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Full Length Research Paper

Ethical perception of human gene in transgenic banana

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Transgenic banana has been developed to prevent hepatitis B through vaccination. Its production seems to be an ideal alternative for cheaper vaccines. The objective of this paper is to assess the ethical perception of transgenic banana which involved the transfer of human albumin gene, and to compare their ethical dimensions across several demographic variables. A survey was carried out in the Klang Valley region from August, 2009 till February, 2010 using self constructed multi-dimensional instrument measuring ethical perception of transgenic banana. The respondents (n=434) were stratified according to stakeholder groups which consisted of eleven groups: Producers, scientists, policy makers, non-governmental organisations (NGOs), media, religious scholars (Islamic, Buddhist, Christian, and Hindu scholars), university students and consumers. Results of the study showed that the Malaysian stakeholders were unfamiliar with transgenic banana, and perceived transgenic banana as having moderate risks and marginally beneficial to the Malaysian society and the ethical aspects were moderately acceptable to them as well as from their religous point of view. ANOVAs showed that all the four ethical dimensions: Familiarity, denying benefits, ethical acceptance and perceived risks significantly differed across stakeholders' groups while the last three dimensions also differed significantly across religion. Perceived risks, denying benefits, ethical and religious acceptance further differed significantly across races. However, with respect to ages, only the factor familiarity differed and no significant difference were found across educational level and gender. Although, the idea of producing an edible vaccine through transgenic banana seems to be an ideal alternative for cheaper vaccines, the Malaysian stakeholders were still not ready and have a cautious stance. The research finding is useful to understand the social construct of the ethical acceptance of cross-species gene transfers in developing country. Further research needs to be done to determine the perspectives of various religions on the use of human gene in plants.

Key words: Ethical perception, transgenic banana, Malaysian stakeholder.

INTRODUCTION

Nowadays, with the development of genetic engineering, plants characteristics can be modified for the development of pharmaceutical products. Through genetic engineering, an edible vaccine can be develop as an alternative for cheaper vaccines compared to the typical vaccine that are more expensive due to the storage, transportation and purification cost (Goldstein and Thomas, 2004). Typical vaccines are composed of killed or attenuated disease-causing organisms (Mishra et al., 2008) while transgenic pharmaceutical plants are modified by the introduction of novel gene sequences which drive the production of proteins or peptides that have properties allowing them to be used as precursors in the synthesis of medical compounds (Goldstein and Thomas, 2004).

An edible vaccines has many advantages identified such as edible means of administration, reduced need for medical personnel and sterile injection conditions, economical in mass production and transportation, therapeutic

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protein are free of pathogens and toxins, storage near the site of use, heat-stable, eliminating the need for refrigeration, antigen protection through bio-encapsulation, subunit vaccine (not attenuated pathogens) means improve safety, seroconversion in the presence of mucosal immunity, enhanced compliance (specially in children), delivery of multiple antigens, integration with other vaccine approaches, plant derived antigens assemble spontaneously into oligomers and onto virus like particles (Mei et al., 2006). But there is still limitations in producing edible vaccines such as the development of immunotolerance of vaccine peptide or protein, consistency of dosage form fruit to fruit, plant-plant and generation-generation is not similar, stability of the vaccine in fruit is not known, evaluation of the dosage requirement is tedious, selection of the best plant is difficult, certain foods are not eaten raw, and cooking the food might weaken the medicine present in it (Mei et al., 2006). However, Kong et al. (2001) claimed that they could substantially reduced the immunogenicity of the vaccine by cooking (boiling) the food. They also found that the plant-derived *HBsAg* which is delivered as food is orally immunogenic in mice and elicit a primary antibody response. Furthermore, the strong secondary response also seen after boosting with rHBsAg represents a true memory response generated from the mice fed by *HBsAg* transgenic potatoes.

Hepatitis B is a major global health problem and the most serious type of viral hepatitis spreads through blood transfusion and sexual contact. It is a viral infection that attacks the liver and can cause both acute and chronic disease. It is estimated that two billion people are infected with hepatitis B virus (HBV), and more than 350 million have chronic (long-term) liver infections in the worldwide(http://www.who.int/mediacentre/factsheets/fs204/en/). Therefore, the production of edible vaccine for hepatitis B through the development of transgenic plants could be an alternative for cheaper vaccine.

Arntzen has developed transgenic banana for the delivery of edible vaccine in developing countries (Prakash, 1996). Banana was considered as an ideal fruit for the production of edible vaccine because of several factors, such as those that easily grows in the tropics (Prakash, 1996) and subtropics (Sunil Kumar et al., 2004), favourite food for small children (Prakash, 1996), digestibility and palatability by the infants (Sunil Kumar et al., 2004) and can be consumed uncooked, thus, eliminating the possibility of protein denaturation due to high temperature (Goldstein and Thomas, 2004).

Since genetic engineering 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, to the environment and to the society (Costa-Font and Gil, 2009). The debate was typically seen as a conflict between supporters who envisage the potential benefits and the opposition groups who view GM products as tampering with nature (Bloomfield, 2011). Although the benefits of transgenic banana was promising, past studies also showed that genetic engineering has been associated with negative constructs, such as ethical concerns, changing nature, and its possible risks to the environment (Blaine et al., 2002). 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, 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 objectionable. 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.

Basic categories of moral or ethical concerns regarding modern biotechnology fall into two classes: intrinsic and extrinsic (Comstock, 2000). Extrinsic objection refers to the concerns regarding the possible concerns and risks of different application of biotechnology to human health, environment, economy and society (Gott and Monamy, 2004). While, intrinsic objections hold that, the process of modern biotechnology is objectionable in itself. This belief is associated with the claim that the technology is not natural. This technology is perceived as changing nature and is attempting to play “God”. Beyond this, other researchers have raised intrinsic issues which include biotechnology being perceived as a threat to the natural order of living things (BABAS, 1999) and whether human has the rights to modify living things for their benefits (Brook 2003). These intrinsic concerns include a religious dimension and concern on the underlying set of religious beliefs and principles concerning the relationships between God, nature and human beings (BABAS, 1999).

Modern biotechnology has been given priority by the Malaysian government to spearhead the country’s economy. The future development and commercialization of modern biotechnology products in Malaysia depends heavily on public acceptance. Besides, main decision on agriculture activities are shown to be influenced by the

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

public (Ogunsumi, 2007). This paper will look at the Malaysians views on transgenic banana. Malaysians has been found to be concerned about the moral aspects of several modern biotechnology applications such as genetically modified food and medicine (ISAAA-UIUC, 2003; Latifah et al., 2008, 2010). Past study has indicated that moral concern was found to be an important determinant of the Malaysians' perceptions in Klang Valley (Latifah et al., 2010). The objective of this paper is to assess the ethical perception of transgenic banana (containing human albumin gene) held by Malaysian stakeholders and to compare their perception across several demographic variables.

MATERIALS AND METHODS

The research data was collected by means of a face to face survey of adults (age: 18 years old and above), residing in the Klang Valley region. A total of 434 respondents completed questionnaires from August, 2009 till February, 2010. The respondents were stratified according to stakeholders' groups which consisted of eleven groups: producers, scientists, policy makers, NGOs, media, religious scholars (Islamic scholars, Buddhist scholars, Christian scholars, and Hindu scholars), university students and consumers (Table 1). Thirty eight percent (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 survey was conducted with the assistant of trained enumerators. A basic concept, pros and cons of modern biotechnology were first introduced before the respondents were asked to complete the questionnaires. Further explanation was also given when enquired. The multi-dimensional instrument to measure ethical aspects of transgenic banana used in this study was constructed based on the work of earlier researches (Latifah et al., 2007, Gaskell et al., 2000; Macer, 2000; Rohrmann, 1999; Kirk et al., 2002). All items were measured on 7 point Likert scales. These scales provided a reliable measure for the ethical aspects of transgenic banana. The principal component factor analyses using varimax rotation yielded five dimensions: Familiarity, perceived risks, denying benefits if it is not developed, religious and ethical acceptance. These dimensions were used to identify the Malaysian stakeholders' perception towards ethical aspects of transgenic banana.

The SPSS 14.0 software was used for data analysis. T-test was carried out to compare the differences in ethical perception across gender while comparison across age groups, educational level, religion, race and stakeholders groups were determined by analysis of variance (ANOVA). However, ANOVAs were only carried out across categories which have the minimum required number of respondents to achieve a medium effect size ($f = 0.25$) at $P = 0.05$, to obtain a power of 0.80 (Cohen, 1969). For race, the minimum required number of samples per category is 52; thus, comparisons were made only across the three major races. As for religion, the minimum required number of sample per category was 44; this means that comparisons were carried out only across the three major religions. For all other background variables, each category meets the minimum number of required samples.

RESULTS

Perception across stakeholders' groups

Overall, the Malaysian stakeholders were not very familiar with transgenic banana with a mean score of 3.22 which is below the mid-point value of 4.0. They perceived transgenic banana as having moderate risks (mean score of 4.22) and were not very acknowledging of the potential benefits of transgenic banana to the society (mean score of 3.97; about the mid-point value of 4.0). However, the

Table 2. Familiarity and perceived risks of transgenic banana across stakeholders' groups.

Stakeholders' group	Familiarity		Perceived risk	
	Mean ± standard deviation	Interpretation	Mean ± standard deviation	Interpretation
Producers	3.20 ± 1.08	Moderate	4.04 ± 1.39	Moderate
Scientists	3.95 ± 1.39	Moderate	4.48 ± 1.06	Moderate
Policy makers	3.04 ± 1.33	Moderate	4.11 ± 1.38	Moderate
NGOs	3.32 ± 1.18	Moderate	4.21 ± 1.20	Moderate
Media	3.69 ± 1.11	Moderate	3.77 ± 1.28	Moderate
University students	3.16 ± 1.05	Moderate	4.37 ± 1.19	Moderate
Islamic scholars	2.62 ± 1.38	Low	4.88 ± 1.45	Moderate
Buddhist scholars	3.32 ± 1.00	Moderate	3.81 ± 1.13	Moderate
Christian scholars	2.85 ± 1.18	Low	4.80 ± 1.23	Moderate
Hindu scholars	2.77 ± 1.09	Low	3.65 ± 1.05	Moderate
Consumers	3.42 ± 0.98	Moderate	4.12 ± 1.30	Moderate
Overall	3.22 ± 1.19	Moderate	4.22 ± 1.30	Moderate

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

Table 3. One way ANOVA to compare ethical perception of transgenic banana across stakeholders' groups.

Variable	F-value	Significant
Familiarity	4.23	0.000***
Perceived risks	3.65	0.000***
Denying benefits	3.75	0.003**
Religious acceptance	1.69	0.080
Ethical acceptance	3.51	0.000***

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

ethical aspects were moderately acceptable (mean score of 4.37) to them as well as from their religous point of view (mean score 4.50).

Almost all stakeholders' groups were classified as not very familiar with transgenic banana (mean score value below the mid-point value, 4.0) including the scientists and policy makers (Table 2). Religious scholars except the Buddhist scholars were found to have low level of familiarity of transgenic banana (Table 2). ANOVA showed significant difference for familiarity across stakeholders' groups ($F = 4.23$, $p < 0.001$) (Table 3). Post hoc tests confirmed that the Scientists were more familiar with transgenic banana compared to the Muslim, Christian and Hindu religious scholars. The media and consumers also have higher familiarity level of transgenic banana compared to the Muslim scholars.

Table 2 also shows that three groups of Klang Valley stakeholders (media, Buddhist and Hindu scholars) perceived less risk (mean score below the mid-point value, 4.0) of transgenic banana compared to the remaining eight stakeholders groups who rated transgenic banana as risky (mean score above the mid-point value, 4.0). ANOVA showed significant difference for perceived risks across stakeholders' groups ($F = 3.65$, $p < 0.001$) (Table 3) but post-hoc tests could not detect any significant differences across the groups. Producers, Scientists, Policy makers, Media and Consumers considered that the benefits of transgenic banana will be denied if it is not developed (mean score above mid-point value of 4.0) while the NGOs, university students and religious scholars (except the Hindu scholars) perceived it as less beneficial to society (mean score below mid-point value of 4.0) (Table 4). ANOVAs were significant for the factor denying benefits of transgenic banana across stakeholders' groups ($F = 3.75$, $p < 0.01$) (Table 3). Post-hoc test confirmed that the Scientists perceived higher benefits compared to the Christian scholars. With respect to religious view, the Islamic scholars were found to accept less of transgenic banana compared to other stakeholders' groups (Table 3). ANOVA were not significant for religious acceptance of transgenic banana across stakeholders' groups (Table 3).

Majority of the stakeholders' groups claimed that transgenic banana was acceptable ethically and from their religious perspectives (mean score above the mid-point value of 4.0) (Tables 4 and 5). Only the Muslim scholars

Table 4. Mean score of the factor denying benefits and religious acceptance of transgenic banana across stakeholders' groups.

Stakeholders' group	Familiarity		Perceived risk	
	Mean ± standard deviation	Interpretation	Mean ± standard deviation	Interpretation
Producers	4.27 ± 1.43	Moderate	4.18 ± 1.63	Moderate
Scientists	4.51 ± 1.31	Moderate	4.63 ± 1.53	Moderate
Policy makers	4.11 ± 1.40	Moderate	4.38 ± 1.95	Moderate
NGOs	3.85 ± 1.34	Moderate	4.08 ± 1.48	Moderate
Media	4.17 ± 1.03	Moderate	4.12 ± 1.85	Moderate
University students	3.89 ± 1.12	Moderate	4.52 ± 1.88	Moderate
Islamic scholars	3.53 ± 1.66	Moderate	3.53 ± 2.00	Moderate
Buddhist scholars	3.98 ± 0.88	Moderate	4.70 ± 1.40	Moderate
Christian scholars	3.23 ±1.36	Moderate	4.66 ± 1.65	Moderate
Hindu scholars	4.25 ± 1.31	Moderate	4.63 ± 1.26	Moderate
Consumers	4.00 ± 1.12	Moderate	4.46 ± 1.56	Moderate
Overall	3.97 ± 1.30	Moderate	4.37 ± 1.69	Moderate

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

Table 5. Ethical acceptance of transgenic banana across stakeholders' groups.

Stakeholders' group	Ethical acceptance	
	Mean score ± standard deviation	Interpretation
Producers	4.25 ± 1.67	Moderate
Scientists	5.00 ± 1.25	Moderate
Policy makers	4.25 ± 1.59	Moderate
NGOs	4.12 ± 1.56	Moderate
Media	4.75 ± 1.57	Moderate
University students	4.38 ± 1.46	Moderate
Islamic scholars	3.83 ± 1.46	Moderate
Buddhist scholars	4.94 ± 1.23	Moderate
Christian scholars	4.10 ± 1.38	Moderate
Hindu scholars	5.28 ± 1.21	High
Consumers	4.62 ± 1.36	Moderate
Overall	4.50 ± 1.47	Moderate

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

were hesitant in their ethical acceptance of transgenic banana as well as acceptance from their religious view (mean score below the mid-point value of 4.0). On the other hand, the Hindu scholars regarded the ethical aspects of transgenic banana as highly acceptable. There is a significant difference in ethical acceptance across stakeholders' groups ($F = 3.51$, $p < 0.001$) (Table 3). Post-hoc test showed significant different in the ethical acceptance of the Hindu scholars compared to the Muslim scholars.

Perception across races

All respondents irrespective of races were not very familiar with transgenic banana (mean score below the mid-point value of 4.0) but were moderately accepting of the ethical aspects of transgenic banana as well as acceptance from their religious views (Table 6). The Malays and Chinese perceived transgenic banana as risky to human and environment (mean score above mid-point value of 4.0) and not beneficial to society (mean score below mid-point value of 4.0) (Table 6). On the other hand, the Indian respondents rated transgenic banana as less risky to the human and environment (mean score below mid-point value of 4.0) and believed that the potential benefits of transgenic banana will be denied if it is not developed (mean score above mid-point value of 4.0) (Table 6). ANOVA were significant for the factor

Table 6. Ethical perception of transgenic banana across races.

Variable	Mean score ± standard deviation	Interpretation
Familiarity		
Malay	3.27 ± 1.20	Moderate
Chinese	3.35 ± 1.11	Moderate
India	2.85 ± 1.19	Low
Perceived risk		
Malay	4.23 ± 1.27	Moderate
Chinese	4.19 ± 1.29	Moderate
India	3.94 ± 1.30	Moderate
Denying benefit		
Malay	3.93 ± 1.27	Moderate
Chinese	3.79 ± 1.22	Moderate
India	4.29 ± 1.45	Moderate
Religious acceptance		
Malay	4.21 ± 1.78	Moderate
Chinese	4.76 ± 1.45	Moderate
India	4.54 ± 1.48	Moderate
Ethical acceptance		
Malay	4.34 ± 1.49	Moderate
Chinese	4.79 ± 1.28	Moderate
India	4.85 ± 1.45	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 transgenic banana across races.

Variable	F-value	Significant
Familiarity	4.15	0.016*
Perceived risks	1.48	0.230
Denying benefits	3.10	0.046*
Religious acceptance	3.71	0.025*
Ethical acceptance	5.19	0.006**

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

denying benefits ($F = 3.10$, $p < 0.05$), religious acceptance ($F = 3.71$, $p < 0.05$) and ethical acceptance across races ($F = 5.19$, $p < 0.01$) (Table 7). Post-hoc tests confirmed that the Indian respondents accepted more of the ethical aspects of transgenic banana compared to the Malays and the Chinese accepted more of transgenic banana from their religious point of view as compared to the Malays.

Perception across religion

Respondents from all religion were not very familiar with transgenic banana (mean score below the mid-point value of 4.0) but accepted the ethical aspects of transgenic banana and from their religious point of view (mean score above the mid-point value of 4.0) (Table 8). Majority of the races except the Hindus perceived transgenic banana as risky (mean score above mid-point value of 4.0) and were not acknowledging the potential benefits of transgenic banana (mean score below mid-point value, 4.0). ANOVA were significant for perceived risks ($F = 5.63$, $p < 0.01$), denying benefits ($F = 3.48$, $p < 0.05$) and ethical acceptance across religion ($F = 4.54$, $p < 0.01$) (Table 9). Post-hoc tests showed that the Hindus

Table 8. Ethical perception of transgenic banana across religion.

Variable	Mean score ± standard deviation	Interpretation
Familiarity		
Islam	3.28 ± 1.20	Moderate
Buddha	3.37 ± 1.12	Moderate
Hindu	2.88 ± 1.15	Low
Christian	3.07 ± 1.22	Moderate
Perceived risk		
Islam	4.24 ± 1.27	Moderate
Buddha	4.26 ± 1.17	Moderate
Hindu	3.78 ± 1.32	Moderate
Christian	4.76 ± 1.29	Moderate
Denying benefit		
Islam	3.93 ± 1.26	Moderate
Buddha	3.94 ± 1.00	Moderate
Hindu	4.38 ± 1.47	Moderate
Christian	3.62 ± 1.38	Moderate
Religious acceptance		
Islam	4.20 ± 1.78	Moderate
Buddha	4.77 ± 1.40	Moderate
Hindu	4.58 ± 1.53	Moderate
Christian	4.57 ± 1.60	Moderate
Ethical acceptance		
Islam	4.33 ± 1.49	Moderate
Buddha	4.72 ± 1.27	Moderate
Hindu	5.05 ± 1.44	High
Christian	4.41 ± 1.40	Moderate

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

Table 9. One way ANOVA to compare ethical perception of transgenic banana across religion.

Variable	F-value	Significant
Familiarity	2.40	0.067
Perceived risks	5.63	0.001**
Denying benefits	3.48	0.016*
Religious acceptance	2.45	0.063
Ethical acceptance	4.54	0.004**

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

perceived lower risks of transgenic banana to human and the environment and felt that transgenic banana was more beneficial to society as compared to the Christians. They also highly accepted the ethical aspects of transgenic banana compared to the Muslims.

Perception across age groups

All groups of respondents irrespective of ages were not very familiar with transgenic banana (mean score below the mid-point value of 4.0), rated transgenic banana as moderately risky (mean score above the mid-point value of 4.0) and moderately accepted its ethical aspects as well as moderately accepting transgenic banana in accordance with their religious perspectives (Table 10). The youth in the age range of 26 to 40 years old considered that the potential benefits of transgenic banana will be more denied if it is not developed (mean score above mid-point value, 4.0) com-

Table 10. Ethical perception of transgenic banana across age groups.

Variable	Mean score ± standard deviation	Interpretation
Familiarity		
18 - 25 years	3.31 ± 1.06	Moderate
26 - 40 years	3.31 ± 1.28	Moderate
≥ 41 years	2.79 ± 1.26	Low
Perceived risk		
18 - 25 years	4.17 ± 1.19	Moderate
26 - 40 years	4.17 ± 1.32	Moderate
≥ 41 years	4.45 ± 1.51	Moderate
Denying benefit		
18 - 25 years	3.96 ± 1.20	Moderate
26 - 40 years	4.07 ± 1.36	Moderate
≥ 41 years	3.77 ± 1.39	Moderate
Religious acceptance		
18 - 25 years	4.39 ± 1.66	Moderate
26 - 40 years	4.33 ± 1.72	Moderate
≥ 41 years	4.36 ± 1.72	Moderate
Ethical acceptance		
18 - 25 years	4.51 ± 1.36	Moderate
26 - 40 years	4.50 ± 1.51	Moderate
≥ 41 years	4.49 ± 1.64	Moderate

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

Table 11. One way ANOVA to compare ethical perception of transgenic banana across age groups.

Variable	F-value	Significant
Familiarity	6.06	0.003**
Perceived risks	1.52	0.221
Denying benefits	1.39	0.251
Religious acceptance	0.06	0.941
Ethical acceptance	0.02	0.998

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

pared to the other two age groups (18 to 25 years and ≥ 41 years). ANOVA was only significant for familiarity across age groups and post-hoc test showed that the younger groups (18 to 25, and 26 to 40 years) were more familiar with transgenic banana compared to the older groups (≥ 41 years) (Table 11).

Perception across educational level

All respondents irrespective of educational levels professed they were not very familiar with transgenic banana (mean score below mid-point value, 4.0) (Table 12), rating transgenic banana as moderately risky, but they considered the ethical aspects of transgenic banana as moderately acceptable and moderately accepting it by their religious perspectives (mean score above mid-point value of 4.0) (Table 12). On the other hand, the respondents with only secondary or diploma/pre-university levels of education believed that the potential benefits of transgenic banana will be more denied if it is not developed (mean score above the mid-point value, 4.0) compared to the respondents with university level of education. However, ANOVA showed no significant diffe-

Table 12. Ethical perception of transgenic banana across educational level.

Variable	Mean score ± standard deviation	Interpretation
Familiarity		
Secondary	3.21 ± 1.24	Moderate
Diploma/pre-university	3.29 ± 1.15	Moderate
University	3.18 ± 1.20	Moderate
Perceived risk		
Secondary	4.32 ± 1.27	Moderate
Diploma/pre-university	4.02 ± 1.26	Moderate
University	4.28 ± 1.31	Moderate
Denying benefit		
Secondary	4.05 ± 1.26	Moderate
Diploma/pre-university	4.06 ± 1.18	Moderate
University	3.91 ± 1.35	Moderate
Religious acceptance		
Secondary	4.26 ± 1.58	Moderate
Diploma/pre-university	4.19 ± 1.67	Moderate
University	4.45 ± 1.72	Moderate
Ethical acceptance		
Secondary	4.35 ± 1.54	Moderate
Diploma/pre-university	4.49 ± 1.32	Moderate
University	4.54 ± 1.51	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 transgenic banana across educational level.

Variable	F-value	Significant
Familiarity	0.28	0.758
Perceived risks	1.68	0.188
Denying benefits	0.58	0.558
Religious acceptance	0.96	0.383
Ethical acceptance	0.44	0.647

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

rences of ethical perception of transgenic banana across educational level (Table 13).

Perception across gender

Both category of respondents, male and female were not very familiar with transgenic banana (mean score below mid-point value of 4.0) and perceived transgenic banana as risky to human and to the environment (mean score above mid-point value). On the other hand, the respondents from both gender were moderately accepting the ethical aspects and from their religious point of views (Table 14). The females believed that the potential benefit of transgenic banana will be more denied if it is not developed compared to the male respondents. However, t-tests were not significant for the ethical perception of transgenic banana across gender (Table 14).

DISCUSSION

Overall, the Malaysian stakeholders were cautious about

Table 14. Ethical perception of transgenic banana across gender.

Variable	Mean score ± standard deviation	t-test	Significant
Familiarity			
Male	3.23 ± 1.34	0.126	0.900
Female	3.21 ± 1.10		
Perceived risk			
Male	4.16 ± 1.41	0.720	0.472
Female	4.25 ± 1.22		
Denying benefit			
Male	3.86 ± 1.36	1.347	0.179
Female	4.03 ± 1.25		
Religious acceptance			
Male	4.50 ± 1.66	1.273	0.204
Female	4.28 ± 1.71		
Ethical acceptance			
Male	4.61 ± 1.50	1.232	0.218
Female	4.43 ± 1.45		

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

transgenic banana. From the results, it becomes apparent that all the stakeholders in the Klang Valley region including the scientists and policy makers were unfamiliar with transgenic banana. This finding is not surprising as modern biotechnology has been associated with only moderate level of awareness and knowledge among the Malaysian public, besides it being considered as novel and complex and with no mandatory labeling of modern biotechnology products in Malaysia as well as limited periodic coverage on modern biotechnology issues in the Malaysian general mass-media (Latifah et al., 2008). 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).

Due to unfamiliarity of transgenic banana, majority of stakeholders perceived it as risky to human and to the environment. They felt that transgenic banana might cause extinction of its original species and possibly can cause a major catastrophe to the Malaysian society. They were also worried in consuming transgenic banana, and were also concerned on its long term harmful effects that will manifest after consuming it. Their concern might be related to their worriness on the safety of transgenic banana for consumption and whether appropriate research has been done to identify all the possible effects. Latifah et al. (2010) found that when a GM product was perceived as less familiar, the risks associated with it will also be less acceptable. On the other hand, if the GM product was perceived as more familiar, it will also be rated as more beneficial. In this study, the scientists who claimed to be more familiar with transgenic banana, perceived it as more beneficial compared to the other stakeholders' groups.

Overall, the Klang Valley respondents acknowledged marginal potential benefits of transgenic banana to the society (mean score of 3.97, that is, about the mid-point value of 4.0). This could be due to the balancing relationship between perceived risks and benefit (Latifah et al., 2010; Gaskel et al., 2004; Rowe, 2004). As transgenic banana was considered as risky, it was perceived as not very beneficial to the society too. Even though the scientists rated transgenic banana as more beneficial but their rating is still considered as moderate and their opinion only significantly differed compared to the Christian scholars. This scenario could also be related to the source of gene inserted into the banana (human albumin gene). Major groups of stakeholders considered the ethical and religious acceptance of transgenic banana as moderate. Moral concern has been negatively associated with perceived benefits and positively link with risks (Latifah et al., 2010, Gaskel et al., 2000; Sjoberg, 2004).

Comparing across stakeholders, the Islamic scholars were the only group who claimed transgenic banana as unacceptable ethically and from their religious point of view. This could again be related to the source of the gene transferred to banana (human albumin gene). The use of human gene in food seemed sensitive and not acceptable to the Muslim scholars. There is a need to determine the permissibility status of the use of human

gene in food from the perspective of Islamic laws and if true, it is not allowed under the Islamic laws; thus, other permissible sources of gene should be considered. On the opposite end, it is interesting to note that the Indians and Hindu followers accepted the ethical aspects of transgenic banana the most, perceived the lowest risks and the highest benefits compared to other races and religions.

The youth respondents (40 years old and below) were found to be more familiar with transgenic banana. This could be due to the fact that the younger generations were either still studying in universities or just beginning their career where they were more likely to be involved in information seeking. Lorence and Park (2006) reported that younger participants (18 to 29 years) exhibited the highest rates in the use of internet. Although, other socio-demographic variables such as, gender and education 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 education on their ethical perception towards transgenic banana.

Conclusion

Although, the idea of producing an edible vaccine through transgenic banana seems to be an ideal alternative for cheaper vaccines in Malaysia, the Malaysian public in the Klang Valley region were still not ready and have a cautious stance. The unfamiliarity of the transgenic banana to them, the moderate level of ethical and religious acceptance translated to their perceiving transgenic banana as risky and marginally beneficial to society. There is a need for a more in-depth study to understand the permissibility status of cross species gene transfers from the perspectives of various religions in Malaysia.

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REFERENCES

Blaine K, Kamaldeen S, Powell D (2002). Public perceptions of biotechnology. J. Food Sci. 67(9): 3200-3208.

Bloomfield BP (2011). Imagination and technoscientific innovations: Goverannce of transgenic cows in New Zealand. Soc. Stud. Sci. 41(1): 59-83.

Connor M, Siegrist M (2010). Factors influencing people's acceptance of gene technology: the role of knowledge, health expectations, naturalness and social trust. Sci. Commun. 32(4): 514-538.

Costa-Font M, Gil JM (2009). Structural equation modelling of consumer acceptance of genetically modified (GM) food in the Mediterranean Europe: a cross country study. Food Qual. Preference. 20: 399-409.

Gaskell G, Alum N, Bauer, Durant J, Allansdottir A, Bonfadelli H, Boy D, Cheveigne D S, Fjaestad B, Gutteling JM, Hampel J, Jelsoe E, Jesuino JG, Kohring M, Krongerger N, Midden, C, Nielsen TH, Przestalski A, Rusanen T, Sakellaris G, Torgersen H, Twardowski T, Wagner W (2000). Biotechnology and the European public. Nat. Biotechnol. (18): 935-938.

Gaskell G, Allum N, Wagner W, Kronberger N, Torgersen H, Hampel J, Bardes J (2004). GM foods and the misperception of risk perception. Risk Anal. 24(1): 185-194.

Goldstein DA, Thomas JA (2004). Biopharmaceuticals derived from genetically modified plants. Int. J. Med. 97: 705-716.

http:///www.gmo-compas.org/database/plants/20.banana.html

http://www.who.int/mediacentre/factsheets/fs204/en/

Karg SR, Kallio PT (2009). The production of biopharmaceuticals in plant systems. Biotechnol. Adv. 27: 879-894.

Kirk SFL, Greenwood D, Cade JE, Pearman AD (2002). Public perception of a range of potential food risks in the United Kingdom. Appetite, 38: 189-197

Kong Q, Ritcher L, Fang Yang Y, Arntzen CJ, Mason HS, Thanavala Y (2001). Oral immunization with hepatitis B surface antigen expressed in transgenic plants. Proc. Natl. Acad. Sci. 98(20): 11539-11544.

Latifah A, Jamaluddin MJ, Abd Rahim MN, Mohamad O, Nor MM (2008). Malaysian Public Attitude Towards Several Modern Biotechnology Applications. Proceedings of the 6th International Conference on Environment, Ecosystems and Development. 29-31 December, Pyramisa Suites Hotel and Casino, Cairo. pp. 1-8.

Latifah A, Jamil A, Jamaluddin MJ, Abd Rahim MN, Mohamad O, Nor MM (2010). Factors Influencing Malaysian Public Attitudes to Agro-biotechnology. Public Underst Sci. DOI: 10.1177/0963662510369622: pp.1-16.

Lorence DP, Park H (2006). New technology and old habits: the role of age as a technology chasm. Technol. Health Care, 14: 91-96.

Macer DRJ (2000). Bioethics: perceptions of biotechnology and policy implications. Int. J. Biotechnol. 3: 116-133.

Mei H, Tao S, Yuan-Gang Z, Zhi-Gang A (2006). Research advances on transgenic plant vaccines. Acta Genet. Sin. 33(4): 285-293

Mishra N, Gupta PN, Khatri K, Goyal AK., Vyas SP(2008). Edible vaccines: A new approach to oral immunization. Indian J. Biotechnol. 7: 283-294.

Ogunsumi LO (2007). Socio- economic conditions of peasant farmers: the case of agricultural technologies' sustainability in southwest Nigeria. Afr. J. Agric. Res. 2(9): 441-446

Prakash CS (1996). Edible Vaccines and Antibody Producing Plants. Biotechnol. Dev. Monit. p. 27.

Rohrmann B (1999). Risk perception research: review and documentation. 1999. Research Center Juelich: RC Studies #68. http://www.kfa-juelinch.de/mut/hefte/heft_69.pdf (3 June 2009)

Rowe G (2004). How can genetically modified foods be made publicly acceptable?. Trends Biotechnol. 22(3): 107-109.

Simon RM (2010). Gender differences in knowledge and attitude towards biotechnology. Public Understand. Sci. 19(6):642-653.

Sjoberg L (2004). Principals of risk perception applied to gene technology. EMBO report 5: 47-51.

Sunil Kumar GB, Ganapathi TR, Bharat VA (2004). Edible vaccines: current status and future prospects. Physiol. Mol. Biol. Plant. 10: 37-47.

Sunil Kumar GB, Ganapathi TR, Revathi CJ, Srinivas L, Bapat VA (2005). Expression of hepatitis B surface antigen in transgenic banana plants. Planta, 222: 484-493