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Full Length Research Paper

Ethical perception of synthetic biology

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Modern biotechnology has moved forward by the introduction of the synthetic biology technique. By using synthetic biology, it is possible to construct mice genes in the laboratory and replace the need for the genes to be split out from the original animal. The purpose of this paper is to examine how the public in the Klang Valley region of Malaysia, perceive the ethical aspects of genetically modified (GM) rice which contain synthetic mice gene to increase its vitamin C content. A survey was carried out using self constructed multi-dimensional instrument measuring ethical perception of GM rice. The respondents (n = 434) were stratified according to stakeholders groups. Results from the survey on 434 respondents have shown that the Malaysian stakeholders were not very familiar with the GM rice and perceived it as having moderate risk, its benefits to the society would not be much denied if it is not developed and the ethical aspects were considered as not acceptable to them as well as from their religous point of view. ANOVAs showed that the five ethical dimensions: Familiarity, denying benefits, religious acceptance, ethical acceptance and perceived risks, significantly differed across stakeholders' groups while the first three dimensions also differed significantly across races. Furthermore, with respect to ages, only the factor of familiarity differed and no significant difference were found across educational level and gender. In conclusion, although the idea of producing GM rice enriched with vitamin C seems to be an ideal alternative to increase vitamin C intake, the Malaysian public in the Klang Valley region were still not ready and have a cautious stance on the use synthetic animal gene. The research finding is useful to understand the social construct of the ethical acceptance of the use of synthetic animal gene in plant. It is suggested that a more in-depth study should be carried out to determine the perspectives of various religion on synthetic biology.

Key words: Ethical perception, genetically modified rice, synthetic biology.

INTRODUCTION

There has been significant advancement in modern biotechnology worldwide in the past ten years. Current biotechnology products mostly focus on the commercialization of biopharmaceuticals (Walsh, 2004) followed by genetically modified crops (James, 2009). In Malaysia, biotechnology has been identified as one of the five core technologies that will accelerate the country's transformation into a highly industrialized nation by 2020 (9th Malaysian Plan). Rice is a staple food in much of Asia countries including Malaysia, and by 2025 about 60% more rice must be produced to meet the needs of the growing population (Khush, 1997). Even though farmers have been cultivating and breeding rice for thousands of years, modern plant breeders are still trying to improve the ability of rice to defend it against diseases [genetically modified organism (GMO) Compass]. Nowadays, with the development of genetic engineering, plants can be modified and used for the development of pharmaceutical

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Abbreviations: GM, Genetically modified; **GMO**, genetically modified organism.

products. More and more, genetic engineering is being used to achieve breeding objectives, and now on its way to fields in several countries. This includes, China who has already approved the commercialization of GM rice since November, 2009 (James, 2009). These approvals are momentous and have enormous implications for GM crop adoption not only for China and Asia, but for the whole world since rice is the most important food crop in the world (James, 2009). The production of GM rice is mainly focusing on several areas including altering its nutritional value, conferring resistance to viral, bacterial, and fungal pathogens. Biofortification, a process of breeding staple food crops for micronutrients, can be considered as an excellent alternative in poor regions (Bekaert et al., 2008; Asante, 2008), since preconceptional use of supplements to combat nutrient deficiencies in such area is not practical.

Organisms that have been genetically modified by genetic engineering are known as genetically modified organisms (GMOs). Herren (2005) refers GMOs, as organisms which some fraction of its genetic have been eliminated and inserted with the new genetic material in order to change its characteristics. The inserted genetic material may not necessarily be as the same species as the receiver since through genetic engineering, the gene transfer between two different species is no more impossible. Thus, organisms that resulted from the transfer of genetic material from the organisms of different species are known as the transgenic animal or plant (Herren, 2005). Synthetic biology is another art of genetic engineering of new biological systems that do not exist in nature (Chopra and Kamma, 2006). Unlike the conventional 'cut and paste' technique of existing genes between species, synthetic biology reproduces the genetic code of living organisms and synthetically constructed it back in the laboratory to create a new system of life from the beginning, producing a biological system with new functions. The word synthetic compounds are derived from organisms, whose genetic codes could not be found in the nature (Chopra and Kamma, 2006). Moreover, synthetic biology is the intersection between biology, chemistry and physics, and there are also overlapping cross between other researches and technology development. Synthetic biology is an important feature of the merger of biology with engineering techniques (Summer school IDEA League Caruso, 2008). In addition, synthetic biology has a different approach. The potential of synthetic biology to synthesize biological component that is able to produce a predictable biological cycle (Chopra and Kamma, 2006).

Successful development and commercialization of modern biotechnology products in Malaysia depends greatly on their acceptance by the Malaysian public. In order to reap the potential economic and social benefits of modern biotechnology, consumer acceptance issues have to be addressed (Stenholm and Waggoner, 1992). In addition, Sjöberg (2008) emphasized that the reactions and attitudes of the public to gene technology constitute important areas of research due to their relation to acceptance or rejection of policies. Since modern biotechnology is new and the advancement in these areas have been so rapid, it has been the object of some doubts, fears, concerns, as well as an intense and divisive debate worldwide on the potential risks to human health, the environment and to the society.

According to Batalion (2000), the central problem underlying the use of biotechnology is not just its short-term benefits and long term drawbacks, but the overall attempt to “control” living nature on an erroneous mechanistic view. Humans generally have conscience and religious beliefs, and many of these religious beliefs do not allow unrestricted interference with life such as can happen in genetic engineering (Epstein, 1998). The pace of discovery in genetic-based biotechnology is very rapid and there is anxiety that a kind of technological compulsion (‘if we can do it, let’s do it’) have been driving developments ahead of proper ethical consideration of their propriety (Polkinghorne, 2000).

Furedi (1997) argued that societal and individual risk perceptions are proportional to a system of moral values. Individuals were willing to accept some level of risk if a product was deemed worthy and was not morally objecttionable. Of the variables studied, namely, usefulness, perceived risk and morality, it was found that moral acceptability was the strongest predictor of support for biotechnology by the Canadians (Eisendel, 2000). Gaskell et al. (2000) also noticed that moral acceptability appeared to act as a veto for the support of biotechnology among the Europeans. The results of the US public survey (Priest, 2000) also suggested the possibility of the US people using moral reasoning in forming opinions towards six applications of biotechnology.

The objective of this paper is to assess the ethical perception of GM rice which contain synthetic mice gene to enrich its Vitamin C among the Malaysian public in the Klang Valley region and to compare their ethical perception across several demographic background.

MATERIALS AND METHODS

Data for this study was collected by means of a survey carried out from early August, 2009 to early February, 2010. The multi-dimensional instrument to measure ethical aspects of modern biotechnology used in this study was constructed based on the work of earlier researches (Comstock, 2000; Gaskel et al., 2003; BABAS, 1999; Glenn, 2004; Singh et al., 2006; Gott and Monamy, 2004). All items were measured on 7 point Likert scales. The questionnaires were administered face to face to 434 adult respondents (age: 18 years old and above) in the Klang Valley region. The respondents were stratified according to stakeholders’ groups which consisted of eleven groups: Producers, scientists, policy makers, NGOs, media, religious scholars, university students and consumers (Table 1). 38% of the respondents were male, 62% were female with age ranging from 17 to 64 years old, 13.6% of the respondents had at least secondary level of educations, 23.5% had pre-university education or diploma holders while the remaining 62.9% had tertiary level of education.

The multi-dimensional instrument to measure ethical aspects of

Table 1. Background of respondents surveyed.

Background	Frequency	Percentage (%)
Stakeholders' group		
Producers	25	5.8
Scientists	32	7.4
Policy Maker	39	9.0
NGOs	26	6.0
Media	29	6.7
University students	44	10.1
Islamic scholars	43	9.9
Buddhist scholars	32	7.4
Christian scholars	34	7.8
Hindu scholars	34	7.8
Consumers	96	22.1
Gender		
Male	165	38.0
Female	269	62.0
Educational level		
Secondary	59	13.6
Diploma/pre-U	102	23.5
University	273	62.9
Age		
18 - 25 years	201	46.3
26 - 40 years	156	35.9
≥ 41 years	77	17.7
Race		
Malay	259	59.7
Chinese	78	18.0
Indian	72	16.6
Sabah natives	11	2.5
Sarawak natives	9	2.1
Others	5	1.2
Religion		
Islam	264	60.8
Buddha	52	12.0
Hindu	60	13.8
Christian	52	12.0
Free thinkers	6	1.4

GM rice used in this study was constructed based on the work of earlier researches (Latifah, 2007; Gaskell et al, 2000; Macer, 2000; Rohrmann, 1999; Kirk et al., 2002). The instrument has been pre-tested in the pilot study was considered has a good validity and reliable to measure the ethical aspects of GM rice. In this study, five dimensions that have been identified (familiarity, perceived risk, denying benefits if it is not developed, religious and ethical acceptance) will be used to identify the Malaysian stakeholder perception towards ethical aspects of GM rice. Data analysis was carried out using SPSS version 14.0. T-test was used to see the differences in the mean value across gender while the differences in mean values across ages, educational level, religion, race and stakeholders groups were determined by analysis of variance (ANOVA).

RESULTS

Perception across stakeholders

Overall, the Malaysian stakeholders were not very familiar with GM rice containing synthetic mice gene which were indicated with the mean score of 3.07, below the mid-point of 4.0 (Table 2). GM rice was also perceived as moderately risky with a mean score of 4.74, above the mid-point of 4.0 (Table 2). They also did not consider the benefits of GM rice to society which would be much denied if it is not developed (mean score of 3.75, below the mid-point value of 4.0) (Table 3). From their religious point of view, they considered GM rice which involved cross-species gene transfer as not acceptable (mean score of 3.16, below the mid-point value of 4.0) (Table 3). The ethical acceptance dimension yielded the conclusion that the development of GM rice was also not acceptable to Klang Valley stakeholders (mean score of 3.74, below the mid-point value of 4.0) (Table 4).

The university students, the policy makers, the Islamic scholars, the Christian scholars, and the Hindu scholars scored low ratings in their familiarity with GM rice compared to other stakeholder groups (Table 2). ANOVA showed significant difference of familiarity for GM rice ($F = 4.24$, $p < 0.001$). Post hoc tests confirmed that the scientists were found to be more familiar with GM rice compared to the university students, the Muslim, Christian and Hindu scholars. The university students, the Islamic and Christian scholars considered the risks of GM rice as high while the other stakeholders rated the risks as moderate. On the other hand, the Buddhist scholars rated GM rice as possessing the lowest risks. ANOVAs was significant for perceived risk of GM rice across stakeholder groups ($F = 4.57$, $p < 0.001$) (Table 5). Post hoc test confirmed that the risk ratings of the Muslim and Christian scholars were significantly higher than the Buddhist scholars.

The scientists, the policy makers and the Hindu scholars were the three groups who considered that the benefits of GM rice containing synthetic mice gene to society would be denied if it is not developed (mean score above the mid-point value of 4.0) (Table 3). The remaining stakeholders rated the beneficial aspects of GM rice as below the mid-point value of 4.0. ANOVAs showed significant difference of the factor denying benefits across stakeholder groups ($F = 2.43$, $p < 0.01$) but post hoc test could not detect specific differences. The scientists, Buddhist and Hindu scholars rated that the ethical aspects of GM rice as acceptable (mean scores above the mid-point value of 4.0) compared to the other stakeholders (mean score below the mid-point

Table 2. Familiarity and perceived risk of GM rice containing synthetic mice genes across stakeholders.

Stakeholders' group	Familiarity		Perceived risk	
	Mean ± standard deviation	Interpretation	Mean ± standard deviation	Interpretation
Producers	3.05 ± 1.10	Moderate	4.60 ± 1.23	Moderate
Scientists	3.95 ± 1.52	Moderate	4.79 ± 1.11	Moderate
Policy makers	2.95 ± 1.53	Low	4.51 ± 1.36	Moderate
NGOs	3.44 ± 1.01	Moderate	4.42 ± 1.33	Moderate
Media	3.41 ± 1.17	Moderate	4.89 ± 1.41	Moderate
University students	2.83 ± 1.11	Low	5.01 ± 1.11	High
Islamic scholars	2.60 ± 1.42	Low	5.31 ± 1.33	High
Buddhist scholars	3.20 ± 1.04	Moderate	3.95 ± 1.03	Moderate
Christian scholars	2.80 ± 1.14	Low	5.36 ± 0.98	High
Hindu scholars	2.59 ± 1.04	Low	4.26 ± 1.05	Moderate
Consumers	3.18 ± 1.06	Moderate	4.71 ± 1.12	Moderate
Overall	3.07 ± 1.21	Moderate	4.74 ± 1.23	Moderate

1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

Table 3. Mean score for the factor denying benefits and religious acceptance of GM rice across stakeholders.

Stakeholders' group	Denying benefit		Religious acceptance	
	Mean ± standard deviation	Interpretation	Mean ± standard deviation	Interpretation
Producers	3.39 ± 1.17	Moderate	3.04 ± 1.71	Moderate
Scientists	4.56 ± 1.48	Moderate	4.38 ± 1.50	Moderate
Policy makers	4.17 ± 1.31	Moderate	3.51 ± 2.02	Moderate
NGOs	3.71 ± 1.32	Moderate	3.48 ± 1.65	Moderate
Media	3.97 ± 1.45	Moderate	2.34 ± 1.52	Low
University students	3.73 ± 1.24	Moderate	3.64 ± 1.67	Moderate
Islamic scholars	3.63 ± 1.61	Moderate	2.66 ± 1.65	Low
Buddhist scholars	3.82 ± 0.91	Moderate	4.36 ± 1.27	Moderate
Christian scholars	3.34 ± 1.51	Moderate	3.75 ± 1.70	Moderate
Hindu scholars	4.07 ± 1.29	Moderate	4.26 ± 1.42	Moderate
Consumers	3.88 ± 0.98	Moderate	3.16 ± 1.49	Moderate
Overall	3.85 ± 1.30	Moderate	3.46 ± 1.69	Moderate

1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

value of 4.0) (Table 4). With respect to religious acceptance, they also rated GM rice containing synthetic mice as acceptable (mean score above the mid-point value of 4.0) (Table 3). ANOVAs were significant for ethical ($F = 3.80$, $p < 0.001$) and religious acceptance ($F = 6.07$, $p < 0.001$) across stakeholder groups. Post hoc test showed that the Scientists, Buddhist and Hindu scholars were more accepting on the ethical aspects of GM rice compared to the Muslim scholars and they were more accepting of GM rice from their religious point of view compared to the media and Islamic scholars and consumers. The Buddhists were also found to have significantly higher religious acceptance compared to the producers.

Perception across educational levels

All respondents irrespective of educational level were not very familiar with GM rice (mean score below the mid-point value of 4.0), perceived GM rice as risky (mean score above the mid-point value of 4.0), not very beneficial (mean score below the mid-point value of 4.0) and not very acceptable ethically and from their religious point of view (Table 6).

ANOVAs did not show any significant differences of familiarity, perceived risks, denying benefits, and ethical acceptance across educational level. However, there were significant differences of religious acceptance for GM rice ($F = 9.70$, $p < 0.001$) across educational level

Table 4. Ethical acceptance of GM rice across stakeholders.

Stakeholders' group	Ethical acceptance	
	Mean score ± standard deviation	Interpretation
Producers	3.30 ± 1.46	Moderate
Scientists	4.64 ± 1.59	Moderate
Policy makers	3.72 ± 1.54	Moderate
NGOs	3.89 ± 1.73	Moderate
Media	3.41 ± 1.58	Moderate
University students	3.70 ± 1.56	Moderate
Islamic scholars	3.28 ± 1.52	Moderate
Buddhist scholars	4.57 ± 1.13	Moderate
Christian scholars	3.94 ± 1.10	Moderate
Hindu scholars	4.41 ± 1.24	Moderate
Consumers	3.79 ± 1.30	Moderate
Overall	3.86 ± 1.47	Moderate

1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

Table 5. One way ANOVA to compare ethical perception of GM rice across stakeholders.

Variable	F-value	Significant
Familiarity	4.158	0.000***
Perceived risks	4.578	0.000***
Denying benefits	2.429	0.008**
Religious acceptance	6.070	0.000***
Ethical acceptance	3.795	0.000***

***p < 0.001, **p < 0.01, p < 0.05.

(Table 7). The Post Hoc test confirmed that the respondents with tertiary education considered GM rice was more acceptable from their religious view compared to those with secondary as well as diploma or pre-university level of education.

Perception across religions

All respondents irrespective of religion claimed that they were not very familiar with GM rice (mean score below mid-point value of 4.0) (Table 8). The Hindus were found to have the lowest level of familiarity. ANOVAs were significant for the differences of familiarity of GM rice across religions ($F = 4.27$, $p < 0.01$) (Table 9). The Post Hoc test confirmed that the Hindus were less familiar with GM rice compared to the Muslims and Buddhists. The level of perceived risks was above the mid-point value for respondents from all the four major religions in Malaysia. The Christians considered GM rice as highly risky. ANOVA was significant for perceived risk across religion ($F = 3.63$, $p < 0.05$) but post hoc test could not detect any specific difference in perceived risk across religion. The Buddhists and Hindus scholars considered the benefit of GM rice that it will be marginally denied if it is not being developed (mean score about the mid-point value of 4.0). The respondents from the remaining three groups of religions rated GM rice as not very beneficial to society (mean score below the mid-point value of 4.0). However, ANOVA were not significant for the factor denying benefits across religion. The Buddhists and the Christians were moderately accepting the ethical aspects of GM rice (mean score about the mid-point value of 4.0) while the Muslims and Hindus were not accepting on the ethical aspects of GM rice (mean score below the mid-point value of 4.0). With respect to religious acceptance, respondents from all the four major religions in Malaysia seemed to agree that GM rice containing mice gene as not acceptable from their religious point of view. ANOVAs were significant for religious acceptance across religion ($F = 4.45$, $p < 0.01$) (Jadual 5.58) (Table 9). Post hoc test confirmed that the Buddhists accepted more of GM rice from their religious point of view compared to the Muslims.

Table 6. Ethical perception of GM rice across educational level.

Variable	Mean score ± standard deviation	Interpretation*
Familiarity		
Secondary	3.15 ± 1.26	Moderate
Diploma/pre-university	3.05 ± 1.13	Moderate
University	3.06 ± 1.23	Moderate
Perceived risks		
Secondary	4.89 ± 1.13	Moderate
Diploma/pre-university	4.78 ± 1.18	Moderate
University	4.69 ± 1.27	Moderate
Denying benefits		
Secondary	3.96 ± 1.17	Moderate
Diploma/pre-university	3.81 ± 1.19	Moderate
University	3.84 ± 1.37	Moderate
Religious acceptance		
Secondary	3.07 ± 1.60	Moderate
Diploma/pre-university	2.95 ± 1.56	Low
University	3.72 ± 1.71	Moderate
Ethical acceptance		
Secondary	3.69 ± 1.45	Moderate
Diploma/pre-university	3.62 ± 1.30	Moderate
University	3.98 ± 1.53	Moderate

*1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

Table 7. One way ANOVA to compare ethical perception of GM rice across educational level.

Variable	F-value	Significant
Familiarity	0.17	0.846
Perceived risks	0.68	0.507
Denying benefits	0.25	0.779
Religious acceptance	9.70	0.000***
Ethical acceptance	2.68	0.070

***p < 0.001, **p < 0.01, p < 0.05.

Perception across races

All respondents from various races (Malay, Chinese and Indian) professed they were not very familiar with GM rice, as their mean scores were below the mid-point value of 4.0) (Table 10). Comparing across races, the Chinese and Malays were found to be more familiar of GM rice than the Indians. ANOVA was significant for familiarity across races ($F = 6.61$, $p < 0.01$) (Table 11) and post hoc test confirmed the mentioned differences. The respondents also perceived GM rice as moderately risky to the environment and health (mean score above the mid-point value of 4.0) and not very beneficial to society if it is developed (mean scores were below the mid-point value of 4.0, Table 9). ANOVAs were not significant for perceived risks and the factor denying benefits (Table 11). Furthermore, the Malay and Indian respondents considered GM rice products as not very acceptable in keeping from their religious point of view (mean scores were below the mid-point value of 4.0) (Table 10). The Chinese were the more accepting of the ethical aspects of GM rice as well as acceptance from their religious view compared to other races. Their mean scores for both dimensions were above the mid-point value of 4.0.

Table 8. Ethical perception of GM rice across religion.

Variable	Mean ± standard deviation	Interpretation*
Familiarity		
Islam	3.10 ± 1.22	Moderate
Buddha	3.40 ± 1.13	Moderate
Hindu	2.62 ± 1.02	Low
Christian	3.04 ± 1.25	Moderate
Perceived risks		
Islam	4.80 ± 1.23	Moderate
Buddha	4.47 ± 1.21	Moderate
Hindu	4.50 ± 1.10	Moderate
Christian	5.13 ± 1.18	High
Denying benefits		
Islam	3.81 ± 1.28	Moderate
Buddha	4.04 ± 1.16	Moderate
Hindu	4.01 ± 1.30	Moderate
Christian	3.65 ± 1.47	Moderate
Religious acceptance		
Islam	3.22 ± 1.69	Moderate
Buddha	3.95 ± 1.55	Moderate
Hindu	3.76 ± 1.68	Moderate
Christian	3.73 ± 1.67	Moderate
Ethical acceptance		
Islam	3.66 ± 1.51	Moderate
Buddha	4.28 ± 1.35	Moderate
Hindu	3.99 ± 1.44	Moderate
Christian	4.12 ± 1.18	Moderate

***p < 0.001, **p < 0.01, p < 0.05.

Table 9. One way ANOVA to compare ethical perception of GM rice across religion.

Variable	F-value	Significant
Familiarity	4.27	0.006**
Perceived risks	3.63	0.013*
Denying benefits	1.19	2.133
Religious acceptance	4.45	0.004**
Ethical acceptance	3.82	0.010*

***p < 0.001, **p < 0.01, p < 0.05

ANOVAs yielded significant differences of religious acceptance for GM rice ($F = 10.59$, $p < 0.001$) and ethical acceptance across races ($F = 7.57$, $p < 0.01$) (Table 11). The Post hoc test confirmed that the Chinese perceived GM rice as more acceptable ethically and from their religious point of view as compared to the Malays.

Perception across age groups

The youth respondents (18 to 25, and 26 to 40 years) expressed that they were more familiar with GM rice compared to the adults (ages 41 years and above) who had low level of familiarity of GM rice (Table 12). However, their ratings were still below the mid-point value of 4.0. ANOVAs showed significant difference of familiarity across ages for GM rice ($F = 3.03$, $p < 0.05$) (Table 13) but post hoc tests could not detect specific differences across ages. The two youngest groups of youth respondents were also found to perceive both GM rice as less risky and more beneficial to society as compared to the oldest group of respondents (Table 12). However, ANOVAs did not show any significant differences of perceived risk and the factor denying benefits across

Table 10. Ethical perception of GM rice across races.

Variable	Mean ± standard deviation	Interpretation
Familiarity		
Malay	3.09 ± 1.23	Moderate
Chinese	3.33 ± 1.15	Moderate
Indians	2.64 ± 1.04	Low
Perceived risks		
Malay	4.80 ± 1.23	Moderate
Chinese	4.49 ± 1.26	Moderate
Indians	4.60 ± 1.10	Moderate
Denying benefits		
Malay	3.82 ± 1.28	Moderate
Chinese	3.91 ± 1.28	Moderate
Indians	3.97 ± 1.33	Moderate
Religious acceptance		
Malay	3.22 ± 1.69	Moderate
Chinese	4.17 ± 1.48	Moderate
Indians	3.67 ± 1.71	Moderate
Ethical acceptance		
Malay	3.67 ± 1.52	Moderate
Chinese	4.39 ± 1.28	Moderate
Indians	3.94 ± 1.39	Moderate

*1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

ages (Table 13). All respondents regardless of their age, considered GM rice as not very acceptable ethically and from their religious point of view (mean score below the mid-point value of 4.0) (Table 12). ANOVAs were not significant for religious and ethical acceptance of GM rice across age groups (Table 13).

Perception across genders

Both the male and female respondents claimed to be not very familiar with GM rice (mean score below the mid-point value of 4.0) (Table 14). They also perceived the GM rice as risky to the environment and health (mean score above the mid-point value of 4.0) and not very beneficial to society (mean score below the mid-point value of 4.0) (Table 14). Both male and female respondents also regarded the ethical aspects of GM rice and its acceptance from their religious point of view as not very acceptable with mean scores below the mid-point value of 4.0 (Table 14). T-test analysis showed no significant differences across gender (Table 14).

DISCUSSION

Overall, the Malaysian stakeholders were not very familiar with GM rice containing synthetic mice gene which were indicated with the mean score of 3.07, below the mid-point of 4.0. GM rice was also perceived as moderately risky with a mean score of 4.74, above the mid-point of 4.0. They also did not consider the benefits of GM rice to society would be much denied if it is not developed (mean score of 3.75, below the mid-point value of 4.0). From their religious point of view, they considered GM rice which involved cross-species gene transfer as not acceptable (mean score of 3.16, below the mid-point value of 4.0). Turning our attention to the ethical acceptance dimension yielded the conclusion that the development of GM rice was also not acceptable to Klang Valley stakeholders (mean score of 3.74, below the mid-point value of 4.0).

From the results, it becomes apparent that all the stakeholders in the Klang Valley region were found to be not very familiar with GM rice. This finding is not surprising as modern biotechnology has typically been associated with only moderate level of awareness and knowledge among the public. Traditionally, it has often been considered as novel and complex by the general public (Latifah et al., 2007), no mandatory labelling of modern biotechnology products in Malaysia and limited periodic coverage on modern biotechnology issues in the

Table 11. One way ANOVA to compare ethical perception of GM rice across races.

Variable	F-value	Significant
Familiarity	6.61	0.001**
Perceived risks	2.38	0.094
Denying benefits	0.46	0.632
Religious acceptance	10.59	0.000***
Ethical acceptance	7.57	0.001**

***p < 0.001, **p < 0.01, p < 0.05.

Table 12. Ethical perception of GM rice across age groups.

Variable	Mean ± standard deviation	Interpretation*
Familiarity		
18 - 25 years	3.13 ± 1.10	Moderate
26 - 40 years	3.15 ± 1.26	Moderate
≥ 41 years	2.77 ± 1.31	Low
Perceived risks		
18 - 25 years	4.74 ± 1.17	Moderate
26 - 40 years	4.66 ± 1.26	Moderate
≥ 41 years	4.88 ± 1.32	Moderate
Denying benefits		
18 - 25 years	3.84 ± 1.20	Moderate
26 - 40 years	4.01 ± 1.37	Moderate
≥ 41 years	3.58 ± 1.36	Moderate
Religious acceptance		
18 - 25 years	3.42 ± 1.57	Moderate
26 - 40 years	3.46 ± 1.80	Moderate
≥ 41 years	3.56 ± 1.79	Moderate
Ethical acceptance		
18 - 25 years	3.80 ± 1.40	Moderate
26 - 40 years	3.87 ± 1.57	Moderate
≥ 41 years	3.97 ± 1.46	Moderate

*1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

Table 13. One way ANOVA to compare ethical perception of GM rice across age groups.

Variable	F-value	Significant
Familiarity	3.03	0.049*
Perceived risks	0.83	0.438
Denying benefits	2.92	0.055
Religious acceptance	0.21	0.811
Ethical acceptance	0.38	0.681

***p < 0.001, **p < 0.01, p < 0.05.

Table 14. Ethical perception of GM rice across gender.

Variable	Mean ± standard deviation	t-test	Significant
Familiarity			
Male	3.14 ± 1.39	0.841	0.401
Female	3.03 ± 1.08		
Perceived risks			
Male	4.80 ± 1.35	0.816	0.415
Female	4.70 ± 1.15		
Denying benefits			
Male	3.84 ± 1.36	0.178	0.859
Female	3.86 ± 1.26		
Religious acceptance			
Male	3.47 ± 1.76	0.108	0.914
Female	3.45 ± 1.65		
Ethical acceptance			
Male	3.84 ± 1.56	0.191	0.849
Female	3.87 ± 1.41		

*1 - 2.99: low, 3.00 - 5.00: moderate, 5.01 - 7.00: high.

Malaysian general mass-media. This situation is not unique to Malaysians. The public in the United Kingdom were also found to have low familiarity with GM foods (Kirk et al., 2002). This could also be due to the lack of networks with other countries such as Philippines, Vietnam, India, Bangladesh, China and Indonesia, where GM rice is developed (Mayer, 2005). In Malaysia, the Malaysian Agricultural Research and Development Institute was focusing in developing GM rice resistance to pesticide rather than developing GM rice with nutritional value enhancement. Comparing across stakeholders, the scientists were found to have significantly higher familiarity level than the university students, the Muslim and the Hindu scholars. This could be due to their involvement in modern biotechnology related research but their familiarity level was still below the mid-point value. The unfamiliarity of the policy makers with GM rice was rather worrying as they are the ones who will be making decisions and regulating modern biotechnology issues in Malaysia. Labelling of GM foods could be one of the solutions in increasing the Malaysian public familiarity level as well as more efforts on the dissemination of more balanced information on the benefits and risks of GM foods and other modern biotechnology products.

In this study, the rice surveyed was inserted with mice gene to enrich its Vitamin C content. Although the GM rice surveyed has the potential to alleviate the Vitamin C deficiency, which is a major health problem in the worldwide, the use of synthetic animal gene in plant was perceived as moderately risky by majority of stakeholders. The university students, the Islamic and Christian scholars perceived the use of synthetic mice gene as highly risky. Majority of the stakeholders also rated GM rice containing synthetic mice gene as not beneficial to society and perceived it as unacceptable ethically and from their religious point of view. The Scientists, Buddhist and Hindu scholars were the only three groups who were accepted more on the ethical aspects of GM rice compared to the Muslim Scholars and they accepted more of GM rice from their religious point of view compared to the media and Islamic scholars and consumers.

Respondents from the major four religions in Malaysia, all major races, all age groups, all categories of educational level and gender also perceived GM rice containing mice gene as risky to the environment and society. They were concerned with probability of the GM rice causing the extinction of its original species, potential risks to health and long term harmful effects of consuming the golden rice and the dangers of golden rice causing a major catastrophe to the Malaysian society. Out of eleven stakeholders, only the scientists thought that the benefits of GM rice will be denied if it is not developed. However, the risk rating of the scientists was higher than their perceived benefits. This finding suggests that the animal to plant gene transfer is a sensitive issue in Malaysia.

Religious perspective is an important dimension for any modern biotechnology product to be well accepted by the Malaysian society. Religion plays a big role in the average Malaysian citizen's daily life (Latifah et al., 2006). Considering the religious acceptance dimension of this study yielded results that suggested that GM rice was only acceptable to the Scientists, Buddhist and Hindu

scholars' religious point of view. Other stakeholders, respondents from all four major religion, major races, all category of education, age groups and gender did not accept the transfer of synthetic animal gene to plant. The Muslims were found to be the least that accepted GM rice containing mice gene ethically and from their religious point of view. There is a need for more in-depth study to understand various religious perspectives on cross species gene transfers.

The respondents with tertiary education considered GM rice containing synthetic mice gene as more acceptable from their religious view compared to those with lower level of education. Although gender and age have been shown to affect people's risk perception and attitude towards science (Connor and Siegrist, 2010; Simon, 2010), but in this study there were no significant effect of gender and age groups on their ethical perception towards GM rice containing mice synthetic gene. The research finding is useful to understand the social construct of the ethical acceptance of the use of synthetic animal gene in plant.

Conclusion

Although the idea of producing GM rice enriched with vitamin C seems to be an ideal alternative to increase vitamin C intake in Malaysia, the Malaysian public in the Klang Valley region were still not ready and have a cautious stance on the use synthetic animal gene. Overall, the Malaysian public in this study seemed not to accept the transfer of synthetic animal gene to plant. There is a need for the various religious authorities and religious scholars to come out with clear guidelines on the permissible status of various kinds of inter-species gene transfers to guide the Malaysian public. The low level of familiarity in this study indicates the need for more dialogue, forums such that more balanced information is made available to the public, religious scholars and other stakeholders involved.

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