African Journal of Biotechnology Vol. 10(58), pp. 12435-12447, 30 September, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.1054
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Ethical perception of modern biotechnology

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Accepted 12 September, 2011

Past studies have shown that successful development and commercialisation of modern biotechnology products depends heavily on public acceptance. Of the many variables studied by earlier researchers, it was found that moral acceptability was an important predictor of support for biotechnology. The purpose of this paper is to examine the ethical perception of modern biotechnology among the public in the Klang Valley region of Malaysia and to compare their ethical perception across several demographic variables. A survey was carried out using a self-constructed multi-dimensional instrument measuring the ethical perception of modern biotechnology. The respondents (n = 434) were stratified according to stakeholder groups which consisted of eleven groups: Producers, scientists, policy makers, NGOs, the media, religious scholars, university students and consumers. Results from the survey showed that the Klang Valley public did not perceive modern biotechnology as very threatening to the natural order of things (mean score 3.76) and they recognised the high benefits that modern biotechnology could provide to society (mean score 5.31). However, they also stressed that humans do not have the absolute right to modify living things (mean score 3.55) and they perceived modern biotechnology as moderately risky (mean score 4.59), whilst they had moderate confidence in regulation (mean score 4.09) and stressed the high need for proper labelling of modern biotechnology products (mean score 5.70). Background variables such as religion, race, age, education level and gender have significant effect on some of the dimensions of Malaysians' ethical perception of modern biotechnology. The research findings are useful for understanding the social construct of the ethical acceptance of modern biotechnology in a developing country.

Key words: Modern biotechnology, ethical aspects, perception, Malaysia.

INTRODUCTION

Malaysia aims to use biotechnology as an economic growth vehicle by the year 2020 (Firdaus-Raih et al., 2005; BIOTEK, 2010). Being an agriculture-based nation, the strength of biotechnology in Malaysia is in agricultural biotechnology which is foreseen as a potential tool to ensure food security and to boost the country's economy (Latifah et al., 2007). Successful development and commercialisation of modern biotechnology products in Malaysia depends greatly on the 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, Sjoberg (2008) emphasizes 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 has been so rapid, it has been the object of some doubts, fears and concerns, as well as an intense and divisive debate worldwide on the potential risks to human health, to the environment and to society (Costa-Font and Gil, 2009). The debate was typically seen as a conflict between supporters who envisage the potential

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Abbreviations: GMOs, Genetically modified organisms; **GM,** genetically modified.

benefits and the opposition groups who view genetically modified (GM) products as tampering with nature (Bloomfield, 2011).

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 a conscience and religious beliefs and many of these religious beliefs do not allow unrestricted interference with life, such that happens 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') has been driving developments ahead of proper ethical consideration of their propriety (Polkinghorne, 2000).

Furedi (1997) argues 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 Canadians (Eisendel, 2000). Gaskell et al. (2000) also noticed that moral acceptability appeared to act as a veto for the support of biotechnology among Europeans. The results of the US public survey (Priest, 2000) also suggested the possibility of the US population 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 risks of different applications of biotechnology to human health, the environment, the economy and society (Gott and Monamy, 2004). The societal concerns include the need for labelling (Wansink and Kim, 2001) and the patenting rights of multinational companies and scientists (Potrykus, 2001). The patenting of living things is objected to by many, on the grounds that genes are naturally occurring entities and the methods for transferring them to plants or animals are well-known and straightforward (EFB, 1996). On the other hand, the economic concerns include denying the benefits of modern biotechnology to society, the economy and farmers (BABAS, 2009) and the monopoly of the modern biotechnology products market by giant companies (Leisinger, 2007).

Intrinsic objection alleges that the process of modern biotechnology is objectionable in itself. This belief is associated with the claim that the technology is not natural, with the technology changing Nature and playing "God". Other researchers have highlighted other intrinsic issues such as modern biotechnology being seen as threatening the natural order of living things (BABAS, 1999) and whether humans have the right to modify living things for their own benefit. In some cases, the intrinsic concerns include a religious dimension when they are accompanied by an underlying set of religious beliefs and principles concerning the relationships between God, Nature and human beings (BABAS, 1999). Many religions do not allow unrestricted interference with life, such as genetic engineering (Epstein, 1998).

Socio-demographic variables such as age, gender and education have been shown to affect people's risk perception and attitude towards science (Connor and Siegrist, 2010; Simon, 2010). In general, men were less concerned about gene technology compared to women, and the level of education has an impact on attitude to modern biotechnology (Hallman et al., 2003). According to Kelley (1995), demographic characteristics such as age must be included because some researchers have argued that the continuing process of scientific discovery leaves older people behind and perceived risk tends to increase with age, up to a point, and then decreases, possibly due to health concerns or ageing (Grobe et al., 1999). Since, the study is carried out in a multiracial country like Malaysia, it is also important to see whether there is any effect of race on ethical perceptions of biotechnology.

The objective of this paper is to assess the ethical perception of modern biotechnology among the Malaysian public in the Klang Valley region and to compare their ethical perceptions across several demographic variables.

MATERIALS AND METHODS

Data for this study was collected by means of a survey using questionnaires 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 research (Comstock, 2000; Gaskel et al., 2003; BABAS, 1999; Glenn, 2004; Singh et al., 2006; Gott and Monamy, 2004). All items were measured on seven point Likert scales. The questionnaires were administered face-to-face with 434 adult respondents (aged 18 years old and above) in the Klang Valley region. Since the respective populations for the stakeholders involved were mostly unknown, the respondents were chosen using a stratified purposive sampling technique, as recommended by Monroe and Monroe (1993). Although the samples chosen using this technique may not reflect the true population of Malaysia, this technique enabled the inclusion of respondents from different stakeholders' groups that might otherwise be underrepresented if random sampling was used.

Public acceptance of a new technology can be measured either by conducting a representative survey among lay people of a certain country, or it can focus on stakeholders' representatives who contribute to the formation of public opinion and claim to represent certain public and private interests and concerns (Aerni, 1999). Most of the earlier research concentrated on the representative public samples (Gaskell et al., 2003; Hallman, 2004; Hamstra, 1998), while other researchers such as Aerni (1999, 2002) recommended the use of the stakeholder-based approach when it is difficult to run representative surveys in developing countries with a low level of public awareness towards biotechnolo-

Table 1. Description of the stakeholder groups.

Stakeholder	Definition
Producers	Officers who have a company or organisation related to food, agriculture and pharmaceuticals. Company or organisation directly involved in the production of products of modern biotechnology, or has an interest to enter the field of modern biotechnology in the future.
Scientists	Professionals involved in the research and development of biotechnology or science.
Policy Makers	Individuals from organisations in which decisions and opinions would affect policy/national policies, laws and acts related to biotechnology as well as the country's biotechnology programs, including production, research, and trade.
Group of non-governmental organisations (NGOs)	Individuals who represent organisations that have an interest in biotechnology.
Media	Media group consisting of editors and news reporters from local newspapers, especially in science and technology (including areas of environment and research and development).
University students	University students with a science background, especially biology.
Muslim scholars	Officials of the Islamic organisations.
Buddhist scholars	Officials of the Buddhist organisations.
Christian scholars	Officials of the Christian organisations.
Hindu scholars	Officials of the Hindu organisations.
Consumers	Individuals who often visit the supermarket to get daily necessities.

gy. Since Malaysia is a developing country where the awareness level is not expected to be high, the stakeholder-based survey approach recommended by Aerni (1999, 2002) was adopted but a wider range of interest groups as well as consumers were included so that comparisons could be made. The respondents in this study were stratified according to stakeholders' groups, which consisted of eleven groups: Producers, scientists, policy makers, NGOs, media, religious scholars, university students and consumers. The description of the selected groups is shown in Table 1.

Taking into account that this study was quantitative, the minimum sample size required for each statistical analysis was considered. Comparison of attitudes across stakeholders (eleven groups) was to be carried out using analysis of variance (ANOVA). In order to have a medium effect size ($f = 0.25$) at $P = 0.05$, $u = 10$, a sample of 25 subjects per group is required to obtain a power of 0.80 (Cohen 1969). So each stakeholder group, except for the general public, was allocated a minimum sample size of 25 but the number was increased where possible to take into account that some questionnaires might be incomplete or when the population size was bigger (Table 2). 38% of the respondents were male, 62% female, ages ranging from 17 to 64 years old, 13.6% of the respondents had at least a secondary level of education, 23.5% had pre-university education or were diploma holders while the remaining 62.9% had a tertiary level of education (degree and above). The majority of the stakeholders (except the consumers, religious scholars and university students) possessed at least a tertiary level of education, which resulted in a high percentage of respondents in this category but the number of respondents in the other categories met the minimum number required to carry out comparison using ANOVAs to achieve a medium effect size ($n = 52$ at $P = 0.05$, to obtain a power of 0.80) as recommended by Cohen (1969).

In a developing country like Malaysia, where biotechnology is still new, it is expected that the majority of the public may not know much about biotechnology. The conventional multiple indicator survey research approach, as proposed by Kelley (1995), was adopted in this study, which resulted in comprehensive items coverage. The public do not perceive technological risk according to a single dimension related to predicted injuries or fatalities akin to a risk assessor's viewpoint but interpret risk as a multi-dimensional concept, concerned with broader qualitative attributes (Rowe, 2004). Within this approach, multi-dimensional risk perception is invoked to explain the expert-lay disagreement that is ascribed to lay ignorance in the knowledge deficit model (Hansen et al., 2003). So the questionnaires were developed to be of the fixed response type to make it easier for the respondents to answer. The questionnaires were handed out personally to respondents by trained biotechnology graduate enumerators. Before answering, the respondents were given an introduction to basic concepts, examples and several possible benefits and risks related to several applications of modern biotechnology and they were also given the chance to enquire further. This approach was suggested by Kelley (1995) in order to assess unsophisticated public attitudes towards complex issues like modern biotechnology. This style works perfectly well for sophisticated respondents as well as unsophisticated respondents, besides allowing the researchers to use sophisticated statistical multivariate procedures to discover whether the attitude responses are empirically sensible. By using a multiplicity of questions, measurement errors are reduced.

Data analysis was carried out using SPSS version 14.0. A t-test was used to see the differences in the mean value across gender while the differences in mean values across age, educational level, religion, race and stakeholders groups were determined by ANOVAs. However, ANOVAs were only carried out across categories which had 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 was 52 so comparisons were made only across the three major races: Malay, Chinese and Indian. As for religion, the minimum required number of samples per category was 44. This meant that comparisons were carried out only across the four major religions in Malaysia: Islam, Buddha, Hindu and Christian. For all other background variables, each category met the minimum number of required samples.

Table 2. Background of respondents surveyed.

Background	Frequency	Percentage
Stakeholders' group		
Producers	25	5.8
Scientists	32	7.4
Policy makers	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

RESULTS

Ethical dimensions

An exploratory principal component factor analysis followed by varimax rotation was carried out to identify items most expressive of ethical dimensions. Seven factors with eigen values greater than one were extracted and were able to account for the majority of the variances in responses (66.68%), indicating that this as good instrument that can measure the general ethical aspects of modern biotechnology. Table 3 shows the results of principal component factor analyses using varimax rotation. This rotation yielded meaningful item groupings or dimensions with strong, unambiguous loadings. All factor loading values were greater than 0.4, which can be considered as more significant, as suggested by Hair et al. (1992).

The first factor or dimension was interpreted as market monopoly by giant companies and developed countries, where five items were strongly loaded on it. The second dimension with four items strongly loaded on it was labelled as risks to human health. The third dimension clearly reflected the labelling aspects of biotechnology, that is, the need for proper and appropriate labelling, and four items were strongly loaded on it as well. Five items were salient to the fourth factor which was labelled as modern biotechnology threatening the natural order of things. The fifth factor, which was made up of another five items represented perceived benefits. Another three items reflected the sixth dimension, described as public confidence in government regulation related to modern biotechnology. The items included whether the respondents agreed that the regulations related to modern biotechnology and the regulatory action on experimental failure of GMOs is adequate in protecting the safety of Malaysian society and whether the government department involved in modern biotechnology regulation has monitored the safety of modern biotechnology products efficiently. The last three items were most salient to the seventh dimension which related to whether humans possess the right to modify living things.

Item analysis and reliability of the instrument

To ensure that each item was measuring a similar dimension as the whole category itself, item scales were correlated with their total scales on all items of a category. As recommended by Aiken (1994) items that correlated with a magnitude of 0.30 or more with the category score were retained. From Table 3, it can be seen that the corrected item-total correlations for almost all items in each dimension generally ranged from reasonably good (correlation value between 0.30 and 0.39) to very good (correlation value greater than 0.40) (Matlock-Hetzel, 1997). It can be concluded that all the items in each dimension are strongly valid to measure ethical aspects of modern biotechnology. Cronbach's coefficient was used to calculate the reliability of all dimensions. Table 2 shows, the standardised alpha coefficients of all dimensions were acceptable (De Vellis, 1991).

Table 3. Factor loadings and Cronbach's alpha values of general ethical aspects.

Dimensions and item	Factor loading	Corrected item-total correlation	Alpha if item deleted	α
The need for labelling				0.85
Labelling is producer's responsibility	0.82	0.62	0.84	
Labelling to differentiate GM and non-GM products	0.82	0.75	0.78	
Labelling to give information	0.76	0.78	0.77	
Labelling important for allergic people	0.71	0.62	0.84	
Risks to human health				0.84
Babies may become premature	0.81	0.64	0.81	
Increase human fatality	0.77	0.59	0.83	
Give rise to unknown diseases	0.76	0.69	0.80	
Produce antibiotic resistant bacteria	0.65	0.66	0.81	
May cause the transfer of animal disease to human	0.60	0.66	0.81	
Threaten natural order of things				0.77
Modification considered over the limit	0.81	0.58	0.71	
Cross the natural boundaries between different species	0.80	0.70	0.67	
Interfere with the living organism natural integrity	0.79	0.66	0.68	
Modern biotechnology considered as blasphemy	0.66	0.42	0.77	
Reduce the economic value of living organism	0.48	0.36	0.79	
Human rights to modify living things				
Human has the right to modify living thing	0.79	0.48	0.52	0.64
If animal do not feel pain, human can modify their genetics makeup	0.68	0.39	0.59	
The use of animals is appropriate	0.64	0.50	0.51	
Has the ability to cure inherited disease	0.50	0.32	0.63	
Monopoly				0.76
Product market dominated by giant companies	0.76	0.59	0.69	
May cause economy divide	0.75	0.63	0.68	
Bring increase in bioterrorism	0.73	0.53	0.71	
Developed countries monopoly the global market	0.70	0.61	0.69	
Equal status between non-living and living organisms	0.40	0.32	0.80	
Patenting rights				0.76
Patent needed to protect scientist IP rights	0.86	0.63	0.62	
Industry encouraged to patent their innovation	0.76	0.62	0.63	
IP to cover developmental cost by industry	0.70	0.64	0.63	
Human status more superior than animal/plant	0.41	0.31	0.82	
Confidence on regulation				0.65
Regulation adequate	0.77	0.49	0.50	
Efficient monitoring by Govt dept	0.75	0.42	0.60	
Regulatory action on GMOs failure adequate	0.58	0.46	0.55	

Ethical perception of modern biotechnology

Overall, the Klang Valley public perceived modern biotechnology as not very threatening to the natural order of things (mean score 3.76) and recognised the high benefits that modern biotechnology could provide to society

Table 4. Ethical perception of modern biotechnology.

Dimension	Mean score ± Standard deviation	Interpretation
Threatening the natural order of things	3.76 ± 1.14	Moderate
Risks to human health	4.59 ± 1.11	Moderate
Human rights to modify living things	3.55 ± 1.18	Moderate
Monopoly by giant companies and developed countries	5.05 ± 1.02	High
The need for proper and appropriate labelling	5.70 ± 1.20	High
Perceived benefits	5.31 ± 1.17	High
Confidence on government regulation towards GMO	4.09 ± 1.11	Moderate

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

(mean score 5.31) (Table 4). However, they also stressed that humans do not have the absolute right to modify living things (mean score 3.55), whilst they perceived modern biotechnology as moderately risky (mean score 4.59) and expressed a high degree of concern that the global market of modern biotechnology is being monopolised by large companies and developed countries (mean score of 5.05). The respondents exhibited only moderate confidence in government regulation (mean score 4.09) and expressed a high level of need for the proper labelling of modern biotechnology products (mean score of 5.70).

Perception across age groups

Respondents from all age groups perceived modern biotechnology as not very threatening to the natural order of things (mean scores below the mid-point value of 4.0) and they perceived that modern biotechnology has high potential benefits to society (mean score above 5.0). However, they also expressed that humans do not have the absolute right to modify living things for their own benefit (mean scores below the mid-point value of 4.0), they rated modern biotechnology as moderately risky to human health (mean score above the mid-point value of 4.0) and they perceived the technology as being highly monopolised by giant companies and developed countries (mean score above 5.0). They considered modern biotechnology as having a high need for proper and appropriate labelling (mean score above 5.0). With regard to regulation, the youth respondents (18 to 25 and 26 to 40 years) were moderately confident in government regulation of GMOs (mean score above the mid-point value of 4.0) (Table 5) but the adults (41 years and above) thought otherwise (mean-score below the mid-point value of 4). ANOVA showed significant differences in the ranking of humans having the right to modify living things and confidence in regulation by the respondents across ages ($F = 8.36$, $p < 0.001$). The post hoc test confirmed that the youth respondents (18 to 25 and 26 to 40 years) felt that humans have more rights to modify living things and were more confident in government regulation of GMOs compared to the adults (41 years and above). Grobe et al. (1999) also reported that perceived risk tended to increase with age.

Ethical perception across educational levels

Irrespective of educational level, all respondents perceived modern biotechnology as not very threatening to the natural order of things (mean scores below the mid-point value of 4.0) and that it has substantial potential benefits to society (mean score about 5.0 and above). However, they felt that humans do not have the absolute right to modify living things for their own benefit (mean scores below the mid-point value of 4.0), they ranked modern biotechnology as moderately risky to human health (mean score above the mid-point value of 4.0) and they considered modern biotechnology as having a high need for proper and appropriate labelling (mean score above 5.0). They also claimed to be moderately confident in government regulation of GMOs (mean score above the mid-point value of 4.0) (Table 6). ANOVA were significant for the factor monopoly by giant companies and developed countries ($F = 5.88$, $p < 0.01$), the need for proper and appropriate labelling ($F = 6.17$, $p < 0.01$), and perceived benefits ($F = 9.61$, $p < 0.001$). Furthermore, the post hoc tests confirmed that the respondents with a tertiary level of education rated modern biotechnology as having more potential benefits but at the same time believed that modern biotechnology needs more proper and appropriate labelling than those with lower levels of education. They also considered the monopoly level of modern biotechnology products by giant companies and developed countries as significantly lower than those with a diploma or pre-university level of education. Tucker et al. (2006) found that respondents with higher levels of education tended to perceive lower levels of perceived risk. The positive effect of a higher education level could be due to more exposure to the culture and power of science as suggested by Priest (2000).

Table 5. Ethical perception of modern biotechnology across age groups.

Variable	Mean score ± Standard deviation	Interpretation
Threatening the natural order of things		
18 - 25 years	3.76 ± 1.03	Moderate
26 - 40 years	3.72 ± 1.24	Moderate
≥ 41 years	3.82 ± 1.21	Moderate
Risks to human health		
18 - 25 years	4.59 ± 0.91	Moderate
26 - 40 years	4.52 ± 1.18	Moderate
≥ 41 years	4.74 ± 1.38	Moderate
Human rights to modify living things		
18 - 25 years	3.46 ± 1.09	Moderate
26 - 40 years	3.83 ± 1.18	Moderate
≥ 41 years	3.21 ± 1.33	Moderate
Monopoly by giant companies and developed countries		
18 - 25 years	5.01 ± 0.94	High
26 - 40 years	5.07 ± 0.93	High
≥ 41 years	5.14 ± 1.34	High
The need for proper and appropriate labelling		
18 - 25 years	5.73 ± 1.13	High
26 - 40 years	5.65 ± 1.10	High
≥ 41 years	5.73 ± 1.54	High
Perceived benefits		
18 - 25 years	5.31 ± 1.07	High
26 - 40 years	5.34 ± 1.08	High
≥ 41 years	5.24 ± 1.57	High
Confidence on government regulation towards GMO		
18 - 25 years	4.18 ± 0.96	Moderate
26 - 40 years	4.18 ± 1.12	Moderate
≥ 41 years	3.66 ± 1.34	Moderate

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

Ethical perception across religion

Respondents from all religions expressed that humans do not have the absolute right to modify living things for their own benefit (mean score below the mid-point value of 4.0) (Table 3), whilst they were moderately concerned about the possible risks associated with modern biotechnology (mean score above the mid-point value of 4.0), and stressed the high need for the proper labelling of modern biotechnology products (mean score of above 5.0). The Muslim, Buddhist and Hindu respondents perceived modern biotechnology as less threatening to the natural order of things (mean score below the mid-point value of 4.0) compared to the Christian respondents who thought otherwise (mean score above the mid-point value of 4.0) (Table 7). The Christian respondents were also more worried about the possible risks of modern biotechnology to human health and had the least confidence in government regulation of GMOs, compared to the Muslim, Buddhist and Hindu respondents. ANOVAs were significant for the comparison of the factors across religions, such as: threatening the natural order of things ($F = 2.69$, $p < 0.05$); perceived risks ($F = 3.42$, $p < 0.05$); and confidence ($F = 387$, $p < 0.01$). Post hoc tests confirmed the significant differences in the opinions of the Christians compared to the Hindus with regards to per-

Table 6. Ethical perception of modern biotechnology across educational level.

Variable	Mean score ± standard deviation	Interpretation
Threatening the natural order of things		
Secondary	3.77 ± 1.04	Moderate
Diploma/pre-university	3.74 ± 1.21	Moderate
University	3.84 ± 0.99	Moderate
Risks to human health		
Secondary	4.56 ± 1.04	Moderate
Diploma/pre-university	4.65 ± 1.11	Moderate
University	4.38 ± 1.20	Moderate
Human rights to modify living things		
Secondary	3.41 ± 1.14	Moderate
Diploma/pre-university	3.58 ± 1.20	Moderate
University	3.64 ± 1.21	Moderate
Monopoly by giant companies and developed countries		
Secondary	4.95 ± 1.09	Moderate
Diploma/pre-university	5.17 ± 0.98	High
University	4.70 ± 0.99	Moderate
The need for proper and appropriate labelling		
Secondary	5.39 ± 1.32	High
Diploma/pre-university	5.50 ± 1.21	High
University	5.86 ± 1.12	High
Perceived benefits		
Secondary	5.01 ± 1.31	High
Diploma/pre-university	4.99 ± 1.10	Moderate
University	5.50 ± 1.13	High
Confidence on government regulation towards GMO		
Secondary	4.24 ± 1.06	Moderate
Diploma/pre-university	4.24 ± 1.07	Moderate
University	4.00 ± 1.12	Moderate

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

ceived risks and confidence. With regard to monopoly, Muslims, Hindus and Christians perceived modern biotechnology as being highly monopolised by giant companies and developed countries, while the rating of the Buddhists was moderate. ANOVA showed significant differences in monopoly across religion but post hoc tests could not detect specific differences.

Differences in some dimensions of ethical perception across religions are supported by earlier theory and studies. According to the cultural approach of risk research, the evaluative process of risk perception is determined by the norms, value systems and cultural idiosyncrasies of societies or societal groups (Rohrmann, 1994). Macer et al. (2000) also noticed that there was diversity of opinion and reasoning across different cultures.

Ethical perception across races

All respondents from various major races in Malaysia (Malay, Chinese and Indian) agreed that modern biotechnology was not very threatening to the natural order of things (mean score below the mid-point value of 4.0) but at the same time they expressed that humans do not have the absolute right to modify living things for their own benefit (mean score below the mid-point value of 4.0) (Table 8). They also expressed moderate concerns

Table 7. Ethical perception of modern biotechnology across religion.

Variable	Mean score ± standard deviation	Interpretation
Threatening the natural order of things		
Islam	3.66 ± 1.18	Moderate
Buddha	3.88 ± 0.90	Moderate
Hindu	3.80 ± 1.03	Moderate
Christian	4.12 ± 1.24	Moderate
Risks to human health		
Islam	4.61 ± 1.08	Moderate
Buddha	4.70 ± 1.06	Moderate
Hindu	4.27 ± 1.13	Moderate
Christian	4.92 ± 1.11	Moderate
Human rights to modify living things		
Islam	3.61 ± 1.13	Moderate
Buddha	3.54 ± 1.35	Moderate
Hindu	3.62 ± 1.15	Moderate
Christian	3.13 ± 1.30	Moderate
Monopoly by giant companies and developed countries		
Islam	5.02 ± 1.02	High
Buddha	4.82 ± 0.89	Moderate
Hindu	5.29 ± 1.10	High
Christian	5.24 ± 1.02	High
The need for proper and appropriate labelling		
Islam	5.73 ± 1.18	High
Buddha	5.44 ± 1.24	High
Hindu	5.61 ± 1.32	High
Christian	5.99 ± 0.95	High
Perceived benefits		
Islam	5.41 ± 1.07	High
Buddha	5.01 ± 1.16	High
Hindu	5.27 ± 1.29	High
Christian	5.22 ± 1.48	High
Confidence on government regulation towards GMO		
Islam	4.12 ± 1.01	Moderate
Buddha	3.92 ± 1.13	Moderate
Hindu	4.39 ± 1.25	Moderate
Christian	3.74 ± 1.19	Moderate

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

on the possible risks associated with modern biotechnology (mean score above the mid-point value of 4.0), were worried about the possibility of the global market of modern biotechnology being monopolised by big companies and developed countries (mean score about 5.0 and above) and stressed the high need for the proper labelling of modern biotechnology products (mean score above 5.0). With respect to confidence, the respondents exhibited only moderate confidence in government regulations (mean score about the mid-point value of 4.0). They also considered modern biotechnology as having high benefits to society (mean score above 5.0).

Table 8. Ethical perception of modern biotechnology across races.

Variable	Mean score ± standard deviation	Interpretation
Threatening the natural order of things		
Malay	3.65 ± 1.19	Moderate
Chinese	3.92 ± 1.02	Moderate
Indian	3.84 ± 1.03	Moderate
Risks to human health		
Malay	4.60 ± 1.08	Moderate
Chinese	4.63 ± 1.11	Moderate
Indian	4.46 ± 1.21	Moderate
Human rights to modify living things		
Malay	3.60 ± 1.13	Moderate
Chinese	3.42 ± 1.28	Moderate
Indian	3.49 ± 1.24	Moderate
Monopoly by giant companies and developed countries		
Malay	5.02 ± 1.02	High
Chinese	4.97 ± 1.00	Moderate
Indian	5.24 ± 1.08	High
The need for proper and appropriate labelling		
Malay	5.73 ± 1.19	High
Chinese	5.61 ± 1.26	High
Indian	5.62 ± 1.26	High
Perceived benefits		
Malay	5.42 ± 1.07	High
Chinese	5.09 ± 1.12	High
Indian	5.11 ± 1.52	High
Confidence on government regulation towards GMO		
Malay	4.12 ± 1.02	Moderate
Chinese	3.84 ± 1.17	Moderate
Indian	4.17 ± 1.34	Moderate

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

ANOVA showed significant differences for perceived benefits across races ($F = 3.61$, $p < 0.05$), but post hoc tests could not detect any specific differences.

Differences in ethical perception towards modern biotechnology across races is not surprising as Tucker et al. (2006) reported that white respondents tended to perceive lower levels of perceived food risks compared to non-white respondents.

Perception across gender

Gender has been strongly associated with risk judgement and attitude (Slovic, 2004). Many studies have found that men tend to judge risks as smaller and as less problematic than women (Brody, 1984; De Joy, 1992; Sjoberg and Drotz-Sjoberg, 1994). Hossain et al. (2002), and Chern and Rikertsen (2002) found no effect of gender on the acceptance of GM food while Lin et al. (2004) found a low impact of gender on only one biotech product (livestock products fed with biotech corn) but no effect of gender on the other three GM products surveyed (GM soybean oil, input-trait GM rice and neutraceutical GM rice). In this study, both male and female respondents were in agreement that modern biotechnology was not very threatening to the natural order of things (mean score below the mid-point value of 4.0) and modern biotechnology was perceived as having high potential

Table 9. Ethical perception of modern biotechnology across gender.

Variable	Mean score ± Standard deviation	t-test	Significant
Threatening the natural order of things			
Male	3.81 ± 1.20	0.711	0.478
Female	3.73 ± 1.10		
Risks to human health			
Male	4.64 ± 1.23	0.707	0.480
Female	4.56 ± 1.03		
Human rights to modify living things			
Male	3.53 ± 1.29	0.218	0.828
Female	3.56 ± 1.12		
Monopoly by giant companies and developed countries			
Male	5.11 ± 1.13	0.965	0.335
Female	5.01 ± 0.94		
The need for proper and appropriate labelling			
Male	5.63 ± 1.28	0.861	0.390
Female	5.74 ± 1.15		
Perceived benefits			
Male	5.29 ± 1.29	0.222	0.824
Female	5.32 ± 1.10		
Confidence on government regulation towards GMO			
Male	3.89 ± 1.27	2.798	0.003**
Female	4.21 ± 0.98		

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

benefits to Malaysian society (mean score above 5.0). However modern biotechnology was also considered as moderately risky to human health (mean score above the mid-point score of 4.0), highly monopolised by giant companies and developed countries (mean score above 5.0) which in turn called for the high need of modern biotechnology products to be properly and appropriately labelled (mean score above 5.0). Meanwhile, female respondents had higher confidence in government regulation of GMOs (Table 9). The t-test was significant for confidence in government regulation of GMOs across gender ($t = 2.798$, $p < 0.01$) (Table 9).

DISCUSSION

The Klang Valley public expressed that humans do not have the absolute right to modify living things for their own benefit (mean score 3.55). Batalion (1999) has highlighted that the central problem underlying 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. Many religions do not allow unrestricted interference with life, such as genetic engineering (Epstein, 1998). There are principles or guidelines on how should we live and what is the right in most religions. The majority of the respondents in this study were Muslims. In Islam, scientific research is encouraged in order to understand natural phenomena and the universe, and to observe the signs of Allah’s glory and, ultimately, to find the truth (Hajj, 2001). However, not everything that is applicable is necessarily applicable, it is important to fully consider the purpose of any actions and their harmful effects towards humans, the environment and society, and the actions must be in line with the rules of Shari’ah (Islamic Fiqh Academy, 2000; Hajj, 2000).

The respondents in this study also showed moderate concerns of the possible risks associated with modern biotechnology (mean score 4.59). The Malaysian public is not isolated. Their concerns about modern biotechnology have been echoed by people worldwide. Europeans

(Gaskel et al., 2000, 2003, 2010; Costa-Font and Gil, 2009), Americans (Priest, 2000), Canadians (Einseidel, 1997), as well as Asians (Macer et al., 2000), have been reported as showing different degrees of concern towards various applications of modern biotechnology.

The Malaysian public centred within the Klang Valley region also expressed a high degree of concern about the global market of modern biotechnology being monopolised by big companies and developed countries (with a higher mean score of 5.05). Quaye et al. (2009) reported that the public who were concerned about GM products in Ghana believed that GM products will only benefit big multinational companies, and that this was combined with a lack of public trust in their government. Uzogara (2000) has highlighted the possibility that patenting might allow big corporations to monopolise GM plants and animals, beside the fact that patenting is said to violate the sanctity of life. Many critics also oppose the fact that seeds are now regarded as propriety products, moreover with the 'terminator gene' technology which renders the seeds sterile (Koch, 1998). The farmers are forced to buy new seeds each year from multinational companies instead of sowing seeds from previous years' harvests.

The Malaysian public in the Klang Valley region were open-minded people. Even though they acknowledged that there are risks associated with modern biotechnology, they did not perceive modern biotechnology as very threatening to the natural order of things (mean score 3.76, below the mid-point value of 4.0) and they recognised the high benefits that modern biotechnology could provide to society (mean score 5.31). Modern biotechnology has the potential to be accepted by the Malaysians. European public opinion showed that the rejection of GM foods was not so much the perception of risks but rather the perceived absence of benefit for consumers (Gaskell et al., 2004). This was particularly true in the "sceptical" group (who perceive GM foods as risky and not useful) who made up the majority of the Europeans' sample (60%). As for the "trade-off" group (who perceive GM foods as both useful and risky), the respondents looked at the perceived benefits first, before considering the risks. Looking across the globe, a high number of Americans (69%) perceived GM foods as useful compared to 46% in Europe, which again relates to a higher acceptance of GM foods in the US.

The respondents in this study exhibited moderate confidence in government regulation (mean score 4.09) and expressed a high level of need for the proper labelling of modern biotechnology products (mean score of 5.70). So it is important that the related government bodies play their expected role in providing regulation and safety protection. The suggestion by Wansink and Kim (2001) that, the government be responsible in setting the direction and pace of development to prevent questionable or premature commercialisation of biotechnology applications/products is highly recommended to the Malaysian government regulatory agencies. The public expression of the necessity for labelling of modern biotechnology applications/products should be heeded by the industries. Although, the main function of labels is to provide information, labelling may also function as an indication of product safety (Wansink and Kim, 2001). Although some consumers may use the labelling to avoid biotechnology products, others may perceive the explicit labelling as a sign of the manufacturers' confidence in a product's safety. Wansink and Kim (2001) highlighted the importance of providing consumers with a sense of control over their choices. When their confusion about what and how to choose diminishes, consumers will be more comfortable and confident in accepting biotechnology.

The empirical results of this study also indicate that background variables such as religion, race, age, education level and gender have a significant effect on some of the dimensions of the Malaysians' ethical perception towards modern biotechnology. These differences should be taken into consideration constructively rather than negatively. More in-depth empirical studies should be carried out to understand the underlying causes behind the differences so that appropriate measures can be confidently introduced to address the issues on what is lacking and what needs further improvement.

Conclusion

The Malaysians in the Klang Valley region are open-minded people. They recognised the potential benefits of modern biotechnology and did not see it as totally against nature. However, they expressed their concerns that humans do not have the absolute right to modify living things and called for the need for proper and appropriate labelling of modern biotechnology products. They were also concerned about the associated risks to human health and the possibility of market monopoly by giant companies and developed countries. So, it is important that the related government bodies play their expected role in providing regulation and safety protection to increase the public's confidence in them. More in-depth study is needed to evaluate the ethical acceptance of specific applications of modern biotechnology, especially those involving inter-species gene transfers in Malaysia. The empirical results of this study also indicate that background variables such as religion, race, age, education level and gender have a significant effect on some of the dimensions of the Malaysians' ethical perception of modern biotechnology. These differences should be taken into consideration constructively rather than negatively. The research findings are useful for understanding the social construct of the ethical acceptance of modern biotechnology in a developing country.

ACKNOWLEDGEMENTS

The authors would like to thank Universiti Kebangsaan Malaysia for supporting this research under the UKM-AP-CMNB-21-2009/1 grant.

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