Although the government dominated the discussion on trust, a minority of participants also cited other stakeholders, such as local news media, international institutions, scientists, family members, and food producers. XP7 cited the local mainstream news media as credible in providing information that is cross-checked with overseas news agencies or other reputable organizations. MP3 said they would trust the U.S. Food and Drug Administration while XP1 broadly mentioned organizations or peer-reviewed scientists who can independently verify the claims from cultured meat producers. Two Baby Boomer participants, BP2 and BP9, stated that they would trust their family members.

Risk perceptions

Risk perceptions relevant to health

Most participants expressed concerns about the impact of cultured meat on individuals' health. The possibility and uncertainty of long-term side effects were the key concerns. Furthermore, concerns over detrimental health impact were linked to the perceived artificiality of cultured meat and the origins of its production. For example, XP5 said, "first thing that came across my mind [was] the longer-term side effects, whether it's really safe for humans... because it's grown artificially." Similarly, MP7 described cultured meat as "so fake" and questioned if it was safe for human consumption. Beyond cultured meat itself, BP2 perceived the laboratory setting as artificial, and emphasized that "it's safer for the community to take natural [food] items."

The perception of risk to individuals' health was also attributed to the opaqueness of the production process. For older participants, the source of cultured meat was a particular cause for concern. For instance, XP6 was sceptical about the components of cultured meat and questioned if there would be transparency in the production process. XP1 narrowed his concern to the source cell line for cultivating meat, worrying that defects in the cells are going to reproduce and consequently harm human health. BP2 and BP6 were similarly concerned about diseases stemming from the source cells.

Another health concern was that the risk of cultured meat could be amplified if it could be reproduced easily by unscrupulous producers. XP6 cited the example of fake food and questioned whether cultured meat could be similarly fake. Lastly, participants were worried about the nutritional content of cultured meat in comparison to conventional meat, with MP2 questioning the point of eating cultured meat if it was devoid of the nutrients found in conventional meat.

Other risk perceptions

Other less mentioned risk perceptions include the psychological impact of eating meat, as well as societal risks such as job loss and ethical implications. MP7 said they would "feel a bit sad" if people choose to eat cultured meat over conventional meat in the future. For MP7, eating conventional meat is linked to their psychological state: "I feel that we are human. We are real human, so we eat real food." MP3 was concerned about

the economic implications for conventional food producers, worrying that the development of cultured meat would "cut the jobs of people who do this for a living." Lastly, XP1 maintained an unequivocal position of cultured meat having no benefits due to the ethical implications of biotechnology. XP1 was concerned about "opening up a world that we don't know what it's going to lead to," mentioning that "...if lab-meat can be produced, why not designed babies?" A similar metaphor was used by a different age group, with MP6 likening cultured meat to "test tube baby," highlighting the artificiality of cultured meat.

Benefit perceptions

The two most commonly cited societal benefit perceptions among participants were the benefits of cultured meat for the environment and for food security.

Perceived benefits for the environment

Some participants mentioned that cultured meat could be beneficial for the environment. For example, XP4 mentioned how cultured meat could handle the "climate issue" and cited Singapore's 2030 Green Plan, which is Singapore's strategy to handle climate change (SG Green Plan, 2022). Other benefits for the environment cited include using fewer natural resources such as water and land for farming, reducing the emission of greenhouse gases, as well as mitigating issues like overfishing.

Perceived benefits for food security

Participants noted that Singapore exported most of its food and remarked that producing cultured meat could make it less reliant on imported food. MP6 commented on how COVID-19 exacerbated Singapore's vulnerability, and how "we are not in a position to depend on other countries during any of this pandemic situation." Other cited benefits related to food security were the speculation that mass production of cultured meat locally could result in lower prices of food (MP4 and MP6), and the possibility that mass production could lead to quicker food production in the future (XP5 and XP6). Overall, BP4 highlighted that the production of cultured meat could reverse the scenario of food shortages in the future.

Other benefit perceptions

Although attaining environmental sustainability and strengthening food security were the main benefits discussed, a few participants also mentioned societal benefits like the reduction of animal slaughter and job creation, as well as individual benefits stemming from a safer production environment and food products. Some participants mentioned that cultured meat could reduce animal cruelty, while XP4 envisioned the creation of the cultured meat industry in Singapore, leading to more jobs for scientists. Furthermore, they also noted the lucrative halal market, and that halal cultured meat could be a boon "for those people who are interested in the halal business."

Participants also mentioned that cultured meat could be healthier as it would be cleaner than traditional meat. MP7 commented on how the laboratory environment might reduce contamination, resulting in cultured meat which could be “100% clean,” a sentiment that was also echoed by BP7. MP8 speculated that cultured meat could be grown without diseases while XP4 mentioned the possibility of cultured meat being useful for people with digestive issues.

Awareness of cultured meat

Participants mentioned that they became aware of cultured meat from both interpersonal and mass media sources. For example, MP3 heard of cultured meat from colleagues, while MP2 said that his friend briefly mentioned cultured meat to him without further elaboration. However, most participants encountered information on cultured meat from the news media, such as from a news documentary on lab-grown chicken (MP8) or from newspaper articles (MP7).

Misconceptions about cultured meat

While not pertaining to religious beliefs, the results from the focus group discussions also uncovered some misconceptions about cultured meat among Muslim groups. For example, some participants (e.g., MP7) equated cultured meat with fake meat, mentioning that “cultured meat is like test tube baby” (XP7) that is created artificially and regard it as “a kind of mock meat” (XP4). Other participants confused cultured meat with other types of novel foods. For example, some participants said that when they first heard of cultured meat, they associated it with Impossible Meat (e.g., MP5), which is meat made from plants (e.g., soybeans and peas). One participant also believed that cultured meat was meat produced from cloned animals (e.g., MP7).

Discussion

The objective of this paper is to examine how Muslims perceive cultured meat in relation to their religious beliefs, who they trust to provide information about the novel food, and their risk and benefit perceptions. For RQ1, participants were unanimous in their belief that cultured meat must be halal before they could consume it. This extended to concerns if animals were slaughtered according to Islamic guidelines, if pork would be present in cultured meat, and if halal cultured meat would be produced near facilities producing cultured pork. Overall, the halal status of cultured meat is a key consideration for participants’ acceptance or rejection of cultured meat, reflecting wider global discourse around Muslims and cultured meat (Hamdan et al., 2018; Awang, 2021; Boereboom et al., 2022; Einhorn et al., 2022).

Another major finding was that participants expressed trust in MUIS to determine the halal status of cultured meat. Participants explained that they mainly trusted MUIS because of the organization’s authority. Trust in MUIS was also due to participants’ perceptions of MUIS as a rigorous, familiar, and

credible organization. This finding shows that while Muslims globally shared the same belief of consuming cultured meat only after it is certified halal, how that belief is materialized is dependent on the circumstances of individual countries. As a government statutory body, MUIS is unique to Singapore. While there is presently no official position on the halal status of cultured meat in Singapore, participants already expect to rely on MUIS when it comes to the hypothetical consumption of cultured meat. In contrast, Muslims in other countries may differ from the participants in this study as they follow guidelines from entities that are specific to their context.

For RQ2, participants trusted the government to provide information about the safety and halal status of cultured meat. Trust in the government in providing information about cultured meat has been detailed in the results section. It is noticeable that most participants emphasized the role of MUIS, a government statutory body, in ensuring the halal status and safety of cultured meat. The finding also shows that, beyond religious beliefs, participants were also concerned about the safety of cultured meat. This is supported by existing studies which have documented public concerns about the safety of cultured meat (Verbeke et al., 2015; Bryant and Barnett, 2020).

Our results show that safety was a fundamental concern, in which participants had to be assured of the safety of cultured meat before seeking religious advice on the halal status of cultured meat. In other words, safety and religious permissibility were entwined considerations. Participants trusted the government to provide information on the aforementioned considerations that could assuage their concerns. Specifically, participants wanted to know if cultured meat complied with safety standards and if consuming it was in accordance with Islamic beliefs. Similar to MUIS, participants trusted food regulatory authorities because they perceived these entities as credible. One potential explanation for the credibility of Singapore’s food regulators is the high food safety standards, which are supported by Singapore’s low rate of food-related diseases compared to the rest of the world (Singapore Food Agency, 2020a).

Another reason the participants cited for trusting the government was that they perceived the safety of cultured meat as a complex topic and did not have the requisite knowledge to assess its safety. As they perceived the government as credible, participants with little technical knowledge of cultured meat could rely on the assessment of the government to determine the food technology’s safety (Siegrist and Cvetkovich, 2000; Siegrist and Hartmann, 2020b). This is exemplified by participants’ reliance on food labels, which are markers of trust stemming from regulatory approval. This finding extends the extant cultured meat literature on trust in institutions, which remains understudied as extant studies have only examined trust in food scientists (Wilks et al., 2019) and the food industry (Siegrist and Hartmann, 2020b).

For RQ3, participants perceived the detrimental impact of cultured meat on individual health as the biggest potential risk. The uncertainty of long-term side effects was attributed to the artificiality of cultured meat and laboratories, the opaqueness of cultured meat production, as well as concerns over fake cultured meat. Other risk perceptions that the participants cited were the psychological impacts of eating cultured meat over conventional meat, as well as societal risks, like the potential loss of jobs and the

ethical implications of cultured meat. These risks are supported by extant studies which have found concerns over the uncertainty of cultured meat on health (Shaw and Iomaire, 2019), and perceptions of unnaturalness as the cause for health concerns (Bryant and Barnett, 2020). This finding shows that the participants had similar risk perceptions as non-Muslims because none of these risks were contextualized in relation to their religious beliefs.

For RQ4, participants mainly perceived cultured meat as beneficial for the environment such as the use of fewer natural resources for agriculture and the reduction of greenhouse gases, as well as beneficial for food security. Other benefits cited were greater animal welfare, safer food, and job creation. These benefits are supported by existing studies which found that environmental benefits (Bryant and Barnett, 2020) and animal welfare (O'Keefe et al., 2016) were key benefit perceptions. Like the risk perceptions detailed above, participants have similar benefit perceptions to non-Muslims. Again, most benefits were not contextualized in relation to religious beliefs.

However, two benefits (i.e., job creation and food security) warrant greater explanation because they are unique to Singapore's context. Although existing literature has highlighted economic concerns over agricultural job loss (Verbeke et al., 2015; Wilks and Phillips, 2017), one participant mentioned the possible creation of jobs for scientists and a new halal food industry. The benefits for job creation could be attributed to Singapore's position at the forefront of the cultured meat industry. Besides being the first country to approve the sale of cultured chicken products, Singapore has also approved production facilities to produce cultured chicken commercially (Tan, 2021; Chew, 2022), and the country possesses strong capabilities in its universities and research institutes (Khoo, 2021). In addition, the halal food industry in Singapore was estimated to be worth about one billion dollars in 2019 (Quek, 2021). Lastly, agricultural job loss may be less pertinent to Singapore as it imports more than 90% of its food (Singapore Food Agency, 2020b). This statistic could also explain why one key benefit perception participants mentioned is food security.

Despite Singapore being the first country to approve cultured meat products for consumption, the awareness of cultured meat among participants was generally not high. Younger participants displayed greater awareness of cultured meat than the older ones, gaining information about the novel food through interpersonal or news sources. Although there is mainstream news coverage, participants were still unsure about specific information on cultured meat. Additionally, most participants mentioned they obtained cultured meat-related information primarily from news media or interpersonal sources. Previous studies revealed that how media represent or describe cultured meat (e.g., lab-grown meat vs. clean meat) is a prominent factor influencing people's perceptions and acceptance of it (e.g., Bryant, 2020). Hence, the neutral and unbiased media representation of cultured meat would be important for the scientific communication of cultured meat to the public, which would help to eliminate the public's misperceptions.

Another misconception of cultured meat was its association with plant-based meat. Cultured meat is grown in a lab using stem cell technology while plant-based meat is made from ingredients without meat (Bhat et al., 2015). This association could possibly be due to the widespread commercial availability of plant-based meat in Singapore. Some participants claimed that they had

eaten cultured meat in restaurants that actually only serve plant-based meat rather than cultured meat. Others also mentioned that they ate cultured meat years before it was approved by the Singaporean authorities. Such misperceptions strengthen the observation that there was a low level of awareness of cultured meat among participants and that plant-based meat has entered public consciousness as the only meat alternative, given the limited availability and awareness of cultured meat.

Implications and limitations

Theoretically, this study contributes to the extant literature on the public understanding of novel food technologies by providing clarity on how Muslims' religious beliefs relate to their perceptions of cultured meat, which is currently understudied. Our findings show that Muslims will only consider consuming cultured meat if it is certified halal and that they are clear about how and where cultured meat is produced. They tend to rely on MUIS, a government organization unique to Singapore, to provide clarity on the halal status of cultured meat. Findings from this study can serve as a reference for future work comparing Muslim perceptions of cultured meat across different countries, or as a reference for cross-religious perspectives on cultured meat.

Our study is the first to use the cognitive miser model to understand how Muslims in Singapore perceive cultured meat based on a set of heuristic cues. Congruent with the propositions of the cognitive miser model, our findings show that Muslims in Singapore are inclined to use heuristic cues such as religious beliefs, trust, as well as risk and benefit perceptions to form attitudes about cultured meat. Specifically, previous studies did not consider trust in government as a heuristic cue in explaining the public's understanding of cultured meat. However, our study demonstrates that trust in the government, which is a key institution that regulates standards and provides information, was found to be important for participants to accept or reject cultured meat. As such, this study contributes to the cognitive miser approach by uncovering that trust in government is an important heuristic cue for Muslim groups to make sense of cultured meat. Given its importance, future studies using the cognitive miser model to examine Muslims' perceptions of cultured meat can consider incorporating trust in government as a consideration in this model. Lastly, various heuristics (e.g., religious beliefs, risk and benefit perceptions, and trust in government) based on which Muslims understand cultured meat could potentially be used to extend the cognitive miser model in future studies investigating Muslims' perception of cultured meat.

Practically, the findings can inform the public communication strategies employed by government authorities and industrial stakeholders on how to facilitate Muslims' understanding of cultured meat and mitigate potential misconceptions about it. Specifically, communicative efforts should center on assisting Muslims to differentiate cultured meat from other types of novel foods (e.g., plant-based meat). Efforts should be made to communicate the risks and benefits of cultured meat accurately and scientifically to the public. Additionally, because Muslims trust the government in deciding the safety and halal status of cultured meat, governmental institutions could leverage this trust to disseminate

accurate scientific information about cultured meat to Muslims and allay their concerns.

Limitations

As an exploratory study, the findings of this study cannot be generalized to the wider Muslim community in Singapore. The perspectives of the participants may vary from other Muslims who did not partake in this study. This limitation was mitigated by ensuring a diverse pool of Muslim participants across different age groups and genders. Furthermore, data saturation was achieved within the purview of the research questions posed (Saunders et al., 2018). This enhanced confidence in the richness of the data collected. Using the findings of this study as a benchmark, further research on Muslim perceptions of cultured meat can employ quantitative methods to make inferences to the larger population. For instance, the heuristics discussed in this study may be operationalized into variables which predict Muslims' attitudes toward cultured meat. Given the unique circumstances of different countries or religions, future studies may also compare Muslim perspectives in Singapore to those in other countries.

Conclusion

Using the cognitive miser model, this study examines how Muslims perceive cultured meat through their religious beliefs, trust in different information providers, as well as their risk and benefit perceptions. Participants were unanimous in their belief that cultured meat must be halal before deciding whether to consume it. Findings showed that participants trusted the government to provide information about the safety and religious aspects of cultured meat. Overall, this study provides insights into how Muslims perceive cultured meat, which can aid policymakers and relevant stakeholders in developing effective communication messages to help Muslims understand the novel food technology.

Data availability statement

The datasets presented in this article are not readily available because based on the requirement of the Institutional Review Board at Nanyang Technological University, all data collected is only

accessible to PI and research team members. Requests to access the datasets should be directed to mengxue002@e.ntu.edu.sg.

Ethics statement

This study involved human participants and was reviewed and approved by Institutional Review Board at Nanyang Technological University [IRB No.: IRB-2021-998]. E-consent was obtained from each participant before conducting this study.

Author contributions

SH: funding, supervision, conceptualization, methodology, data analysis, writing, reviewing, and editing. MO: conceptualization, methodology, data collection, data analysis, visualization, writing, revision, and editing. AV: conceptualization, methodology, data collection, data analysis, and writing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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