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Full Length Research Paper

Awareness and knowledge on modern biotechnology

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Biotechnology has been considered as a very important industry in helping Malaysia to achieve its goal of becoming a highly industrialized nation by 2020. Thus, assessment of people's knowledge and awareness on biotechnology is very important and according to a theory on decision making, people only form attitudes about technologies when they have acquired relevant information. The purpose of this paper is to study the awareness and knowledge level of the Malaysia public in the Klang Valley region and to compare their awareness and knowledge level across stakeholder groups. 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, NGOs, media, religious scholars, university students and consumers. Results of the survey showed that overall mean score for awareness and knowledge on modern biotechnology were moderate. ANOVAs showed significant differences in awareness on modern biotechnology across several background variables such as stakeholders' group and educational level. Knowledge level differed significantly across stakeholder groups, educational level, religion, races, age groups and gender. The research findings serve as a useful database for understanding the level of awareness among the public in developing country.

Key words: Awareness, knowledge, engagement, modern biotechnology, Malaysia.

INTRODUCTION

Modern biotechnology has expanded rapidly around the world especially in developing countries through the application of these techniques in the fields of medicine, pharmaceuticals, agriculture and livestock and industrial (James, 2009; Rosenberg-Yunger et al., 2008; Walsh, 2004). Most developing countries have been able to produce and commercialize biotechnology products to the world markets. Public perceptions of biotechnology have received extensive attention in recent years in most Western countries. There have been numerous surveys on public perceptions of biotechnology in Europe, USA and Canada (Gaskel et al., 2003; Kamaldeen and Powell, 2000) but there have been few similar studies in developing country. General consumer awareness towards biotechnology varies according to countries and type of biotechnology applications or questions asked.

It is important to assess people's knowledge or awareness on modern biotechnology as according to a theory on decision making (Kelly, 1995), people only form attitudes about technologies after they have acquired relevant information. Some researchers hold that more knowledge makes people more sympathetic to genetic engineering while other researchers proposed the opposite effect. Understanding has also been cited by Covello and Merkhofer (1994), as one of the factors modulating risk perception. According to Barling et al. (1999), perception of risk is higher amongst those with greater objective knowledge and those who have discussed bio-

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Abbreviations: GMOs, Genetically modified organisms; **NGOs**, non-governmental organization; **GMF**, genetically modified food; **MABIC**, Malaysian Biotechnology Information Centre.

technology over recent months, but such perception is low amongst those with little knowledge.

Most studies around the world show that public awareness is in line with the development of modern biotechnology. According to McCann Erickson (2000), consumers in the United States, Canada and Southern Europe have a high level of awareness, but users in Southeast Asia, Asia and Latin America have low levels of awareness. The public at large are aware of the modern biotechnology development with 80% of respondents in the United Kingdom have heard of cloning and organ transplant (Xeno-transplantation), while 70% of them have heard of GMF and genetic testing (genetic testing) (Gaskell et. al., 2003), 96% of teachers of geography in Turkey (Demirci, 2008), 90% of respondents in the Swedish (Hursti et al., 2002), 75% of students and 18% of non- students in Iran (Sheikhha et al., 2006), 70% of respondents in Italy (Soregaroli et al., 2003), 67% (23% always and 44% at times) than consumers who live in urban areas in China (Huang et al., 2006) and 46% of respondents in Kenya (Kimenju et al., 2005) stated that they had heard of modern biotechnology.

Modern biotechnology has been given priority by the Malaysian government to spearhead the country's economy and modern biotechnology products from other countries are slowly coming in. The future development and commercialization of modern biotechnology products in Malaysia depends heavily on public acceptance. If consumer acceptance issues are not adequately addressed, then the potential economic and social benefits of modern biotechnology may not be realized. In Malaysia, a study conducted by MASTIC (Centre for Science and Technology Information) shows the level of public awareness about modern biotechnology, especially genetic engineering is increasing. In 1996, only 17% of the general public had heard of genetic engineering. The level of public awareness increased to 33.8% in 1998 and 42.4% in 2000 (MASTIC, 2005). Studies conducted subsequently indicated that more than half of respondents (56.1%) had heard of genetic engineering by 2004 (MASTIC, 2005). However, 56.1% of the general public who had heard of genetic engineering, only 15.8% agreed that genetic engineering should be carried out in Malaysia, while 47.4% thought otherwise. 36.8% of Malaysia is not sure whether to apply the genetic engineering of organisms (MASTIC, 2005). Another study by Latifah et al. (2007) showed a low level of awareness (3.88 out of total mean score of 9.0) and moderate level of knowledge (4.70 out of total mean score of 9.0) among the Malaysian stakeholders in the Klang Valley region. Significant advancements in modern biotechnology in Malaysia and worldwide have happened since then. Information on modern biotechnology has also been made more available to the public through the internet as well as periodic coverage of modern biotechnology issues in the Malaysian general media. Malaysian Biotechnology Information Centre (MABIC) has also made an effort to provide on-line information on modern biotechnology issues and development in Malaysia and provide linkage to several international website on modern biotechnology education besides organizing public seminars in Malaysia (MABIC, 2002). It is expected that the level of awareness on modern biotechnology issues should have been increased in the last few years. So there is a need to assess the current level of awareness and knowledge of the Malaysian public towards modern biotechnology. The objective of this paper is to assess the level awareness and knowledge of modern biotechnology among the Malaysian public in the Klang Valley region and to compare their awareness and knowledge level across several demographic variables.

MATERIALS AND METHODS

The research data was collected by means of a face to face survey of adult (age 18 years old and above) stakeholders who are residing in Klang Valley region. The questionnaires were administered face to face to 434 adult respondents (age 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 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 but this technique would enable the inclusion of respondents from different stakeholders group that might otherwise be underrepresented if random sampling were used. 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). Taking into account that this study was quantitative, the minimum sample size required for each statistical analysis was considered. Comparison of attitude across stakeholders (11 groups) was to be carried out using ANOVA. In order to have 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 stakeholders 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 1). 38% of the respondents were male, 62% female, age ranging from 17 to 64 years old, 13.6% of the respondents had at least secondary level of education, 23.5% had pre-university education or diploma holders while the remaining 62.9% had tertiary level of education (degree and above) (Table 2). Majority of the stakeholders' (except the consumers, religious scholars and university students) possess at least tertiary level of education which resulted in 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).

According to Nassar-McMillan and Borders (2002), an important step in developing a questionnaire lies in the construction of items and its details. There are two methods to identify the appropriate items that can be used in the study, first, by the literature review of professionals (Jaeger, 1984) and second, by obtaining feedbacks from individuals who are related to the field of study (Loesch and Vacc, 1993). The instrument to measure awareness and knowledge in this study was constructed based on the work of earlier researches. For the knowledge scale, the respondents were asked whether the nine statements regarding concepts and facts about biotechnology were true or false (Gaskell et al., 2000) with the

Table 1. Operational definitions of the stakeholders.

Stakeholder	Definition
Producers	Officers who have a company or organization related to food, agriculture and pharmaceuticals. Company or organization 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 (R and D) of biotechnology or science.
Policy makers	Individuals from organizations 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 NGOs	Individuals who represent organizations 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 science background, especially biology.
Muslim scholars	Officials of the Islamic organizations.
Buddhist scholars	Officials of the Buddhist organizations.
Christian scholars	Officials of the Christian organizations.
Hindu scholars	Officials of the Hindu organizations.
Consumers	Individuals who often visit the supermarket to get daily necessities.

NGOs, non-governmental organizations.

omission of item one, “it is impossible to transfer animal genes into plants”. Item one was replaced with “there are useful bacteria which live in our body” while item six was slightly modified where the term “beer” from the original question “yeast for brewing beer consists of living organisms” was changed to “bread” to suit local culture where most of the respondents are Muslims and therefore do not drink beer. As for awareness, the concept used by Gaskel et al. (2000) was followed where the respondents were asked whether they had heard of seven applications of modern biotechnology and two related developments in Malaysia. The instrument has been pre-tested in the pilot study and considered to have an acceptable validity. The alpha value for awareness is 0.75 while knowledge is 0.66.

The SPSS 14.0 software was used for data analysis. T-test was carried out to see the differences in the mean value for perception between genders while the differences in mean for awareness and knowledge across respondents of different ages, educational level, religion, and race and stakeholders groups were determined by Analysis of Variance (ANOVA).

RESULTS

Comparison across stakeholders

Table 3 below shows the level of awareness and knowledge of modern biotechnology across stakeholder groups. Overall, the level of awareness and knowledge are classified as moderate with mean scores of 5.06 and 5.31, respectively. Comparing across stakeholder groups, only two stakeholder groups, the policy makers and university students were found to have high level of awareness. Although, both stakeholders have high level of awareness, their levels of knowledge about modern biotechnology are classified as moderate. This is different from the Christian scholars who have a moderate level of awareness, but have a high level of knowledge. The rest of the stakeholder groups, such as the producers, scientists, NGOs, media, Muslim scholars, Buddhist scholars, Hindu scholars and consumers have moderate level of awareness and knowledge. Among the eight stakeholder groups, Islamic scholars group has the lowest mean score which is lower than the midpoint value of 4.5. The ANOVA tests show that there is a significant difference in the mean score among the stakeholder groups’ level of awareness on modern biotechnology ($F = 5.87$, $p < 0.00$) (Table 4). The Post-Hoc tests confirm that, the policy makers and university students have significantly high level of awareness compared to the media and Muslim scholars. The policy makers group also has a higher level of awareness compared to the Buddhist scholars. Four groups of stakeholders, the NGO, producers, consumers and Buddhist scholars also have a higher level of awareness compared with Muslim scholars.

ANOVA was significant for the comparison of knowledge across stakeholder groups ($F = 6.43$, $p < 0.001$) (Table 4). The Post Hoc test confirmed that the Christian scholars have a higher level of knowledge when compared the policy makers, producers, Buddhist scholars, university students, Hindu scholars, consumers and scientists. These eight stakeholder groups also have a significant higher level of knowledge than the Muslim scholars.

Comparison across educational level

All respondents from the three educational levels (secondary school, diploma/pre-university, and university) were found to have moderate level of awareness and knowledge on modern biotechnology (Table 5). ANOVAs

Table 2. 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

were significant for the comparison of awareness ($F = 3.36$, $p < 0.05$) as well as knowledge level ($F = 16.72$, $p < 0.001$) across educational levels (Table 6). The Post-Hoc test proved that the respondents with a higher educational level do have a higher knowledge level on modern biotechnology. University students were found to have significantly higher knowledge level compared to the respondents from secondary schools and diploma/pre-university level of education. As for awareness, post hoc test could not detect specific differences across educational level.

Comparison across religions

All respondents from the four major religions in Malaysia

Table 3. The level of awareness and knowledge about modern biotechnology across stakeholder groups.

Stakeholder	Awareness		Knowledge	
	Mean score ± std dev.	Interpretation	Mean score ± std dev.	Interpretation
Producers	5.16 ± 2.06	Moderate	5.16 ± 2.06	Moderate
Scientists	5.06 ± 2.48	Moderate	5.16 ± 2.06	Moderate
Policy makers	6.18 ± 1.59	High	5.16 ± 2.06	Moderate
NGO	5.39 ± 2.51	Moderate	5.16 ± 2.06	Moderate
Media	4.10 ± 2.41	Moderate	5.16 ± 2.06	Moderate
University students	6.09 ± 1.94	High	5.16 ± 2.06	Moderate
Muslim scholars	3.26 ± 2.41	Moderate	5.16 ± 2.06	Moderate
Buddhist scholars	5.00 ± 1.34	Moderate	5.16 ± 2.06	Moderate
Christian scholars	4.91 ± 2.08	Moderate	6.03 ± 2.06	High
Hindu scholars	5.12 ± 2.52	Moderate	5.16 ± 2.06	Moderate
Consumers	5.15 ± 2.06	Moderate	5.16 ± 2.06	Moderate
Overall	5.06 ± 2.25	Moderate	5.16 ± 2.06	Moderate

*0 - 2.99, low; 3.00 - 6.00, moderate; 6.01 - 9.00, high; std dev., standard deviation.

Table 4. One-way ANOVA to compare awareness and knowledge on modern biotechnology across stakeholders.

Variable	F-value	Significance
Awareness	5.87	0.000***
Knowledge	6.43	0.000***

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

Table 5. Awareness and knowledge across educational level.

Variable	Mean score ± Standard deviation	Interpretation
Awareness		
Secondary school	4.61 ± 1.88	Moderate
Diploma/Pre-university	4.74 ± 2.26	Moderate
University	5.27 ± 2.30	Moderate
Knowledge level		
Secondary school	4.16 ± 1.79	Moderate
Diploma/pre-university	4.90 ± 1.94	Moderate
University	5.73 ± 1.23	Moderate

Table 6. One-way ANOVA to compare awareness and knowledge level on modern biotechnology across educational level.

Variable	F-value	Significance
Awareness	3.36	0.036*
Knowledge	16.72	0.000***

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

(Muslim, Buddhist, Hindu, and Christian), not only have a moderate level of awareness about modern biotechnology, but also moderate level of knowledge (Table 7). ANOVA was only significant for the comparison of knowledge ($F = 2.98$, $p < 0.05$) (Table 8) across religion but not awareness. However, post hoc test could not detect any specific differences for the comparison of knowledge across religion.

Table 7. Awareness and knowledge across religion.

Variable	Mean score ± std dev.	Interpretation
Awareness		
Islam	4.96 ± 2.33	Moderate
Buddha	5.19 ± 1.62	Moderate
Hindu	5.50 ± 2.39	Moderate
Christian	4.77 ± 2.25	Moderate
Knowledge level		
Islam	5.06 ± 2.06	Moderate
Buddha	5.69 ± 2.48	Moderate
Hindu	5.52 ± 2.05	Moderate
Christian	5.83 ± 2.06	Moderate

Std dev., Standard deviation.

Table 8. Awareness and knowledge on modern biotechnology across races.

Variable	Mean score ± std dev.	Interpretation
Awareness		
Malay	4.92 ± 2.32	Moderate
Chinese	5.13 ± 1.72	Moderate
Indian	5.39 ± 2.41	Moderate
Knowledge level		
Malay	5.05 ± 2.06	Moderate
Chinese	6.08 ± 2.30	Moderate
Indian	5.36 ± 2.04	Moderate

Std dev., Standard deviation.

Table 9. One-way ANOVA to compare awareness and knowledge level on modern biotechnology across races.

Variable	F-value	Significance
Awareness	1.32	0.268
Knowledge	7.11	0.001**

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

Comparison across races

Table 8 shows that the Malay and Indian respondents have moderate level of awareness and knowledge on modern biotechnology. The Chinese respondents also have a moderate level of awareness despite having a high level of knowledge on modern biotechnology. ANOVA was significant for the comparison of knowledge across races ($F = 7.11$, $p < 0.01$) (Table 9) but not awareness. Post Hoc test proved that the Chinese respondents have higher level of knowledge on modern biotechnology compared to the Malay respondents.

Comparisons across age groups

All the respondents from age 18 and above have moderate level of awareness and knowledge on modern biotechnology (Table 10). The youngest group of respondents (aged 18 to 25 years), seemed to have the highest level of awareness and knowledge compared to the older respondents. ANOVA showed that both the level of awareness ($F = 8.18$, $p < 0.001$) and knowledge ($F = 4.80$, $p < 0.01$) were significant across age groups (Table 11). Post hoc tests proved that the youth respondents in the 18 to 25 year age range had a higher level of awareness of modern biotechnology as compared to youth in the age range of 26 to 40 years and adults (41 years and above). Post hoc tests also showed that youths aged 18 to 25 years had higher knowledge than the adults (41 years and above).

Comparisons across gender

The female respondents showed higher level of awareness and knowledge than the male respondents (Table 12). ANOVA was significant for the comparison of knowledge across gender ($t = 2:33$, $p < 0.05$) (Table 12) but not awareness. The female were more knowledgeable on modern biotechnology issues as compared to the males.

DISCUSSION

This study showed that the level of awareness of stakeholders in the Klang Valley is moderate with an overall mean score of 5.06. It is quite interesting to note that there has been an increase in awareness level among the Klang Valley stakeholders in the year 2009 to 2010 as compared to the awareness level of the Klang Valley stakeholders in the last survey which was carried out in 2005 (mean score 3.88) (Latifah et al., 2007). The increase in awareness is likely to be closely related to the dissemination of modern biotechnology that could have increased from time to time with several efforts, such as by the MABIC to provide an open access online information on modern biotechnology (www.bic.org.my) besides efforts by the Biosafety Department of Malaysia to create public awareness through workshops.

Direct involvement of some stakeholders in the field of modern biotechnology is likely to contribute to their increase awareness on the development of modern biotechnology. The policy makers who are directly involved in the regulation of genetically modified organisms (GMOs) in Malaysia exhibited the highest level of awareness. The university students who probably have direct exposure on modern biotechnology issues through formal education would have contributed to their high awareness level. However, surprisingly the high level of awareness among the policy makers and university stu-

Table 10. Awareness and knowledge on modern biotechnology across age groups.

Variable	Mean score ± Standard deviation	Interpretation
Awareness		
18 - 25 years old	5.52 ± 2.02	Moderate
26 - 40 years old	4.64 ± 2.21	Moderate
≥ 41 years old	4.69 ± 2.65	Moderate
Knowledge level		
18 - 25 years old	5.56 ± 2.13	Moderate
26 - 40 years old	5.29 ± 0.27	Moderate
≥ 41 years old	4.69 ± 2.12	Moderate

Table 11. One-way ANOVA to compare awareness and knowledge level on modern biotechnology across age groups.

Variable	F-value	Significant
Awareness	1.32	0.268
Knowledge	7.11	0.001**

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

Table 12. Awareness and knowledge across gender.

Variable	Mean score ± Standard deviation	t-value	Significant
Awareness			
Male	4.82 ± 2.32	-1.68	0.094
Female	5.20 ± 2.20		
Knowledge			
Male	4.99 ± 2.35		
Female	5.50 ± 1.96	-2.33	0.021*

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

dents did not translate to high knowledge level.

On the other hand, the lowest level of awareness among the Muslim scholars on the development of modern biotechnology is probably due to their day to day focus was more on existing religious issues. However, more efforts by relevant bodies and professionals such as the media, government agencies related to biotechnology, academicians and research scientists should be geared to disseminate more information to the general public and religious expert groups on modern biotechnology concepts and issues through the general mass media, pamphlets or public forums. This is important to prepare the Malaysian public in facing the biotechnology era where they have to make informed decisions regarding modern biotechnology issues in their everyday lives. Modern biotechnology has been associated with being novel and complex making it not an easy subject to be understood by the non-biologists and lay people. There is a need to disseminate more information on modern biotechnology in simple term that can be understood by the Muslim Scholars as well as organizing open forums to discuss modern biotechnology issues. They are an important group of stakeholders in a country such as Malaysia where the major religion is Islam. People and the policy makers will consult them on issues of permissibility status of various modern biotechnology applications. Infective decision can only be made only if they have better understanding of modern biotechnology principles and issues.

The overall knowledge of the stakeholders in the Klang Valley was found to be moderate (mean score 5.31) which shows an increase from the knowledge level of the Klang Valley public in 2005 (mean score 4.70) (Latifah et al., 2007). For other countries, such as Italy, the study conducted by Soregaroli et al. (2003) showed that 65% of respondents know the meaning behind the acronym GMO. In addition, they also know that GMO refers to the transfer of foreign DNA into the organism. Februhartanty

et al. (2007) found that 70% of respondents had good knowledge about genetically modified food (GMF).

This study also shows that Christian scholars have a very high knowledge level on modern biotechnology. Respondents who are considered as students or university students have a higher knowledge on modern biotechnology compared to respondents with lower educational level. Thus, individuals with higher educational level most probably have a higher and better knowledge on modern biotechnology. It was also found that educational level and age also had significant impact on respondents' knowledge on modern biotechnology. The study found that university students were more knowledgeable on the development of biotechnology than respondents from diploma/pre-university and secondary school. The youngest group of respondents (aged: 18 to 25 years) also had a higher level of awareness than the respondents from the older age ranges. This may be because they are more likely to get extensive information resource and most of them are most likely are university students. Lorence et al. (2006) also found that education level was not related to health information seeking activity.

It is quite interesting that the female respondents in the Klang Valley were found to have significantly higher knowledge level than the males in this study. Past studies reported the opposite trend where men were found to possess more knowledge on scientific matters (Simon, 2010; von Roten, 2004). However, Moahi (1991) noted that women have been found to be knowledgeable in some substantive scientific areas.

Conclusion

Increased level of awareness and knowledge among the Malaysian stakeholders in the Klang Valley region as compared to an earlier study is a good indication that the effort by some sectors in Malaysia to increase public awareness is having an impact. However, more effort should be carried out to disseminate adequate information on modern biotechnology to the less aware and knowledgeable groups so that Malaysians irrespective of whom they are will be able to make inform decision on modern biotechnology issues. The empirical results of this study indicate that background variables do have significant effect on awareness and knowledge level of the Klang Valley stakeholders on modern biotechnology. These differences should be taken into consideration constructively rather than negatively by the government policy makers and regulators to understand the social construct of public attitude towards modern biotechnology. Demographic characteristics have been known to affect attitudes towards science (Connor and Siegrist, 2010). 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 needed further improvement.

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