Stakeholders’ Attitudes Toward Genetically Modified Rice in Malaysia

Muhammad Adzran Che Mustapa1, Ahmad Firdhaus Arham1, Latifah Amin1,2, and Hasrizul Hashim3

Abstract
Rice, as a staple food for a large proportion of the world, is a vitally important food crop. More than 3.5 billion people in the world depend on rice, which provides 20% of human calorific needs per day. This paper aims to analyze several sociodemographic factors that affect stakeholders’ attitudes toward genetically modified (GM) rice in Malaysia. This research involved a total of 509 adult respondents in the Klang Valley. The results of the study showed that Malaysian stakeholders’ attitudes toward GM rice can be classified as positive. They perceived GM rice as having moderate benefits and risks, and they considered the moral aspects to be moderate, as was religious acceptance. One-way MANOVA initially detected a significant difference in attitude toward GM rice across stakeholder groups, educational level, and age. Additionally, univariate as well as post hoc analysis, confirmed significant differences in attitudes across stakeholders (perceived moral concerns, religious acceptance, and encouragement); educational level (perceived benefits, religious acceptance); and age (religious acceptance). These findings are useful for scientists and government regulators in terms of understanding the effects of sociodemographic factors on attitudes toward GM rice in Malaysia.

Keywords
stakeholders, attitude, GM rice, education, religion, age, Malaysia

Introduction
Rice is an essential food crop and a staple food for most parts of the world (Ali et al., 2020; Demont & Stein, 2013). More than 3.5 billion people in the world depend on rice, which provides 20% of human calorific needs per day (Amin & Hashim, 2015; Seck et al., 2012). Moreover, to feed the growing population, rice production must be increased by 60% by 2025 (Amin et al., 2011). This increase in population is expected to occur mainly in developing countries (FAO, 2009). According to a 2019 United States Department of Agriculture report, rice contains trace elements that are essential for human health, such as vitamin B1 (thiamine), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B5 (pantothenic acid), and vitamin B6 (pyridoxine) (USDA, 2019). Moreover, rice is also a well-known source of carbohydrates (the primary source of energy of the human body) and rich with nutrients, vitamins, and minerals (Seck et al., 2012).

Nowadays, advances in genetic engineering have enabled scientists to upgrade and modify plants for the development of pharmaceutical products (Amin et al., 2011). China is one of several countries that already approved the commercialization of GM rice in 2009 (James, 2009). This approval has caused momentous and significant implications for the adoption of GM crops throughout the world (James, 2009). Meanwhile, Rejesus et al. (2012) reported that there would be an increase in the consumption of rice globally to about 490 million tons in 2020 and to about 650 million tons by 2050. Given that the projections show substantial increases in demand for rice in the future, scientists and producers have taken steps to meet the demand. In this regard, one of the alternatives is to produce a high-yield variety of rice with resistance toward disease and pests (Amin & Hashim, 2015).

The reasons for utilizing genetic engineering in the production of rice are to increase yields, improve disease resistance and lower the cost of rice production, as well as to enrich its nutritional value (Brookes & Barfoot, 2003; Demont & Stein, 2013; Dubock, 2019). Moreover, the successful development and commercialization of GM rice will help to reduce poverty, hunger, and malnutrition, a goal which applies not only to rice-consuming countries but also to all GM crops. The reasons for utilizing genetic engineering in the production of rice are to increase yields, improve disease resistance and lower the cost of rice production, as well as to enrich its nutritional value (Brookes & Barfoot, 2003; Demont & Stein, 2013; Dubock, 2019). Moreover, the successful development and commercialization of GM rice will help to reduce poverty, hunger, and malnutrition, a goal which applies not only to rice-consuming countries but also to all GM crops.

1Pusat Pengajian Citra Universiti, Universiti Kebangsaan Malaysia, Bangi, Malaysia
2The Institute of Islam Hadhari, Universiti Kebangsaan Malaysia, Bangi, Malaysia
3The Ministry of Science, Technology, and Innovation (MOSTI), Federal Government Administrative Centre, Putrajaya, Malaysia

Corresponding Author:
Latifah Amin, Pusat Pengajian Citra Universiti, Universiti Kebangsaan Malaysia, UKM Bangi, Selangor 43600, Malaysia.
Email: nilam@ukm.edu.my
and their acceptance on a global basis (James, 2007). However, GM rice has not yet been commercialized on a large scale worldwide (Demont & Stein, 2013). Past studies have shown that public attitudes toward GM rice, such as Golden Rice (containing pro-vitamin A) and vitamin C enhanced rice, are driven by certain predictors such as perceived benefit and religious acceptance (Amin et al., 2014).

There have been so many controversies about GM crops with the majority of the respondents holding negative attitudes toward its use and commercialization (Adeoti & Adekunle, 2007; Oluwakemi et al., 2020). Several factors have been reported to be associated with these negative attitudes such as limited knowledge about GMOs, low perception of benefits, and religious, moral or ethical beliefs (Ali et al., 2020; Costa-Font & Gil, 2012; Oluwakemi et al., 2020; Pino et al., 2016). Apart from that, incomplete/inadequate information might also affect consumers’ view as well as resistance toward the GM technology (Chuang et al., 2012; Ghoochani et al., 2017). Public acceptance of GM technology can both promote and hamper their commercialization and adoption (Amin et al., 2014). According to Kikulwe et al. (2011), consumers’ attitudes with regards to the potential benefits and risks of GM crops vary across cultures and geographic regions, as well as in terms of types of application. For example, in Europe, the perceived benefits associated with the gene technology has been found to be a precondition for its support (Connor & Siegrist, 2010; Gaskell et al., 2000), while the moral aspects of GM applications appeared to act as a veto (Gaskell et al., 2000; Knight, 2007). Meanwhile, in Malaysia, knowledge, and the characteristics of GM products in general have been significant predictors of both benefits and perceptions of risk that have had a positive effect on attitude, with attitude then affecting the intention of buying GM products (Hassan et al., 2016). According to the International Service for the Acquisition of Agri-biotech Applications (ISAAA) in 2019, several countries such as the Philippines, the US, Canada, New Zealand, and Australia have approved Golden Rice for use as a food, feed, and for processing. Accordingly, with regard to GM rice stacked with antioxidants, many traits have been developed such as stress tolerance (13 traits), salinity tolerance (9 traits), drought tolerance (6 traits), heavy metal tolerance (6 traits), disease resistance (6 traits), and cold stress tolerance (5 traits) (Ali et al., 2020).

Demographic characteristics such as education, age, religion, and individual background have been known to affect consumers’ attitudes toward GM technology (Amin et al., 2011; Breustedt et al., 2008; Chiang et al., 2012; Curtis & Moeltner, 2007; Grimsrud et al., 2004). For example, consumers who lack education and proper knowledge regarding GM foods may have a distorted perspective about them (Anderson et al., 2006; Sörqvist et al., 2016). Fernandez and McBride (2002) established that when farmers have better education, it positively influences their attitudes toward GM Herbicide Tolerant (HT) soybean adoption. Meanwhile, a study conducted by Todua and Gogitidze (2017) found that both education and age influence the awareness of farmers with regard to GM crops, in that more educated and younger farmers are more informed about genetic engineering. Furthermore, Xu et al. (2016) found that the age of farmers was inversely related to the intention to adopt GM rice. Religious beliefs are also enduring characteristics that shape many social and political opinions on a wide range of topics (Hordern, 2016; Kelley, 1995), in that religion plays an important role in forming public opinion (Allum et al., 2014). Consequently, in a multireligious country such as Malaysia, it is also important to determine whether or not religion has any effect on attitudes toward GM rice. People from different religions usually have different beliefs that may affect their attitudes.

Therefore, this paper aims to assess stakeholders’ attitudes toward GM rice containing the “yield gene,” which improves its yield and quality, on the part of the Malaysian public in the Klang Valley region, and to compare their attitudes in terms of several socioeconomic factors. The questionnaire used was based on a conceptual framework and previous studies on public attitudes to modern biotechnology applications. The present study will benefit decision-makers and policymakers, as well as the government sector as it will provide them with an insight into the acceptance of the different stakeholders. Information about the stakeholders’ attitudes can therefore have profound implications for introducing GM rice in an effort to increase food security. Moreover, there is limited number of publications with regard to stakeholder attitudes specific to GM rice and to a comparison across background variables, especially in the case of developing countries. Understanding the attitudes of these multi-stakeholders toward the adoption of GM rice is crucial to understanding how biotechnology might be applied in the country.

Theoretical Framework and Hypotheses Development

This study uses the Theory of Reasoned Action (TRA), as developed by Ajzen and Fishbein (1980). This theory has been frequently used in the health literature, especially with regard to food consumption, to identify actual behavioral intentions (Chen, 2008; Fishbein, 2008; Garza & Stover, 2003; Hosseini et al., 2015; Silk et al., 2005). According to Mishra et al. (2014), the theory provides an important fundamental conceptual model for examining human behavior, with the aim of identifying the relationship between attitude and behavior. Furthermore, Fishbein and Yzer (2003) proposed that behavioral attitudes and subjective norms are themselves functions of more distal factors, including sociodemographic characteristics, culture and religion, attitudes toward targets, and psychological factors. Such attitudes consist of affective, cognitive, and behavioral components (Fishbein, 1963; Secord & Backman, 1964).
Pennington (1996) asserted that the affective and cognitive components are framed to reflect the positive or negative evaluations of an entity or product, according to peoples’ beliefs. The cognitive and affective components in the Chen and Li (2007) framework are perceived as benefits and perceived risks that have been reported in attitude models toward contemporary issues such as GM foods (Costa-Font & Gil, 2009; Prati et al., 2012). Gaskell et al. (2000, 2003, 2006) adopted four dimensions of attitude: perceived use, perceived risk, moral acceptability, and encouragement, in their studies of the European public response to biotechnology and GM foods. Other researchers have suggested the need to include religious acceptance as an additional variable in countries such as Malaysia, where religion plays an important part in decision making (Allum et al., 2014; Amin et al., 2014; Nicholas, 2000). In this study, the variables chosen are based on their importance, as revealed in past studies. They consist of encouragement (Amin et al., 2011, 2014; Amin & Hashim, 2015; Gaskell et al., 2004), perception of benefits and risks toward GM food technology (Amin et al., 2017; Chen & Li, 2007; Ghanian et al., 2016; Ghoochani et al., 2017; Prati et al., 2012; Xu et al., 2020; Zhang et al., 2019), religious acceptance (Allum et al., 2014; Amin et al., 2014; Nicholas, 2000), and perceived moral concerns (Amin et al., 2011; Gott & Monamy, 2004; Sjöberg, 2004). Therefore, the authors proposed the following hypotheses for the present paper to test the effect of several background variables on attitude:

H1: There is no significant difference in the mean score for perceived benefits, perceived risks, perceived moral concerns, religious acceptance, and encouragement across stakeholders’ groups.

H2: There is no significant difference in the mean score for perceived benefits, perceived risks, perceived moral concerns, religious acceptance, and encouragement across educational levels.

H3: There is no significant difference in the mean score for perceived benefits, perceived risks, perceived moral concerns, religious acceptance, and encouragement across religion.

H4: There is no significant difference in the mean score for perceived benefits, perceived risks, perceived moral concerns, religious acceptance, and encouragement across age.

Methods

Survey Data Collection

The data were collected using a face-to-face survey involving a validated questionnaire. These were given to 509 adult respondents (aged 18 years and above) located in the Klang Valley region, Malaysia. The Klang Valley is an urban city based in Kuala Lumpur and includes the surrounding towns and cities in the state of Selangor. The people in the Klang Valley region were chosen as the targeted population as they are central to the country’s economic and social development. There are numerous universities, Research and Development (R&D) institutions, and biotechnology-related industries located in this region. In addition, and most importantly, the respondents in this region meet the requirements in terms of the diversity of backgrounds that uniquely represent the Malaysian population. The respondents were stratified into 11 stakeholder groups (Table 1) and were chosen using a stratified purposive sampling technique, based on their shared characteristics. Using one-way Multivariate Analysis of Variance (MANOVA), a comparison of attitudinal factors across stakeholders (11 groups), education (three groups), religion (four groups), and age (three groups) was carried out.

Taking into account that this study was quantitative, the minimum sample size required for each sample group was considered. According to Cohen (2013), in order to have a medium effect size ($f=0.25$) at $p=.05$, $u=10$, a minimum sample of 25 respondents per stakeholder group is required to obtain the power of 0.80, a minimum sample size of 52 subjects per group is required for the education levels and age category ($f=0.25$ at $p=.05$, $u=2$), and 44 subjects per group is required for the religion category ($f=0.25$, $p=.05$, $u=3$). Krejcie and Morgan (1970) indicated that, for a population size beyond 5,000, a total sample size of 400 would be adequate, and more confidence would exist with a total sample of 500. Hence, this study involved 509 respondents.

The questionnaires were administered to the targeted respondents by a group of trained enumerators who have a background in biotechnology. A brief introduction regarding modern biotechnology and its applications, including the purpose of GM rice, was also presented to the respondents prior to the questionnaire. In addition, the respondents were allowed to ask questions to make sure they understood the topic. The participation of the respondents was entirely voluntary, and verbal consent was obtained from all prior to the questionnaire being responded to.

Research Instrument

The multi-dimensional measurement of attitudes toward GM rice was constructed based on earlier published work (Amin et al., 2013). The instruments used in this study were incorporated into five dimensions: perceived benefits, perceived risks, perceived moral concerns, religious acceptance, and encouragement (Amin et al., 2013; Gaskell et al., 2003; Kelley, 1995; Nicholas, 2000), and were measured using a 7-point Likert scale which ranged from strongly disagree to strongly agree.

Data Analysis

Descriptive as well as MANOVA data analysis was performed using SPSS software version 24.0. Prior to that, SPSS software was used to measure the consistency, validity,
and reliability of the factors which influence attitudes toward GM rice. Validity was measured using factor loading, and the value of all items in Table 2 were greater than 0.5, which indicated good validity (Hair et al., 2010; Heale & Twycross, 2015). The reliability value for each construct exceeded 0.7, which was considered good (Awang, 2014; Hair et al., 2010; Heale & Twycross, 2015).

### Results

#### Perceived Benefits

Generally, all groups of Malaysian stakeholders and from the categories of religion, age and educational level perceived GM rice to have a moderate level of benefits (mean score of 4.47) (Tables 4 and 6). One-way MANOVA was performed to compare the stakeholders’ attitudes toward GM rice, as well as to explore the effect of religion, age, and educational level on attitudes to GM rice, respectively. However, the variance–covariance matrices were found not to be homogenous (unequal) across all categories, as shown by the following results: Box’s $M=311.759$, $F=1.970$, $p<.001$ for stakeholder groups; Box’s $M=90.331$, $F=2.949$, $p<.001$ for educational levels; Box’s $M=115.987$, $F=2.507$, $p<.001$ for religion; and Box’s $M=86.228$, $F=2.826$, $p<.001$ for age (Table 3). Thus, Pillai’s trace was utilized, as recommended by previously published works (Hair et al., 2010; Tabachnick & Fidell, 2001).

One-way MANOVA identified three categories with significant differences in attitudes toward GM rice: stakeholder groups (Pillai’s trace $=0.173$, $F=1.765$, $p<.05$); educational levels (Pillai’s trace $=0.054$, $F=2.767$, $p<.05$); and age (Pillai’s trace $=0.045$, $F=2.263$, $p<.05$) (Table 3). Post hoc results of perceived benefits reported that no significant differences have been detected for perceived benefits across all the stakeholders (Table 4). One-way MANOVA initially detected significant differences in attitude toward GM rice across educational levels (Pillai’s trace $=0.054$, $F=2.767$, $p<.05$) and age (Pillai’s trace $=0.045$, $F=2.263$, $p<.05$) (Table 3). Post hoc tests confirmed significant difference in perceived benefits between respondents of diploma/pre-university level compared with those of university level (Table 6). However, univariate one-way MANOVA could not detect significant differences in the perceived benefits across religion and age (Table 6).

#### Perceived Risks

The overall Malaysian stakeholders’ perceived risk of GM rice was moderate (with a mean score of 4.05) (Tables 4 and 6). The media was shown to have the lowest perceived risk of GM rice among all the stakeholder groups tested in this study (with a mean score of 3.74), while Islamic scholars reported the highest risk perception (mean score of 4.31) (Table 4). Risk perceptions across educational level, religion, and age were also reported to be at a moderate level (Table 6). Post hoc analysis confirmed that no significant difference exists for stakeholder groups (Table 4). Further analysis of one-way MANOVA showed that no significant differences were detected for perceived risks across educational, religious, and age levels (Table 6).

#### Perceived Moral Concerns

With regard to moral aspects, Malaysian stakeholders perceived GM rice as being of moderate moral concern (with a mean score of 3.57) (Table 4). Scientists showed the lowest perceptions of moral concern with regard to GM rice among all stakeholder groups tested in this study (with a mean score of 3.18), whereas the Islamic scholars had the highest moral concern (with a mean score of 4.35) (Table 4). Post hoc analysis confirmed that the scientists’ view on the issue differed significantly from that of the Islamic scholars (Table 4); however, further analysis of one-way MANOVA could not detect any significant difference in moral concern with regard to GM rice across educational levels, religion, and age (Table 6).

#### Religious Acceptance

Interestingly, all stakeholders in this study agreed that GM rice could be moderately accepted by their religion and
Table 2. Measurement Scales and Reliability (GM Rice).

| Factor                  | Items                                                                 | Standardized factor loading | Corrected item-total correlated | α   |
|-------------------------|------------------------------------------------------------------------|-----------------------------|---------------------------------|-----|
| Perceived benefits      | 1. Enhance quality of life                                             | 0.566                       | 0.569                           | 0.768 |
|                         | 2. Future research will deal with existing danger                      | 0.624                       | 0.441                           |      |
|                         | 3. Scientific evidence on the safety of the product is adequate        | 0.629                       | 0.486                           |      |
|                         | 4. Ought to be regulated by the government                              | 0.644                       | 0.453                           |      |
|                         | 5. Solve problems that cannot be solved by the traditional method      | 0.544                       | 0.490                           |      |
|                         | 6. Benefits exceed risks                                               | 0.655                       | 0.638                           |      |
| Perceived risks         | 1. Worry of risk to health                                             | 0.811                       | 0.703                           | 0.886 |
|                         | 2. Harm to the ecosystem and environment                               | 0.764                       | 0.688                           |      |
|                         | 3. Will reduce Earth’s biodiversity                                    | 0.716                       | 0.633                           |      |
|                         | 4. Feeling of anxiety                                                  | 0.750                       | 0.656                           |      |
|                         | 5. Long-term effect                                                    | 0.766                       | 0.696                           |      |
|                         | 6. Pose threat to future generation                                    | 0.729                       | 0.710                           |      |
|                         | 7. May give rise to unknown consequences                               | 0.688                       | 0.576                           |      |
|                         | 8. Overall risk magnitude                                              | 0.620                       | 0.587                           |      |
| Perceived moral concerns| 1. Over the limit                                                      | 0.622                       | 0.705                           | 0.805 |
|                         | 2. “Playing God”                                                       | 0.700                       | 0.664                           |      |
|                         | 3. Reduce the status of living things to machines                      | 0.676                       | 0.595                           |      |
| Religious acceptance    | 1. Accepted by religion                                                | 0.820                       | 0.731                           | 0.845 |
|                         | 2. Accepted by customs                                                 | 0.820                       | 0.731                           |      |
| Encouragement            | 1. Intensive research should be encouraged                             | 0.744                       | 0.648                           | 0.879 |
|                         | 2. Should be commercialized                                            | 0.753                       | 0.708                           |      |
|                         | 3. Should be given monetary support by government                      | 0.820                       | 0.806                           |      |
|                         | 4. Overall encouragement                                               | 0.797                       | 0.686                           |      |
|                         | 5. Government’s responsibility to ensure it is beneficial               | 0.747                       | 0.713                           |      |

Table 3. Box’s M and One-Way MANOVA Tests for Attitudes Toward GM Rice Across Stakeholders, Education, Religion, and Age.

| Category               | Box’s M | F   | df 1 | df 2 | Sig.    |
|------------------------|---------|-----|------|------|---------|
| Stakeholders           | 311.759 | 1.970 | 150 | 127,455.731 | 0.000*  |
| Education              | 90.331  | 2.949 | 30  | 192,386.872 | 0.000*  |
| Religion               | 115.987 | 2.507 | 45  | 149,122.265 | 0.000*  |
| Age                    | 86.228  | 2.826 | 30  | 324,529.116 | 0.000*  |

| Category               | Pillai’s trace | F   | df.h | df.e | Sig.    |
|------------------------|----------------|-----|------|------|---------|
| Stakeholders           | 0.173          | 1.765 | 50   | 2,460 | 0.001*  |
| Education              | 0.054          | 2.767 | 10   | 994   | 0.002*  |
| Religion               | 0.052          | 1.320 | 20   | 1,988 | 0.155   |
| Age                    | 0.045          | 2.263 | 10   | 994   | 0.013*  |

*Box’s M test to determine the homogeneity of variance-covariance within the attitude variables, *p < .001.
*One-way MANOVA test to determine the attitude toward GM Rice across demographic factors, *p < .05.

customs (with a mean score of 4.42) (Table 5). The Buddhist scholars strongly indicated that GM rice is more acceptable according to their religion and customs (with a mean score of 5.08) as compared with other groups (Table 5). Post hoc analysis confirmed that respondents of university level had significantly different views on religious acceptance from those of diploma/pre-university level (Table 6). Post hoc analysis across age showed that the views of respondents aged 41 and above differed significantly from those of respondents aged 18 to 25 (Table 6).

Encouragement

The overall encouragement for GM rice by Malaysian stakeholders was reported as high (with a mean score of 5.19) (Table 5). Producers were ranked the highest, followed by university students and scientists (with mean scores of 5.57, 5.60, and 5.49, respectively) (Table 5). The encouragement toward GM rice shown by producers was confirmed by post hoc analysis to differ significantly from that shown by the producers and that of Islamic scholars (Table 6). Further univariate
Table 4. Mean Scores, Standard Deviation and Post Hoc Test Results for Perceived Benefits, Perceived Risks, and Perceived Moral Concerns of GM Rice Across Stakeholders’ Groups.

| Stakeholders          | Perceived benefits | Perceived risks | Perceived moral concerns |
|-----------------------|--------------------|----------------|--------------------------|
| 1. Producers          | 4.52 ± 0.81        | Moderate       | 4.23 ± 1.00              | Moderate                   |
| 2. Scientists         | 4.82 ± 0.84        | Moderate       | 3.81 ± 1.11              | Moderate                   |
| 3. Policy makers      | 4.66 ± 1.13        | Moderate       | 3.95 ± 1.17              | Moderate                   |
| 4. NGOs               | 4.46 ± 0.84        | Moderate       | 4.02 ± 0.99              | Moderate                   |
| 5. Media              | 4.20 ± 0.75        | Moderate       | 3.74 ± 0.64              | Moderate                   |
| 6. University students| 4.66 ± 0.97        | Moderate       | 4.17 ± 1.05              | Moderate                   |
| 7. Islamic scholars   | 4.22 ± 0.81        | Moderate       | 4.31 ± 0.90              | Moderate                   |
| 8. Buddhist scholars  | 4.55 ± 0.77        | Moderate       | 4.24 ± 0.82              | Moderate                   |
| 9. Christian scholars | 4.46 ± 1.00        | Moderate       | 4.06 ± 0.92              | Moderate                   |
| 10. Hindu scholars    | 4.38 ± 1.09        | Moderate       | 4.06 ± 0.98              | Moderate                   |
| 11. Consumers         | 4.37 ± 1.05        | Moderate       | 4.07 ± 1.21              | Moderate                   |
| Overall (n = 509)     | 4.47 ± 0.95        | Moderate       | 4.05 ± 1.04              | Moderate                   |

Note. Code of stakeholders: 1Producers, 2Scientists, 3Policy Makers, 4NGOs, 5Media, 6University students, 7Islamic scholars, 8Buddhist scholars, 9Christian scholars, 10Hindu scholars, 11Consumers. The bold indicates the significant different of the mean score across different stakeholders.

Post hoc test results showing significant differences of at least $p < .01$ between the indicated stakeholders’ groups, numbered in superscript. Games-Howell’s test was carried out to compare perceived benefits, perceived risks, and perceived moral concerns across the indicated stakeholder groups. **1.00–2.99, Low; 3.00–5.00, Moderate; 5.01–7.00, High.

Table 5. Mean Scores, Standard Deviation, and Post Hoc Test Results for Religious Acceptance, and Encouragement of GM Rice Across Stakeholders’ Groups.

| Stakeholders          | Religious acceptance | Encouragement |
|-----------------------|----------------------|---------------|
| 1. Producers          | 4.46 ± 1.14          | 5.65 ± 0.96   | High          |
| 2. Scientists         | 4.78 ± 0.98          | 5.49 ± 0.95   | High          |
| 3. Policy makers      | 4.45 ± 1.67          | 5.29 ± 1.33   | High          |
| 4. NGOs               | 4.56 ± 1.17          | 5.10 ± 1.04   | High          |
| 5. Media              | 4.19 ± 1.00          | 4.85 ± 1.05   | Moderate      |
| 6. University students| 4.60 ± 1.37          | 5.57 ± 1.13   | High          |
| 7. Islamic scholars   | 4.47 ± 1.20          | 4.71 ± 0.95   | Moderate      |
| 8. Buddhist scholars  | 5.08 ± 0.93          | 5.34 ± 1.06   | High          |
| 9. Christian scholars | 4.37 ± 1.34          | 5.23 ± 1.10   | High          |
| 10. Hindu scholars    | 4.23 ± 1.40          | 4.94 ± 1.17   | Moderate      |
| 11. Consumers         | 4.16 ± 1.41          | 5.09 ± 1.36   | High          |
| Overall (n = 509)     | 4.42 ± 1.29          | 5.19 ± 1.17   | High          |

Note. Code of stakeholders: 1Producers, 2Scientists, 3Policy Makers, 4NGOs, 5Media, 6University students, 7Islamic scholars, 8Buddhist scholars, 9Christian scholars, 10Hindu scholars, 11Consumers. The bold indicates the significant different of the mean score across different stakeholders.

Post hoc test results showing significant differences of at least $p < .01$ between the indicated stakeholder groups, numbered in superscript. Games-Howell’s test was carried out to compare perceived benefits, perceived risks, and perceived moral concerns across the indicated stakeholder groups. **1.00–2.99, Low; 3.00–5.00, Moderate; 5.01–7.00, High.

analysis, however, confirmed that there are no significant differences for encouragement toward GM rice across educational level, religion, and age (Table 6).

Discussion

Ultimately, all the Malaysian stakeholders in the Klang Valley who were involved in this study, considered GM rice to be associated with moderate benefits and risks, as well as involving moderate moral issues and religious acceptance; however, they strongly agreed that further research, and the commercialization of GM rice in Malaysia, should be encouraged (Tables 4 and 5). One reasonable explanation for this might be that Malaysian stakeholders are still unfamiliar with, and lack information about, GM rice. Although both perceived benefits and risks have been assessed as
being moderate, Malaysian stakeholders have actually seen more benefits associated with GM rice compared to its risks (Table 4). This explains that when the stakeholders perceive the benefits of GM rice as outweighing the risks, this influences their positive attitudes with regard to GM rice. These results are in line with those obtained by De Steur et al. (2010) who indicated that the majority of consumers in China expressed their support for GM rice as having potential benefits, but that they were also of the belief that the technology could bring potential risks for biodiversity. Moreover, many countries, including those in North America and in Asia, also indicated a positive attitude to GM applications in general, while at the same time believing that GM crops may raise several moral issues (Frewer et al., 2013). Kajale and Becker (2015) highlighted that while half of their respondents have a positive attitude toward GM rice, the rest are not willing to buy it because they are concerned about unforeseen health problems. Although GM rice appears to be the perfect answer to the global food crisis, many people are very worried that GM crops may cause allergic reactions or human illnesses (Challa et al., 2020).

The results show that across all 11 stakeholders, they were showing moderate perceived benefits and perceived risks and no significant difference in their opinion on the beneficial and risk aspects associated with GM rice. This indicates that all Malaysian stakeholders, regardless of their background, perceive GM rice as being moderately beneficial in terms of ensuring the resilience of the country, in terms of eradicating hunger and malnutrition, and ensuring long-term food security, albeit accompanied by moderate risks. Although both risks and benefits were perceived by all stakeholders in this study, Malaysian stakeholders still perceive benefits associated with GM rice to be higher than risks; thus, the application would be highly accepted. This finding is backed by previous findings on public perception in Malaysia toward several modern biotechnology applications (Amin et al., 2013). Similarly, there is a vast literature on the importance of balancing the risk and benefit perceptions for the acceptance and success of a technology or product (Bearth & Siegrist, 2020; Ghoochani et al., 2017; Ronteltap et al., 2007; Raue et al., 2018).

The findings of this study demonstrate that stakeholders are affected by perceived moral concerns (Table 4), and religious acceptance and encouragement (Table 5). Firstly, post-hoc analysis of the perceived moral concerns with regard to GM rice confirmed that the views of scientists differ significantly from those of Islamic scholars (Table 4). A possible explanation for this might be that, as we know, scientists

### Table 6. Mean Scores and MANOVA Results of Attitudes Toward GM Rice Across Educational Level, Religion, and Age.

| Factors                | Educational level | Mean | Sig.  | Religion | Mean | Sig.  | Age  | Mean | Sig.  |
|------------------------|-------------------|------|-------|----------|------|-------|------|------|-------|
| Perceived benefits     | Secondary schools | 4.36 | 0.006*| Muslim   | 4.48 | 0.544 | 18–25| 4.49 | 0.858 |
|                        | Diploma/pre-university | 4.25 | 0.341 | Buddhist | 4.44 | 0.019 | 26–40| 4.48 | 0.034 |
|                        | University        | 4.57 | 0.710 | Hindu    | 4.57 | 0.024 | 26–40| 4.48 | 0.770 |
|                        | Overall           | 4.47 |       |          | 4.05 |       |      |      |       |
| Perceived risks        | Secondary schools | 4.00 | 0.080 | Muslim   | 4.02 | 0.019 | 18–25| 4.21 | 0.034 |
|                        | Diploma/pre-university | 4.18 |       | Buddhist | 4.12 |       | 26–40| 3.97 |       |
|                        | University        | 4.02 |       | Hindu    | 3.81 |       | ≥41  | 3.93 |       |
|                        | Overall           | 4.05 |       |          | 3.57 |       |      |      |       |
| Perceived moral concern| Secondary schools | 3.61 | 0.000*| Muslim   | 3.58 | 0.105 | 18–25| 3.60 | 0.005*|
|                        | Diploma/pre-university | 3.80 |       | Buddhist | 3.54 |       | 26–40| 3.53 |       |
|                        | University        | 3.47 |       | Hindu    | 3.50 |       | ≥41  | 3.58 |       |
|                        | Overall           | 3.57 |       |          | 4.42 |       |      |      |       |
| Religious acceptance   | Secondary schools | 4.56 | 0.024 | Muslim   | 4.50 | 0.248 | 18–25| 5.24 | 0.770 |
|                        | Diploma/pre-university | 4.96 |       | Buddhist | 5.26 |       | 26–40| 5.15 |       |
|                        | University        | 5.30 |       | Hindu    | 4.94 |       | ≥41  | 5.18 |       |
|                        | Overall           | 5.19 |       |          |      |       |      |      |       |

*Note. Mean score interpretation: 1.00–2.99, Low; 3.00–5.00, Moderate; 5.01–7.00, High.*

MANOVA (significant): *p < .01.
have been involved in the development of modern biotechnology as well as making progress in research. Therefore, they have a positive perception and have fewer moral concerns with regard to the application as compared to the media and to consumers who have low awareness or knowledge about the technology involved. This result is also similar to previous studies which reported that religious scholars expressed more moral concerns and displayed greater negative attitudes toward technology such as biobanks (Hashim et al., 2017) and biomedical applications (Allum et al., 2014).

Buddhist’s scholars also rated GM rice as being more acceptable in religious terms as compared to the media and consumers (Table 6). A possible explanation for this might be that in Buddhism, human technology is linked to natural phenomena and such scholars would accept technology such as genetic modification if it would help to reduce suffering (dukkha) in the world (Shoot, 2009). Moreover, GM food technology could help to increase the yield, which is important for food security and sustainability. Hence, this could be the reason why they are more accepting of the technology.

Producers were found to be more supportive of GM rice, and their support level differed significantly from that of Islamic scholars (Table 5). This could be due to the fact that producers believe that GM rice may increase their productivity and profitability, hence making them be more supportive of the technology. This finding is supported by Deng et al. (2019) who indicated that producers are more supportive of the adoption of GM crops because it could bring economic benefits. Similarly, Pilcher et al. (2002) also reported that around one-half of Illinois GM corn producers had a positive perception that GM corn could give higher yields compared to non-GM, and this influenced the positive attitudes to adoption. In addition, previous papers also revealed that Islamic scholars were found to be relatively less optimistic with regard to technology (Amin et al., 2016; Hashim et al., 2017). Hence this may be why Islamic scholars tend to be less supportive of GM rice. This could be because they are more cautious with regard to genetic modification. In a similar study by Amin et al. (2010) it was reported that the Muslim respondents were not really supportive of the use of animal genes to plants, because they tended to think that it threatens the natural order of things and were indecisive with regard to whether humans have the right to modify living things. Moreover, the Muslims were also particular with regard to whether humans have the right to modify living things. Hence, this could explain why Muslims were less supportive of GM rice.

Comparing across educational levels, the MANOVA analysis confirmed that there are significant differences in terms of perceived benefits and religious acceptance of GM rice (Table 6). Respondents who hold a tertiary level of education (university level) expressed their beliefs in greater benefits and believed that the application is acceptable from their religious point of view. This differs significantly from respondents who have achieved a secondary level of education (diploma/pre-university). This can be explained by the fact that people with more education usually have a better public understanding of scientific issues. Consequently, this influences their positive perception as compared with those who have a lower educational background. This view is supported by Ghoochani et al. (2017) who write that stakeholders’ knowledge regarding GM crops will influence their perception of the benefits of GM crops. Moreover, a study conducted by Evans and Kelley (2011) in the United States revealed that people with a higher education background were found to be more supportive of human embryonic stem cell research compared to those with lower levels of education.

Meanwhile, older respondents (41 years and above) perceived GM rice to be more acceptable in terms of their religious points of view, compared to younger respondents (18–25 years) (Table 6). This could be because older respondents recognize the benefits it promises, along with the religious view, when they made a decision to support it. Similarly, Ali et al. (2016) found that older consumers were more willing to accept GM food compared to younger consumers because they are less informed about the adverse effect of GM food. In the same vein, Strong et al. (2017) also indicated that older participants expressed more positive attitudes toward human clinical gene transfer therapy than did younger participants, who raised a major concern with regard to the treatment involved. Meanwhile, in this study, there was no significant age group effect in terms of risk perception with regard to GM rice, although age has been shown to affect people’s risk perceptions and attitudes toward science (Connor & Siegrist, 2010; Simon, 2010).

Conclusion

In general, therefore, it appears that the Malaysian stakeholders in the Klang Valley have shown a positive attitude towards GM rice. Although they indicated it as possessing moderate benefits, risks, religious acceptance, and moral concerns, they still expressed high encouragement toward it. Several sociodemographic factors have been identified to affect the factors that have been studied. The education factor has a significant impact on the perceived benefits and religious acceptance, while the age factor has a significant effect on religious acceptance. However, it was found that the religion factor did not affect any variables in this study. Therefore, the results presented in this study are useful for understanding the effect of sociodemographic variables on attitude of Malaysian stakeholders in the Klang Valley toward GM rice. It is proposed that future research analyses the relationships among the variables more closely as well as consider additional factors, such as government support, willingness to pay, and cost as determinants of attitude toward GM rice. The coverage of research locations can also be extended across Malaysia.
Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The authors would like to thank Universiti Kebangsaan Malaysia for supporting this research under the MI-2020-010 and DCP-2017-005/2 grants. The project was coordinated by Professor Latifah Amin, Pusat Pengajian Citra Universiti, UKM Bangi, Malaysia.

ORCID iDs
Muhammad Adzran Che Mustapa https://orcid.org/0000-0002-1358-627X
Latifah Amin https://orcid.org/0000-0002-8086-3329

References
Adeoti, J. O., & Adekunle, A. A. (2007). Awareness of and attitudes towards biotechnology and GMOs in southwest Nigeria: A survey of people with access to information. International Journal of Biotechnology, 9, 209. https://doi.org/10.1504/ijbi.2007.013052
Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Prentice Hall.
Aleksejeva, I. (2014). EU experts’ attitude towards use of GMO in food and feed and other industries. Procedia – Social and Behavioral Sciences, 110, 494–501. https://doi.org/10.1016/j.sbspro.2013.12.893
Ali, A., Rahut, D. B., & Imtiaz, M. (2016). Acceptability of GM foods among Pakistani consumers. GM Crops & Food, 7, 117–124. https://doi.org/10.1080/21645698.2016.1211216
Ali, Q., Shabaan, M., Ashraf, S., Rehman, A., & Asghar, H. N. (2020). Genetically modified rice stacked with antioxidants for nutrient enhancement and stress tolerance. In A. Roychoudhury (Ed.), Rice research for quality improvement: Genomics and genetic engineering (pp. 433–467). Springer.
Allum, N., Sibley, E., Sturgis, P., & Stoneman, P. (2014). Religious beliefs, knowledge about science and attitudes towards medical genetics. Public Understanding of Science, 23(7), 833–849. https://doi.org/10.1177/0963662513492485
Amin, L., Azad, M. A. K., Ahmad Azlan, N. A., & Zulkifli, F. (2014). Factors influencing stakeholders’ attitudes toward cross-kingdom gene transfer in rice. New Genetics and Society, 33(4), 370–399. https://doi.org/10.1080/14636778.2014.951992
Amin, L., Azlan, A., Gausman, M., Ahmad, J., Samian, A., Haron, M., & Sidik, N. (2010). Ethical perception of modern biotechnology with special focus on genetically modified food among Muslims in Malaysia. Asia-Pacific Journal of Molecular Biology and Biotechnology, 18, 359–367.
Amin, L., Azlan, N. A. A., Hashim, H., Haron, M. S., Ahmad, J., & Samian, A. L. (2011). Ethical perception of synthetic biology. African Journal of Biotechnology, 10(58), 12469–12480. https://doi.org/10.5897/AJB11.1057
Amin, L., & Hashim, H. (2015). Understanding the factors influencing attitudes toward genetically modified rice. In R. R. Watson & V. R. Preedy, (Eds.), Genetically modified organisms in food: Production, safety, regulation and public health (pp. 75–85). Elsevier.
Amin, L., Hashim, H., Ibrahim, M., Ngah, A. C., & Sidik, N. M. (2016). Effect of education level and religion on attitude to stem cells in Malaysia (Kesan Tahap Pendidikan dan Agama ke atas Sikap terhadap Sel Stem di Malaysia). Akademiaka, 86(2), 111–124. https://doi.org/10.17576/academic-2016-8602-09
Amin, L., Hashim, H., Mahadi, Z., Ibrahim, M., & Ismail, K. (2017). Determinants of stakeholders’ attitudes towards biodiesel. Biotechnology for Biofuels, 10(1), 219. https://doi.org/10.1186/s13068-017-0908-8
Amin, L., Md Jali, J., & Md Nor, A. R. (2013). Stakeholders’ attitude to genetically modified foods and medicine. Science World Journal, 2013, 1–14. https://doi.org/10.1155/2013/516742
Anderson, J. C., Wachenheim, C. J., & Lesch, W. C. (2006). Perceptions of genetically modified and organic foods and processes. Journal of Agrobiotechnology Management Economy, 9, 180–194.
Awang, Z. (2014). A handbook on SEM for academicians and practitioners: The step-by-step practical guides for the beginners. MPWS Rich Resources.
Bearth, A., & Siegrist, M. (2020). Psychological factors that determine people’s willingness-to-share genetic data for research. Clinical Genetics, 97(3), 483–491. https://doi.org/10.1111/cge.13666
Breustedt, G., Müller-Scheeßel, J., & Latacz-Lohmann, U. (2008). Forecasting the adoption of GM oilseed rape: Evidence from a discrete choice experiment in Germany. Journal of Agricultural Economics, 59(2), 237–256. https://doi.org/10.1111/j.1477-9552.2007.00147.x
Brookes, G., & Barfoot, P. (2003). GM rice: Will this lead the way for global acceptance of GM crop technology? (Issue 28). https://www.isaaa.org/Resources/publications/briefs/28/download/isaaa-brief-28.2003.pdf
Challa, S., Neelapu, N. R. R., Dutta, T., & Mishra, M. R. (2020). Involvement of policymakers, public acceptance, and commercialization of nutritionally enhanced and genetically modified rice. In A. Roychoudhury (Ed.), Rice research for quality improvement: Genomics and genetic engineering: Volume 2: Nutrient biofortification and herbicide and biotic stress resistance in rice (pp. 749–780). Springer.
Chen, M. (2008). An integrated research framework to understand consumer attitudes and purchase intentions toward genetically modified foods. British Food Journal, 110, 559–579. https://doi.org/10.1108/00070700810877889
Chen, M.-F., & Li, H.-L. (2007). The consumer’s attitude toward genetically modified foods and medicine. Journal of Agrobiotechnology Management Economy, 49(42), 662–674. https://doi.org/10.1016/j.foodqual.2006.10.002
Chiang, J.-T., Lin, C.-Y., Fu, T.-T., & Chen, C.-H. (2012). Using cross-kingdom gene transfer in rice. Biotechnology for Biofuels, 5, 7. https://doi.org/10.1177/0963662513492485
Chung, S. C., Kao, D. T., Cheng, Y. H., & Chou, C. A. (2012). The effect of incomplete information on the compromise effect. Judgment & Decision Making, 7(2), 196–206.
Cohen, J. (2013). Statistical power analysis for the behavioral sciences. Academic press.
Pennington, M. C. (1996). Global status of commercialized Biotech/GM crops: The first Fourteen Years, 1996 to 2009. ISAAA Briefs no. 41. ISAAA. http://www.isaaa.org/resources/publications/briefs/41/executivesummaryY/Default.asp

Kajale, D. B., & Becker, T. C. (2015). Willingness to pay for golden rice in India: A contingent valuation method analysis. Journal of Food Products Marketing, 21, 319–336. https://doi.org/10.1080/10454446.2012.726946

Kelley, J. (1995). Public perceptions of genetic engineering: Australia, 1994. Department of Industry, Science and Technology. www.international-survey.org

Kikulwe, E. M., Wesseler, J., & Falck-Zepeda, J. (2011). Attitudes, perceptions, and trust. Insights from a consumer survey regarding genetically modified banana in Uganda. Appetite, 57, 401–413. https://doi.org/10.1016/j.appet.2011.06.001

Knight, A. (2007). Intervening effects of knowledge, morality, trust, and benefits on support for animal and plant biotechnology applications. Risk Analysis, 27(6), 1553–1563. https://doi.org/10.1111/j.1539-6924.2007.00988.x

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30, 607–610. https://doi.org/10.1177/001316447003000030

Mishra, D., Akman, I., & Mishra, A. (2014). Theory of reasoned action application for green information technology acceptance. Computers in Human Behavior, 36, 29–40. https://doi.org/10.1016/j.chb.2014.03.030

Nicholas, B. (2000). The ethical issues of genetic modification. Reflections on the use of human.

Oluwakemi, H. O., Rauf, R. I., Seyi, E. A., & Harry, K. (2020). Readiness of the Nigerian public for the introduction of genetically modified crops into the food market. African Journal of Biotechnology, 19(7), 426–438. https://doi.org/10.5897/ajb2020.17136

Pennington, M. C. (1996). The “cognitive-affective filter” in teacher development: Transmission-based and interpretation-based schemas for change. System, 24, 337–350. https://doi.org/10.1016/0346-251X(96)00026-7

Pilcher, C. D., Rice, M. E., Higgins, R. A., Steffey, K. L., Hellmich, R. L., Witkowski, J., Calvin, D., Ostlie, K. R., & Gray, M. (2002). Biotechnology and the European corn borer: Measuring historical farmer perceptions and adoption of transgenic Bt corn as a pest management strategy. Journal of Economic Entomology, 95(5), 878–892. https://doi.org/10.1093/jee/95.5.878

Pino, G., Amatulli, C., De Angelis, M., & Peluso, A. M. (2016). The influence of corporate social responsibility on consumers’ attitudes and intentions toward genetically modified foods: Evidence from Italy. Journal of Cleaner Production, 112(4), 2861–2869. https://doi.org/10.1016/j.jclepro.2015.10.008

Prati, G., Pietrantoni, L., & Zani, B. (2012). The prediction of intention to consume genetically modified food: Test of an integrated psychosocial model. Food Quality and Preference, 25, 163–170. https://doi.org/10.1016/j.foodqual.2012.02.011

Raeu, M., Lermer, E., Streicher, B., & Slovic, P. (2018). Psychological perspectives on risk and risk analysis. Springer.

Rejesus, R. M., Mohanty, S., & Balagtas, J. V. (2012). Forecasting global rice consumption, Department of Agricultural and Resource Economics, North Carolina State University. Critical Reviews in Food Science and Nutrition, 57, 2455–2481.

Ronteltap, A., van Trijp, J. C., Renes, R. J., & Frewer, L. J. (2007). Consumer acceptance of technology-based food innovations: Lessons for the future of nutrigenomics. Appetite, 49(1), 1–17. https://doi.org/10.1016/j.appet.2007.02.002

Seck, P. A., Diagne, A., Mohanty, S., & Wopereis, M. C. S. (2012). Crops that feed the world 7: Rice. Food Security, 4, 7–24. https://doi.org/10.1007/s12571-012-0168-1

Secord, P. F., & Backman, C. W. (1964). Interpersonal congruence, perceived similarity, and friendship. Sociometry, 27(2), 115–127. https://doi.org/10.2307/2785710

Shoot, B. (2009). GMO or no: Problematic intersections of religion, biotechnology, and food. Retrieved December 17, 2020, from https://religiondispatches.org/gmo-or-no-problematic-intersections-of-religion-biotechnology-and-food/

Silk, J. K., Weiner, J., & Parrott, R. L. (2005). Gene Cuisine or Franken food? The theory of reasoned action as an audience segmentation strategy for messages about genetically modified foods. Journal of Health Communication, 10, 751–767. https://doi.org/10.1080/10810730500326740

Simón, R. M. (2010). Gender differences in knowledge and attitude towards biotechnology. Public Understanding of Science, 19(6), 642–653. https://doi.org/10.1177/09666250935449

Sjöberg, L. (2004). Principles of risk perception applied to gene technology: To overcome the resistance to applications of biotechnology, research on risk perception must take a closer look at the public’s reasons for rejecting this technology. EMBO Reports, 5(S1), S47–S51.

Sörqvist, P., Marsh, J. E., Holmgren, M., Hulme, R., Haga, A., & Seager, P. B. (2016). Effects of labeling a product eco-friendly and genetically modified: A cross-cultural comparison for estimates of taste, willingness to pay and health consequences. Food Quality and Preference, 50, 65–70. https://doi.org/10.1016/j.foodqual.2016.01.007

Strong, H., Mitchell, M. J., Goldstein-Leever, A., Shook, L., Malik, P., & Crosby, L. E. (2017). Erratum to: Patient perspectives on gene transfer therapy for sickle cell disease. Advances in Therapy, 34, 2177. https://doi.org/10.1007/s12265-017-0599-3

Tabachnick, B. G., & Fidell, L. S. (2001). Principal components and factor analysis. Using Multivariate Statistics, 4(1), 582–633.

Todua, N., & Gogitidze, T. (2017). Georgian farmers’ attitudes towards genetically modified crops. Economics World, 5(4), 362–369. https://doi.org/10.17265/2328-7144/2017.04.009

United States Department of Agriculture. (2019). Agricultural research service. FoodData Central. fdc.nal.usda.gov

Xu, R., Wu, Y., & Luan, J. (2016). Analysis of farmers’ willingness to adopt genetically modified insect-resistant rice in China. China Agricultural Economic Review, 8(3), 368–382. https://doi.org/10.1108/caer-08-2015-0102

Xu, R., Wu, Y., & Luan, J. (2020). Consumer-perceived risks of genetically modified food in China. Appetite, 147, 104520. https://doi.org/10.1016/j.appet.2019.104520

Zhang, W., Xue, J., Folmer, H., & Hussain, K. (2019). Perceived risk of genetically modified foods among residents in Xi’an, China: A structural equation modeling approach. International Journal of Environmental Research and Public Health, 16(4), 574. https://doi.org/10.3390/ijerph16040574