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Exploring Muslim Consumers' Acceptance of Cultured Beef Meat

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ABSTRACT

The advancement in cultured meat research in cellular agriculture has greatly surged. The concerns of halalness and *thayibban* (cleanliness and permissibility to consume) of cultured beef meat will arise among Muslim consumers, prompting the question, "Who will consume the cultured meat, and are Muslims ready to consume it?" This study aimed to clarify how Muslims perceive cultured meat and the issues surrounding their acceptance. A chi-square test and a binary logistic regression analysis were applied to reveal the acceptance of cultured meat. The results revealed that 44.1% of the respondents accepted cultured meat as their food, while 55.9% expressed doubts due to religious concerns. Their attitudes toward cultured meat influenced their decision to accept it as food. Some consumers had high expectations for cultured meat because they believed it would be superior in taste and have nutritional value and health effects. In conclusion, those Muslims who did not doubt cultured meat accepted it as future food with expectations for better function and value.

Keywords: Attitude; Cultured meat; Food acceptance; Halal; Muslim

INTRODUCTION

Concerns regarding food shortages and environmental issues caused by agricultural activities have been discussed in many forums worldwide (Adegbeye et al., 2020; Chung, 2021; Food and Agriculture Organization, 2013; National Research Council (US) Committee on Identifying and Assessing Unintended Effects of Genetically Engineered Foods on Human Health, 2004; Tuomisto & Teixeira de Mattos, 2011; World Water Assessment Programme, 2019). Meat-culturing technology provides an alternative form of meat that does not require livestock to be reared on a farm. In the frontlines of meat-culturing technology advancement, the Memphis Meats company, known as Upside Foods till May 2021, produced meatball cells of pork and cattle in 2016, and its line of New Age Meats made cultured pork cells for sausages (Schwartz, 2016; Upside Foods, 2022). However, the commercialization of this technology, in terms of cost and mass production, is still in progress (Stephens et al., 2018).

As the feasibility of producing cultured meat for the consumer market seems plausible, the question of acceptability needs to be addressed before embarking on mass production. Nevertheless, this paper utilized cultured meat to represent cultured beef meat. Hocquette (2016) pointed out that acceptance by final consumers has become the primary issue when considering the marketability of cultured meat. The Pew Research Center published the findings of a survey on American consumers entitled "U.S. Views of Technology and the Future" (Smith, 2014). The survey revealed that 78% of 1,001 respondents rejected eating meat grown in labs, whereas only 20% said they would eat cultured meat. Meanwhile, Rolland, Markus, and Post (2020) discovered positive attitudes toward cultured meat for the environment, animal welfare, and taste among 193 Dutch consumers. Thus, an in-depth understanding of consumers' behavior regarding cultured meat acceptance from the perspective of ethical issues associated with meat cultivation in labs could cause significant conflict despite psychological barriers to accepting it.

People's lack of willingness or openness to accept new or novel food is termed as their food neophobia and technophobia related to their feelings, such as fear of eating (Coppola & Verneau, 2014; Faccio & Fovino, 2019; Gaydhane, Mahanta, Sharma, Khandelwal, & Ramakrishna, 2018). Hence, to identify barriers and problems in accepting cultured meat, Bryant and Dillard (2019) conducted a study to address consumers' concerns over the unnaturalness and artificial production of cultured meat. A survey was performed to collect data from 1,185 American consumers to gauge their willingness to consume cultured meat. The survey results unveiled that the perception of naturalness played an essential role in the public's acceptance of cultured meat; the results disclosed that one-third of the respondents believed that cultured meat was unnatural.

Since cultured meat technology raises the provocative argument as indicated by Bryant and Barnett (2018), it becomes more crucial to understand not only who will accept this new type of food but also the individual food ethics, morals, and beliefs underlying the acceptance behavior of consumers. For example, a series of consumer surveys have been undertaken in Europe and the United States, including the research conducted by Verbeke, Sans, & van Loo (2015) with 180 Belgian respondents. The findings revealed that acceptance was related to people's expectations, such as healthiness, taste, affordability, and sustainability.

In the field of consumer research, consumers' behavior associated with food acceptance or rejection was often measured using sensory surveys (Cardello, 1994; Sajdakowska et al., 2018; Symmank, 2019), indicating that the sense of taste was linked to people's acceptance of food. On the other hand, Costell, Tárrega, and Bayarri (2010) and Tan et al. (2015) studied that consumers' acceptance or rejection was related to their experiences, attitude, and beliefs, implying that sensory taste did not simply influence acceptance behavior. Dupont, Harms, and Fiebelkorn (2022) adopted the planned behavior theory to uncover that food disgust, indicated as people's sensitivity, was negatively related to people's willingness to consume cultured meat. Moreover, de Oliveira Padilha, Malek, and Umberger (2022) also revealed that among attributes, healthiness, eating enjoyability, and safety were positively associated with consumers' willingness to eat lab-grown beef. Marshall (1995) also explained the association

between food acceptance and attitudes due to attitudes could profoundly affect acceptance. Food acceptance could be determined by individual perceptions or attitudinal characteristics.

Among Muslims, a critical attribute of food is halal status and producers' halal certifications, influencing consumers' preferences and purchasing behaviors, thereby reflecting both their perceived needs and those of society. An unfamiliar brand with no clear list of ingredients evokes consumers' insecurity about the products (Rezai, Mohamed, & Shamsudin, 2012). Muslims follow the laws clearly stated in the Qur'an and Sunnah. Nothing is unlawful unless specifically prohibited by these texts. Allah, glory be upon Him, says,

"I do not find within that, which was revealed to me [anything] forbidden to one who would eat it unless it be a dead animal or blood spilled out or the flesh of swine—for indeed, it is impure—or it is [that slaughtered in] disobedience, dedicated to other than Allah. Nevertheless, whoever is forced [by necessity], neither desiring [it] nor transgressing [its limit], then indeed, your Lord is Forgiving and Merciful. [Al-An`am (6): 145]."

The verse (the Qur'an) states that the meat of dead animals (also known as carrion), such as from sheep, goats, and cattle, or any other animals that can be consumed by the Muslims, blood, and pork are classified as forbidden to the Muslims to consume them. Besides the halal classification, *thayibban* describes when that food is safe, clean, high quality, and nutritious. It is an essential designation in Islam. Hamdan, Post, Ramli, and Mustafa (2018) studied cultured meat's source cells and media, making it possibly halal. According to Sharia Law, cultured meat can be defined as halal if the cells are derived from slaughtered animals. Furthermore, the cultured media used must not include blood or any components extracted from blood, such as serum, which is unclean and is considered *haram* (forbidden) in Islamic Law (Hamdan et al., 2018; Nurdeng, 2009).

According to Islamic teachings, the general principle concerning food is that everything is halal except impure (or mixed with impurities), harmful, or intoxicating. In addition, the animals must come from those permitted to be slaughtered and used as food. For example, in Malaysia, halal certification is conducted by the Halal Malaysia Official Portal (Portal Resmi Halal Malaysia, 2022). Thus, Muslim consumers in this country often rely on the halal logo displayed on packaging and restaurant banners to confirm the halalness of the food. Similar procedures might be applied in other Muslim countries or those with minor Muslim populations by their respective Muslim organizations.

According to Lugo, Cooperman, O'Connell, and Stencel (2011), a quarter of the world's population will be Muslim by 2030, making the size of the potential market crucial to successfully understanding diverse consumers, including Muslims. This exploratory study discusses the acceptance and consumption of cultured meat in the Muslim community in Malaysia. Therefore, the novelty of this study focuses on Muslims' attitudes toward the future demand for cultured meat. Thus, the research questions are as follows.

1. Will Muslim consumers accept cultured meat as food?
2. What attitudinal factors contribute to Muslim consumers' accepting cultured beef meat to replace cattle beef in their food consumption?

RESEARCH METHOD

This study hypothesized that Muslims' intention to accept cultured meat as food in the future was influenced by several factors, including attitudinal characteristics and religious concerns. Attitudes such as superior taste, environmental benefits, health effects, nutritional benefits, doubts about food, and the halalness of cultured meat (slaughtering method) must be considered. Figure 1 illustrates the conceptual framework of this study.

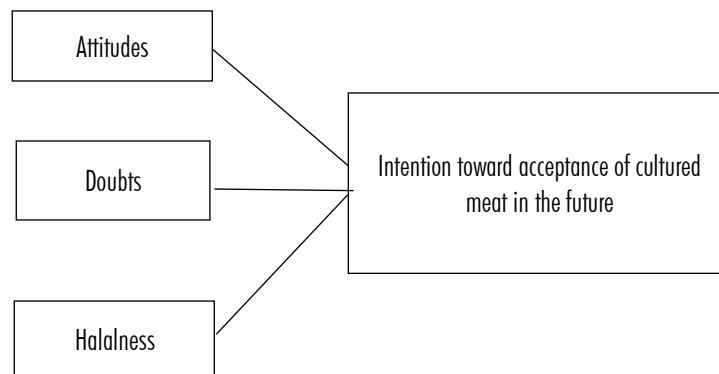


FIGURE 1. CONCEPTUAL FRAMEWORK OF MUSLIMS' INTENTION IN ACCEPTING CULTURED MEAT IN THE FUTURE
SOURCE: MODIFIED FROM THE THEORY OF PLANNED BEHAVIOR BY AJZEN (1991, 2001)

This study was conducted in Malaysia, with Islam as the national religion; given the country's diverse population, nearly 35% of people were non-Muslim (Department of Statistics Malaysia, 2022). While Malaysia has a multi-ethnic population, including Malays, who are Muslim by religion; Chinese, who are mainly Buddhist; Indians, who are mostly Hindu; and other ethnic groups, rigid halal certification systems, compliance measures, and training systems have been established under Islamic government institutions ahead of other countries (Asa & Azm, 2017). Muslims tend to be conscious of the halalness of their entire lifestyle, not only in food consumption habits but also in other aspects of interaction with people and business.

As the food concept discussed in this paper is new to the people of Malaysia, the survey was conducted among university graduates and professionals studying or working in universities. This study was performed in Malaysia and involved 102 respondents from urban areas in Selangor. The questionnaire was administered either online or through a paper-based interview. A short explanation of beef culture and meat technology was provided in the middle of the survey. Until there were questions about cultured meat technology, the survey progressed without informing the respondents of the "cultured meat production process". Initially, the respondents were asked whether they had heard about cultured meat. If they indicated that they were aware of the term "cultured meat," the outline was presented to them between questions. As the questions on awareness were limited to an initial awareness of cultured meat, a common understanding of cultured meat was provided by the "prior information" text constructed by authors, as displayed in Figure 2.

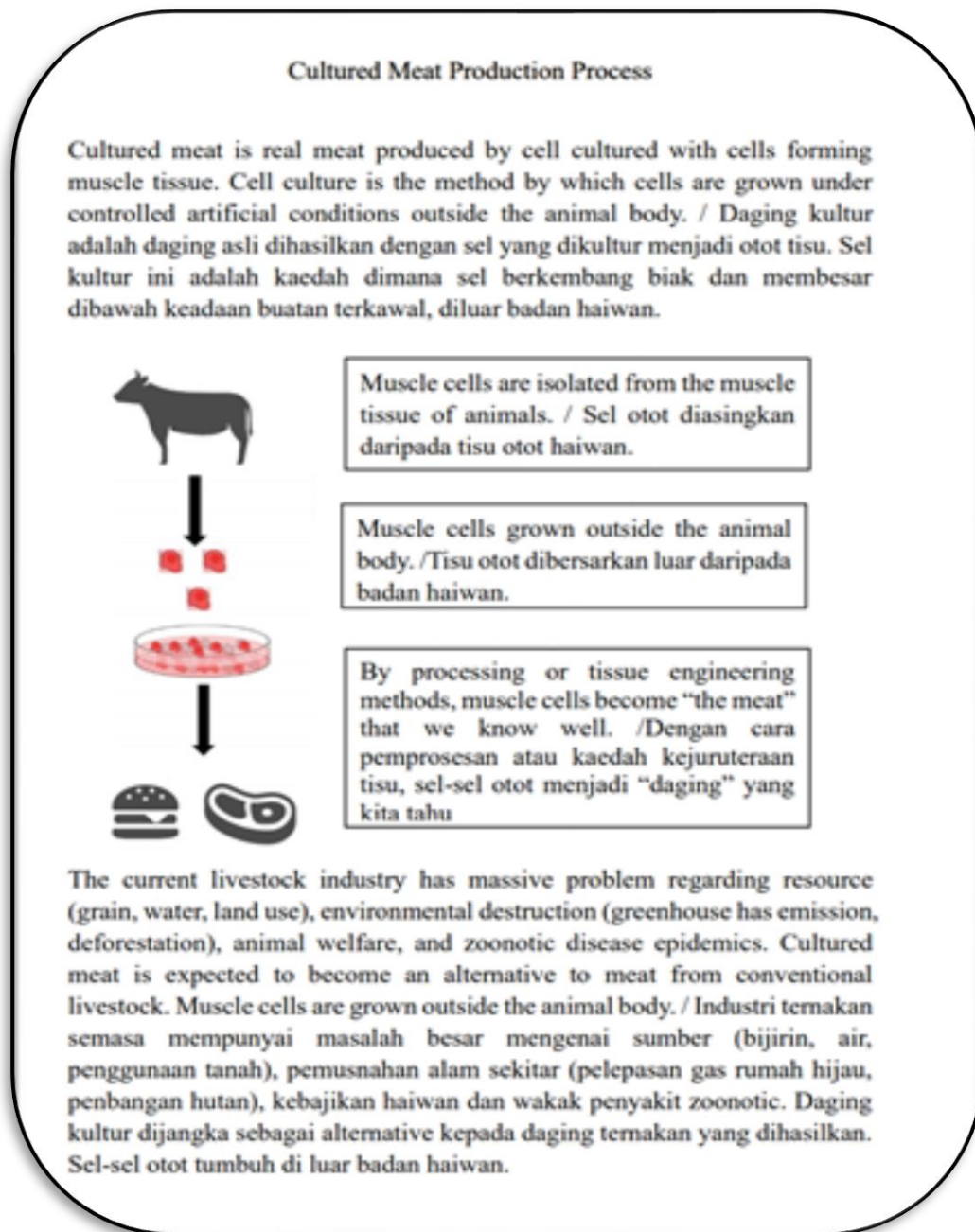


FIGURE 2. INFORMATION ON CULTURED MEAT PRODUCTION

Research Materials and Methods

The research sample comprised 102 respondents, of whom 62 were online and 40 were interviewed in person. The collected data were described using descriptive analysis. The chi-square test and binary logistic regression analysis were performed as part of the statistical analysis. The chi-square test was run to determine the association between acceptance and rejection of cultured meat as an alternative type of meat in the future against the attitudes toward it. Hence, six hypotheses gauged the respondents' opinions on accepting and rejecting

cultured meat as their future meat in terms of their attitudes toward it. In this study, as indicated earlier, cultured beef is represented with the term “cultured meat.”

H₁: There is no significant association between concerns about the halalness (method of slaughter) of cultured meat with the intention to accept cultured meat as food.

H₂: There is no significant association between doubts about food and the intention to accept cultured meat as food.

H₃: There is no significant association between superior taste and the intention to accept cultured meat as food.

H₄: There is no significant association between health effects and the intention to accept cultured meat as food.

H₅: There is no significant association between nutritional benefits and the intention to accept cultured meat as food.

H₆: There is no significant association between environmental benefits and the intention to accept cultured meat as food.

Binary logistic regression was applied to disclose the level of people’s acceptance among Muslim consumers as a choice of new food in the future. In the binary logistic model, “Y” represents the respondents’ acceptance or rejection of cultured meat in the future, measured using two categories encompassing “acceptance of cultured meat” coded as “1” and “lack of acceptance of cultured meat” coded as “0”. Meanwhile, “X_i” signifies the respondents’ attitudes toward cultured meat: superior taste, positive health effects, environmental and nutritional benefits, doubts about food, and its halalness. Attitudes regarding superior taste, health effects, and nutrition indicate benefits for consumers, while the attitude that cultured meat could solve environmental issues by replacing meat with conventional livestock implies an environmental benefit. Doubts about food were related to how the respondents perceived unfamiliar food and whether they ever felt doubtful about it. The variable of halalness represents the respondents’ concerns about the method of slaughter and whether the cells used to culture meat were taken from an animal slaughtered under Sharia Law. The variables were applied using a binary scale of 1 and 0 to determine whether the respondents agreed with the questions related to their concerns about cultured meat. The binary logistic regression model is as Formula 1.

$$\text{Logit}(Y) = \ln(\text{odds}) = \ln\left(\frac{\pi}{1-\pi}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_6 X_6 \quad (1)$$

Y indicates acceptance of cultured meat (0 = not accepting cultured meat as food in the future, 1 = accepting cultured meat as food in the future). X₁ illustrates respondents’ concerns about the halalness (method of slaughter) of cultured meat (0= not concerned about slaughtering methods, 1= concerned about slaughtering methods that must follow Sharia Law). X₂ indicates respondents’ doubts regarding cultured meat as a new type of meat in the market (0= no doubt as food; 1= doubting it as food). X₃ signifies respondents’ attitudes regarding the superior taste of cultured meat (0= not having a superior taste to natural meat, 1= having a superior taste to natural meat). X₄ implies respondents’ attitudes regarding the positive health effects of

cultured meat (0= no positive health effects, 1= having positive health effects). X_5 demonstrates respondents' attitudes regarding the nutritional benefits of cultured meat (0= no nutritional benefits; 1= having nutritional benefits). Finally, X_6 depicts respondents' attitudes regarding the environmental benefits of cultured meat (0= no environmental benefits; 1= benefiting the environment).

RESULTS AND DISCUSSION

Descriptive Analysis

Table 1 presents the demographic profile and consumer awareness of 102 respondents interviewed in person and via an online questionnaire in Selangor, Malaysia. The respondents comprised 37 males and 65 females, with an average age of 33. Most respondents had completed college or university studies, half were employed as academic professionals, and the rest were university students. Due to the novelty of cultured meat, this research included students and officers at Universiti Putra Malaysia (UPM), who were likely to be exposed to the concept of cultured meat. All respondents were Muslim and of Malay ethnicity, and their income was more than the country's average household income; however, 30 (29.4%) earned less than RM 1,000.00 (approximately 230 USD) monthly as students. "Awareness of cultured meat" indicated whether a respondent had heard "cultured meat" or about similar food technologies in cellular agriculture. Among the 102 respondents, 45 (44.1%) were aware of cultured meat, the research conducted, and the initial prototyping stage of global development.

TABLE 1. DEMOGRAPHIC PROFILE OF THE RESPONDENTS (N = 102)

| Demographic profile | Characteristic |
|---------------------|--|
| Age | 18 to 62 years old (Mean = 33.2 years old) |
| Gender | 37 (36.3%) males and 65 (63.7%) females |
| Working status | 60 (58.8%) were employees, and 42 (41.2%) were students |
| Religion | Islam |
| Income range | 30 (29.4%) earned less than RM 1,000; 26 (25.5%) earned between RM 1,001 and RM 3,000; 16 (15.7%) earned between RM 3,001 and RM 5,000; and 30 (29.4%) earned more than RM 5,000 |

Chi-square Analysis

Bryant and Sanctorum (2021) measured consumers' intentions and reasons to support cultured meat, including consumers' attitudes toward the environment, healthiness, and others as alternative meat, to unveil the association between consumers' intentions and attitudes. Table 2 describes the chi-square analysis results, indicating that some factors were significantly associated with the respondents' intention to accept cultured meat as their future food. The study included consumers' concerns about the slaughtering methods of the parent cattle, whether it was performed under Sharia Law, and consumers' doubts about cultured meat as future food, followed by superior taste, better nutritional value, better health effects, high nutritional content, and environmental benefits in a sense as compared to real meat. The

results revealed a significant association between doubts about food, superior taste, health effects, nutritional benefits, and environmental benefits, and the intention to accept cultured meat as food. The contingency table further indicated that the negative statements on superior taste, health benefits, nutritional benefits, and environmental benefits reflected the negative association with the intention to accept cultured meat as food in the future.

TABLE 2. THE CHI-SQUARE ANALYSIS RESULTS BETWEEN THE ATTITUDINAL STATEMENTS AND INTENTION TO ACCEPT CULTURED MEAT

| Attitudinal statement | No intention to accept | | Intention to accept | | Chi-sq Value | Significant level |
|--|------------------------|-------|---------------------|-------|--------------|-------------------|
| | No. | Ratio | No. | Ratio | | |
| <i>Halalness (slaughtering method)</i> | | | | | | |
| Not slaughtered under Sharia Law | 40 | 39% | 30 | 29% | 7.208 | 0.066 |
| Slaughtered under Sharia Law | 12 | 12% | 20 | 20% | | |
| <i>Doubts about food</i> | | | | | | |
| No doubt as food | 8 | 8% | 34 | 34% | 29.134 | 0.000 |
| Doubting it as food | 44 | 43% | 16 | 16% | | |
| <i>Superior taste</i> | | | | | | |
| No superior taste to the real meat | 50 | 49% | 16 | 16% | 53.829 | 0.000 |
| Having a superior taste to the real meat | 2 | 2% | 34 | 33% | | |
| <i>Positive health effects</i> | | | | | | |
| No health effects | 46 | 45% | 13 | 13% | 48.458 | 0.000 |
| Having health effects | 6 | 6% | 37 | 36% | | |
| <i>Nutritional benefits</i> | | | | | | |
| No nutritional benefits | 51 | 50% | 23 | 23% | 42.099 | 0.000 |
| Having nutritional benefits | 1 | 1% | 27 | 26% | | |
| <i>Environmental benefits</i> | | | | | | |
| The reduction of beef cattle will not affect the environment | 50 | 49% | 29 | 28% | 27.781 | 0.000 |
| The reduction of beef cattle will have positive environmental benefits | 2 | 2% | 21 | 21% | | |

Binary Logistic Regression

This study applied a logit regression model to measure the magnitude and significance of the respondents' responses to the expectation concerns and doubts about cultured meat. Table 3 elaborates on the respondents' responses on the intention and no intention to consume cultured meat versus the explanatory variables. It also exhibits the breakdown of the variables in the binary logistic regression model.

Binary logistic regression revealed how variables influenced the acceptance of cultured meat, attitudes, doubts about food, and concerns about its halalness. Binary logistic regression indicated that the model's classification was 91.2% accurate. The Hosmer-Lemeshow test for goodness of fit was 5.872. The analysis disclosed two types of pseudo-R-squared statistics: the Cox and Snell R^2 was 0.564, and the Nagelkerke R^2 was 0.752. The results in the model ($X^2 = 84.634$, 6 degrees of freedom, $P=0.00$) signified that the model was fit and valid for discriminating the observed data. As described in Table 4, four of the six explanatory variables in the logit regression model were statistically significant, including three attitudinal factors and doubts about food. This study acquired a Wald value of 9.396 for the attitude toward superior taste as the most crucial factor, followed by doubts about food at 5.387.

TABLE 3. RESPONSES AND EXPLANATORY VARIABLES IN THE LOGISTIC REGRESSION (N = 102)

| Explanatory variable | No. | Percentage |
|--|-----|------------|
| <i>Acceptance of cultured meat as food in the future</i> | | |
| Accepting | 50 | 49.0 |
| Not accepting | 52 | 51.0 |
| <i>Attitude: Superior taste</i> | | |
| Expecting that cultured meat would have a superior taste to conventional meat | 36 | 35.3 |
| Not expecting that cultured meat would have a superior taste to conventional meat | 66 | 64.7 |
| <i>Attitude: Positive health effects</i> | | |
| Expecting positive health effects from cultured meat | 43 | 42.2 |
| Not expecting positive health effects from cultured meat | 59 | 57.8 |
| <i>Attitude: Nutritional benefits</i> | | |
| Expecting nutritional benefits from cultured meat | 28 | 27.5 |
| Not expecting nutritional benefits from cultured meat | 74 | 72.5 |
| <i>Attitude: Environmental benefits</i> | | |
| Expecting cultured meat to become a solution to environmental issues | 23 | 22.5 |
| Not expecting cultured meat to become a solution to environmental issues | 79 | 77.5 |
| <i>Doubts about food</i> | | |
| Expressing doubts about unfamiliar food | 60 | 58.8 |
| Not expressing doubts about unfamiliar food | 42 | 41.2 |
| <i>Halalness (method of slaughter)</i> | | |
| Expressing concerns about whether the slaughtering method followed <i>Sharia Law</i> | 70 | 68.6 |
| Not expressing concerns about whether the slaughtering method followed <i>Sharia Law</i> | 32 | 31.4 |

TABLE 4. ESTIMATED BINARY LOGISTIC REGRESSION MODEL FOR MUSLIMS' ACCEPTANCE OF CULTURED MEAT (N=102)

| | B | SD | Wald | DF | Exp(B) | |
|--------------------------|--------|-------|-------|----|--------|-----|
| Attitudes | | | | | | |
| Halalness (Slaughtering) | 1.168 | 1.044 | 1.252 | 1 | 3.216 | |
| Food doubts | -2.314 | 0.997 | 5.387 | 1 | 0.099 | ** |
| Superior taste | 2.869 | 0.936 | 9.396 | 1 | 17.617 | *** |
| Health effects | 1.472 | 0.849 | 3.007 | 1 | 4.360 | * |
| Nutrition | 2.146 | 1.255 | 2.924 | 1 | 8.551 | * |
| Environment | 0.498 | 1.174 | 0.180 | 1 | 1.645 | |
| Constant | -1.266 | 0.841 | 2.266 | 1 | 0.282 | |

Note: ***p < .01; ** p < .05; * p < .1.

The variable indicating attitudes toward the superior taste of cultured meat was statistically significant at the 1% level. This result implied that respondents expecting cultured meat to be tastier than conventional meat would be more willing to accept it as their food in the future. In addition to attitudes toward taste, the variables regarding positive health effects and nutritional benefits were statistically significant at the 5% level. Hence, some respondents expected cultured meat to be healthier and more nutritious than conventional meat. Similarly, Costell et al. (2010) highlighted that attitudes significantly impacted food acceptance. These results also align with those of Rolland et al., (2020), revealing that people's thoughts about the environment and taste positively influenced acceptance. Regarding the variable related to doubts about food, like Dupont et al. (2022), respondents with neophobia and technophobia tended to be doubtful about the concept of cultured meat and were less likely to accept it.

These findings are similar to research conducted among British and non-Muslim consumers, discovering that health and nutritional characteristics were essential in consuming cultured meat (Boereboom, Sheikh, Islam, Achirimbi, & Vriesekoop, 2022).

As studied by de Oliveira Padilha et al. (2022), the variable related to the possible environmental benefits of cultured meat and its potential to become a solution to the environmental load was caused by conventional livestock production. However, Verbeke et al. (2015) disclosed that people perceived cultured meat as very ecological and ethical. This literature emphasizes that people's ethics and environmental beliefs are critical in addition to food taste and nutrition expectations. The variable of halalness (method of slaughtering) did not differentiate people's acceptance. Even though this study approached food acceptance from *halalan* and *thayibban* as the concepts of halalness and food safety, the responses to the method of slaughtering—halal, in animal slaughtering to extract the cell out of the cow, demonstrated the influence of Muslims' concerns. As Tomiyama et al. (2020) listed barriers between consumers and food technology, food doubts in this research appeared to be a problem for consumers to accept cultured meat as their future food. Chriki and Hocquette, (2020) directed that consumers' ethics, morality, and religion regarding meat consumption would be a continued argument. Therefore, halalness and Muslims' perceptions should be understood by further research for future cultured meat markets.

CONCLUSION

In light of the growing importance of encouraging the acceptance of cultured meat among consumers, this study focused on the attitudes of Muslims, accounting for nearly a quarter of the world's population and might compose an even larger proportion of future meat consumers toward cultured meat. This study addressed how Muslims perceived cultured meat and the factors encouraging the acceptance of cultured meat among these potential consumers. Nearly half of Muslim consumers accepted cultured meat as food in the future. Attitudinal factors such as taste, nutrition, health effects, and no doubt about food contributed to Muslim consumers' acceptance of cultured meat as alternative meat in their food consumption. The study's findings on Muslims in Malaysia unveiled relationships between people's attitudes toward taste, nutritional and health effects, and the acceptance of cultured meat. These results implied the anticipation of future consumers of cultured meat that it would not simply become a replacement for rearing livestock meat but a better and more beneficial alternative. Simultaneously, the results indicated that people's doubts about cultured meat were caused by a lack of understanding of the technology and concerns about its halalness, which hindered its acceptance. Ultimately, this study provided insights into how Muslim consumers viewed cultured meat and how their perceptions affected their acceptance, attitudes, and doubts about food. Research on cultured meat should focus on restricting Muslim food, better taste, health effects, and nutrition. Information and knowledge on the culture of meat technology should be more exposed to the consumers, especially Muslims, to understand.

Authors' Contributions: RT, YM and AAA were responsible for data collection. RT and AAA were also responsible for the literature review, forecasting analysis and manuscript drafting. NNR and ZAM were responsible for drafting and editing the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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