



Assessment of the Awareness, Acceptance, and Willingness of Bahraini Public to Consume Genetically Modified Food

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Authors' contributions

This study was carried out in collaboration among all authors. Author SMZH designed the study, managed the literature searches and wrote the first draft of the manuscript. Author NS performed the statistical analysis and interpreted the data. Author EMAE edited the manuscript. Authors MMAH and NEA managed the questionnaire survey and gathered data. All authors read and approved the final manuscript.

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ABSTRACT

Assessment of the perception and willingness of public to buy genetically modified food are important areas of empirical research in food science and agricultural economics. In this paper, the results of a questionnaire survey conducted to investigate the awareness, acceptance, and willingness of Bahraini public to buy GM food are described. A total of 410 responses were collected and the data were analyzed using statistical software, SPSS. A logit model was also developed to examine the possible determinants that significantly affect the consumption of GM food. The results indicate that a majority of the participants are not aware of GM food and are

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oblivious to whether they consume them or not. They expect the government/food regulatory agency to ensure appropriate labeling and proper monitoring of GM food. In addition, the consumers are not ready yet to accept GM food due to lack of pertinent information about them.

Keywords: GM food; logit models; determinants; Bahraini public.

1. INTRODUCTION

Genetic engineering techniques are used to alter the genetic code (DNA) to impart traits, which do not occur naturally in organisms, to produce genetically modified (GM) food for both human and animal consumption. Although the enhancement of desired traits has been traditionally undertaken through selective breeding using conventional plant breeding methods, they can be very time consuming and are often not very accurate. Genetic engineering technology on the other hand, can create plants with the required desirable traits. GM crops, similar to non-GM crops, have a range of current and potential uses as in human food, animal feed, textiles (e.g., cotton), and a range of industrial uses (e.g., to produce pharmaceuticals or health products). Many crops are used for more than one purpose. Therefore, GM food is currently a widely researched topic in both academic and political circles regarding their implications in food security [1,2], economic growth, income distribution, human health, the environment, and agricultural trade [3-6].

Higher yields [7-10], lower prices [7,9,11] lower requirement of pesticides and herbicides [7,10] longer shelf life [3], higher resistance to dry and excessive wet weather [12] and improved nutritional value and taste [13] are the focus of most of the research conducted. Despite all of the above advantages, GM products have caused many controversies and raised concerns among scientists, environmental activists, religious organizations, public interest groups, professional associations and government officials. General concerns include environmental pollution [3], cross-pollination [10] the possible creation of new viruses and toxins, limited access to seeds due to patents on GM plants, the threat to crop genetic diversity [10], religious, cultural, and ethical concerns [9,14] and unknown consequences [15,16].

However, understanding the attitude of consumers towards GM food is important not only for the decision makers, but also for the biotechnology industries, food producers, and food retailers. A number of studies on the knowledge, attitude, and behavior of consumers

regarding GM food in both developed [10,17-24] and developing countries [7,9,12,25-29] have been conducted. Acceptance of GM food by consumers varies from country to country. Many consumers in Europe and Japan are vary of accepting GM food, while consumers in the US and many developing countries are much less worried about consuming GM food [7,14,19,27].

The most common food items containing or produced from genetically modified organisms such as corn, sugar cane, tomatoes, potatoes, carrot, soya beans, canola oil, and cotton seed oil are consumed in Bahrain [30,31]. As the world population is predicted to double in the next 50 years, ensuring an adequate food supply for this growing population will be a major challenge. Introducing GM food technology to the Middle Eastern region can help meet this challenge. Besides, a high percentage of food consumed in the Middle Eastern region is currently imported from outside the region. However, both the imported food and locally produced food are not labeled appropriately and thus sold as conventional food due to lack of information and strict regulations controlling GM food.

Therefore, the aim of this study was to conduct a comprehensive survey to measure the knowledge and awareness of Bahrainis about GM food and determine if they are willing to buy these products. One of the key challenges of introducing GM food into the Bahraini market is their acceptance by the public. A positive attitude of the public towards GM food is one of the necessary requirements for the growth and spread of GM food consumption. Hence, the obstacles such as the deficiencies in knowledge, sources of information, safety testing, regulation, government policy, food labeling etc. were assessed. A statistical model that can explain and predict the attitude and the purchasing intentions of the public with regard to GM food was also developed.

2. METHODS

2.1 Questionnaire Design

The questionnaire used for data collection in this study was based on previous studies on

GM food [3,7,9,11,13,20,26,27,32]. The survey form (appendix A) consisted of a short description of the research topic, assurance of confidentiality (name, address and phone number), and the contact information of the researcher. The survey consisted of the following four main parts: (i) demographic questions (e.g. age, gender, education etc); (ii) questions which assess the knowledge of GM food of the participants (understanding, ability to classify, awareness of labeling etc.); (iii) questions assessing the acceptance and willingness of the participants to buy GM food (based on benefits of health, price and taste etc.); and (iv) questions designed to determine the presence of any obstacles to purchasing GM food (availability of information, sources of information, government responsibilities etc). A total of thirteen variables were considered as independent variables for the analysis, while only one variable 'GM food consumption' was considered as a dependent variable (Table 1).

2.2 Study Area and Samples

The survey was conducted in December 2014 in the Kingdom of Bahrain. The participants were from nine cities, from various neighborhoods, geographically covering a substantial portion of Bahrain (surveyed cities are circled in Fig. 1). Bahrain is a small island country with a land area of 780 square kilometers and population of around 1.2 million. The survey form was distributed among participants both as a hardcopy or online via social media such as Facebook, WhatsApp, and Instagram. All questions were restricted and the participants could not submit the questionnaire without fully answering every question. The sample size was calculated according to the following (equation 1) established formula [33]:

$$n = \frac{p \times (1-p) \times z^2}{m^2} \quad (1)$$

where n = minimum sample size, z = critical value for 95% confidence interval, 1.96, m = margin of error for no more than 5%. As there are no studies on GM food consumption in Bahrain, we assumed that 50% of the participants consume GM food. Hence, the sample size for this study was calculated to be 385. 410 responses were collected, which is more than the calculated minimum sample size. The sample size does not depend on the magnitude of the population when population size is large or unknown [34].

2.3 Participants

Age of the participants ranged from 16 to 76 with a mean age of 36.6 (SD=15.78). Almost 50% of the participants are males and other 50% females. In terms of education, about half of the respondents (50%) hold a bachelor's degree, 35% having higher degrees, and the balance 15% of high school degree only.

2.4 Statistical Analysis

Data analysis was performed using the statistical package SPSS, Version 17. Descriptive statistics are expressed as frequencies, percentages, and as the mean \pm standard deviation (SD). Chi-square (χ^2) test was used to compare between categorical variables. For controlling confounding factors, the following (equation 2) binomial logit model (or logistic regression model) was established to determine the predictors of GM food consumption.

$$p(Y = 1) = \frac{\exp(z)}{1 + \exp(z)} \quad (2)$$

$$\text{where, } z = \beta_0 + \sum_{i=1}^n \beta_i x_i + \varepsilon_i$$



Fig. 1. The map of the survey area

In which, p is the percentage of the population, β is a vector of parameters to be estimated, x_i the vector of observations of explanatory or independent variables, and ε the random error

term (assumed to follow a standard normal distribution). The dependent variable was set equal to one if the respondent expressed a positive willingness to consume GM food, and zero for expression of a negative willingness to consume GM food. A full logistic regression model with all variables was considered as Model 1 while a logistic regression model with selected variables (backward stepwise selection method) was assumed as Model 2. Model 2 was developed to determine the best predictive model. Akaike Information Criterion (AIC) was calculated to establish the best fit to the model. The Hosmer and Lemeshow test was conducted to determine the goodness-of-fit for the selected model. Odds Ratio (OR) and 95% Confidence Intervals (CI) for OR were calculated. A p -value < 0.05 was considered statistically significant at 5% level while $0.05 < p\text{-value} < 0.1$ was also considered significant at 10% level.

3. RESULTS AND DISCUSSION

A total of 410 individuals participated in this study and Table 1 shows the association of selected socio-demographic variables to the attitude towards consumption of GM food among regular users. The survey sample consisted of 52% males and 48% females with an average age of approximately 37 years. About half of the participants (46%) were in the age group of 31 and above who do their own grocery shopping, as it was assumed that they were the most concerned about consuming GM food. The survey also targeted people with different education levels to investigate whether the education level affects the awareness and acceptance of consuming GM food. About half of the respondents (50%) hold a bachelor's degree, 35% had higher degrees, while only 15% of them were high school students, which means that the sample can be considered as an educated sample. The chi-square test indicates that variables such as age, gender, and education are not significantly associated with GM food consumption (all p -values > 0.05). Except in the category of education these findings agree with the results of a Chinese study [7].

The survey initially measured the awareness of GM food of the participants by classifying their level of understanding, which is shown in Table 1. More than half of the respondents (55%) has a moderate understanding about GM food

while about 40% of them has a very low knowledge of the subject. Analysis indicates that only 5% of the participants have a high level of understanding about GM food regardless of their age or educational level (Table 1). Results indicate that 45% of the participants (medium + high understanding levels) has some knowledge of GM food though the variable 'knowledge about GM food' is not significantly associated with GM food consumption (p -value = 0.431). However, when asked whether they can distinguish GM food from natural food in the market, a majority of the participants (78%) were either unsure or unable to distinguish genetically altered products from natural products (Table 1). The results prove that the Bahraini society did not pay attention at all to this issue. Even if they notice that some food products look abnormal, it did not occur to them that the product might not be naturally produced. As such, in order to assess the awareness of the participants, they were asked about GM food labeling. As shown in Table 1, about 61% of the participants are not aware at all that GM food is sold in the Bahraini market without labels. The data indicate that most of the Bahraini consumers lack awareness of GM food. Their educational level made no difference, though this variable is insignificantly associated with GM food consumption (p -value= 0.381). However, 91% of the participants (who agree + strongly agree) demand that GM food be labeled, while only 7% of them are neutral, which is shown in Table 1. The chi-square test indicates that variables such as 'able to classify GM food in the market', and 'should GM food be labeled?' are very strongly associated with GM food consumption (all p -values < 0.01).

Hence, the next question asked is whether the consumers read product labels before buying food from the market. Almost 37% of the participants always read product labels, 54% of them read them occasionally while only 8.5% of them never read the label (Table 1). Therefore, 62.5% of the participants (read occasionally + never read groups) does not seem to care about reading labels before buying food. This may be due to the fact that some consumers are shoppers who routinely buy the same food products for years, thus consider unnecessary to read the product labels. Also, some consumers may be unaware of the existence of GM food, thus not reading labels [11]. However, the data for 'read the labels before buying' are not statistically significant (p -value = 0.776).

Table 1. Relationship between the attitude towards the consumption of GM food and variables evaluated

Variables	Options	GM food consumption				χ^2 (df)	p
		No (%)	Not sure (%)	Yes (%)	Total (%)		
Age	16 - 20	31 (40.3)	32 (41.6)	14 (18.2)	77 (18.8)	1.883 (6)	0.930
	21 - 25	37 (37.8)	44 (44.9)	17 (17.3)	98 (23.9)		
	26 - 30	17 (36.2)	23 (48.9)	7 (14.9)	47 (11.5)		
	31 and over	77 (41.0)	86 (45.7)	25 (13.3)	188 (45.9)		
Gender	Male	83 (39.0)	103 (48.4)	27 (12.7)	213 (52)	3.149 (2)	0.207
	Female	79 (40.1)	82 (41.6)	36 (18.3)	197(48)		
Education	High school	27 (42.9)	24 (38.1)	12 (19.0)	63 (15.4)	3.140 (6)	0.791
	Bachelor	83 (40.7)	90 (44.1)	31 (15.2)	204 (49.8)		
	Master	19 (34.5)	27 (49.1)	9 (16.4)	55 (13.4)		
	PhD	33 (37.5)	44 (50.0)	11 (12.5)	88 (21.5)		
Knowledge about GM food	Low	58 (35.8)	80 (49.4)	24 (14.8)	162 (39.5)	3.821 (4)	0.431
	Medium	95 (42.4)	96 (42.9)	33 (14.7)	224 (54.6)		
	High	9 (37.5)	9 (37.5)	6 (25.0)	24 (5.9)		
Can classify GM food in the market?	No	68 (49.3)	61 (44.2)	9 (6.5)	138 (33.7)	17.831 (4)	0.001
	Not Sure	60 (32.8)	89 (48.6)	34 (18.6)	183 (44.6)		
	Yes	34 (38.2)	35 (39.3)	20 (22.5)	89 (21.7)		
Are aware of the labeling of GM food in the market?	No	95 (37.8)	120 (47.8)	36 (14.3)	251(61.2)	1.930 (2)	0.381
	Yes	67 (42.1)	65 (40.9)	27 (17.0)	159 (38.8)		
Should GM food be labeled?	Strongly agree	133 (44.9)	129 (43.6)	34 (11.5)	296 (72.2)	28.379 (8)	0.000
	Agree	17 (21.5)	39 (49.4)	23 (29.1)	79 (19.3)		
	Neutral	8 (27.6)	15 (51.7)	6 (20.7)	29 (7.1)		
	Disagree	4 (80.0)	1 (20.0)	0 (.0)	5 (1.2)		
	Strongly disagree	0 (.0)	1 (100.0)	0 (.0)	1(0.2)		
Read the labels before buying	Never	16 (45.7)	13 (37.1)	6 (17.1)	35 (8.5)	1.783 (4)	0.776
	Sometimes	88 (39.6)	98 (44.1)	36 (16.2)	222 (54.1)		
	Always	58 (37.9)	74 (48.4)	21 (13.7)	153 (37.3)		
Is enough information available on GM food?	No	154 (41.1)	170 (45.3)	51 (13.6)	375 (91.5)	11.645 (2)	0.003
	Yes	8 (22.9)	15 (42.9)	12 (34.3)	35 (8.5)		
Preference of the source of information	TV	62 (44.3)	65 (46.4)	13 (9.3)	140 (34.1)	6.487 (4)	0.166
	Lecture	17 (35.4)	22 (45.8)	9 (18.8)	48 (11.7)		
	Publication	83 (37.4)	98 (44.1)	41 (18.5)	222 (54.2)		

Variables	Options	GM food consumption				χ^2 (df)	p
		No (%)	Not sure (%)	Yes (%)	Total (%)		
Government responsibilities	Low	4 (21.1)	11 (57.9)	4 (21.1)	19 (4.6)	19.050 (4)	0.001
	Medium	22 (26.8)	37 (45.1)	23 (28.0)	82 (20)		
	High	136 (44.0)	137 (44.3)	36 (11.7)	309 (75.4)		
Main benefits of GM food based on different factors	Price	93 (53.4)	61 (35.1)	20 (11.5)	174 (42.5)	44.747 (4)	0.000
	Taste	42 (44.7)	44 (46.8)	8 (8.5)	94 (22.9)		
	Health	27 (19.0)	80 (56.3)	35 (24.6)	142 (34.6)		
Seeks more information on GM food	No	12 (41.4)	10 (34.5)	7 (24.1)	29 (7.1)	5.970 (4)	0.201
	May be	63 (38.0)	84 (50.6)	19 (11.4)	166 (40.5)		
	Yes	87 (40.5)	91 (42.3)	37 (17.2)	215 (52.4)		

Consumers have the right to know what they are consuming and whether it is safe for them or not. The participants in this study lack information about GM food and the pros and cons of consuming them. This is probably due to inadequate sources of information as well as the lack of public debate about GM food in the domestic media [26,27]. As shown in Table 1, about 91% of the participants agree that adequate information on GM food is not available, which is strongly associated with GM food consumption (p-value for chi-square test is 0.003). Therefore, the participants were asked about preferred sources of information such as TV, lectures/seminars, and publications in newspaper, magazines, and brochures. The data indicate that about 54% of the respondents preferred to get the information from publications while 38% of them preferred TV. Only a few of them preferred to get information from lectures and seminars (Table 1). The data are not significantly associated (p-value= 0.166). However, some participants stated that, as this is the age of smart phones and social media, information about GM food should be posted on them. As a majority of the participants chose publications, social media can play an important role in this regard. However, critical information about GM food appearing in social media is less likely to be believed unless the information comes from very reliable sources of government such as the ministry of health, food regulation agency etc. This conclusion is supported by the fact that 75% of the participants (Table 1) indicating that the government should take responsibility towards ensuring the safety of GM food by providing detailed information to the consumers. This group also feels that the government should stand up and protect the consumers from potential health problems, and as shown in Table 1 the data are significantly associated (p-value= 0.001).

The acceptance of GM food does not necessarily imply the willingness of consumers to buy them. Other factors such as prices may determine the purchase of GM food. Most of the consumers would go for cheaper products over healthier products if they are unaware of the health implications of the food. This conclusion is supported by the survey with 42% of the participants choosing price over both health (35%) and taste (23%) as the main benefit of GM food. In general, people place a higher priority on their health over low cost products, which is indicated by their willingness to spend more money on food that are healthier such as organic

food. These results may be attributed to the lack of knowledge and awareness about GM food among consumers. This independent variable was found to be very strongly significant (p-value=000).

The questionnaire was designed also to measure the keenness of consumers to search for further information about GM food. The majority of the participants (93%) agreed (those who gave 'may be answer') and strongly agreed (those who gave 'yes answer') to get more information, while only 7% of them disagreed with it. The results are insignificant statistically (Table 1).

Consumers with different characteristics have different attitudes towards GM food. The consumers who have not heard of GM food have a lower approval rate than those who are aware of them. The frequency of willingness to consume GM food is shown in Fig. 2, which indicates that only 15.37% of the participants would consume GM food, about 39.51% do not prefer them, while 45.12% of the participants are uncertain, indicating that a majority of the participants are not aware that GM food is available in the Bahraini Market. This reinforces the argument that 'adequate information' is an important factor affecting the attitude of consumers, which is in good agreement with literature reports [3,7,10,26,27].

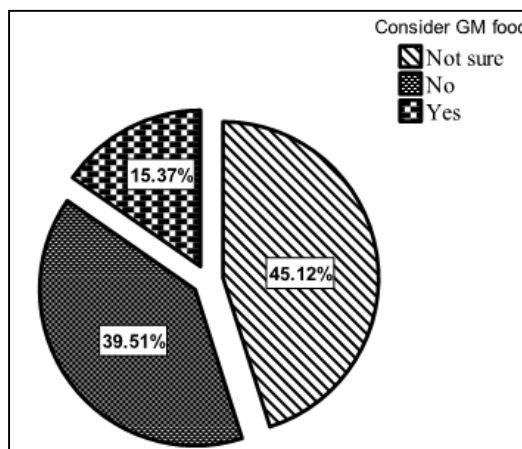


Fig. 2. Frequency of GM food consumption

The initial analysis did not indicate which variables are better at predicting the relationship between awareness and willingness of Bahraini consumers to consume GM food. Therefore, two binary logit models were developed to measure the relationship between the attitude towards GM food consumption and variables evaluated. A full

logistic regression model with all variables, named Model 1, was evaluated and the results obtained from fitting the data to Model 1 are presented in Table 2. The results indicate that the variables such as 'able to classify GM food in the market', 'preference of the source of information', 'government responsibilities', and 'main benefits of GM food based on different factors' are significant at 5% level, while 'adequate information available on GM food' is also significant at 10% level. The backward stepwise selection method was also used to determine the best predictive model, named Model 2, and the results are shown in Table 3. The results indicate that the same variables (that are significant in Model 1) are also significant in Model 2. In order to choose the model that provides the best fit, the values of the Akaike Information Criterion (AIC) for the two models

were calculated as AIC is a measure of the relative quality of a statistical model for a given set of data [35]. The preferred model is the one with the minimum AIC value among a set of candidate models. The AIC values of Model 1 and Model 2 are 339.99 and 327.54, respectively, indicating that Model 2 is better than Model 1.

Furthermore, the Hosmer and Lemeshow test was conducted to determine the goodness-of-fit for Model 2. The contingency table for Hosmer and Lemeshow test is shown in Table 4. A p-value greater than the established cutoff (~ 0.05) indicates a good fit and the p value for Model 2 is higher than 0.05, indicating the goodness of the fit. Overall, Model 2 is sufficient and is able to examine possible determinants that significantly affect GM food consumption.

Table 2. Logistic regression analysis of the willingness to consume GM food

Variables in the equation	Parameter estimates (β values)	S.E.	p	Exp (β)	95% C.I. for Exp (β)	
					Lower	Upper
Age	-.175	.388	.652	.840	.392	1.796
Gender	.295	.309	.340	1.343	.733	2.461
Education	.077	.200	.699	1.080	.730	1.600
Level of knowledge about GM food	-.039	.287	.893	.962	.548	1.688
Can classify GM food in the market?	.634	.228	.005	1.886	1.206	2.949
Are aware of the labeling of GM food in the market?	.099	.308	.748	1.104	.603	2.019
Should GM food be labeled?	.167	.207	.420	1.182	.787	1.776
Reads the labels before buying	-.209	.261	.424	.812	.487	1.353
Is enough information available on GM food?	.758	.431	.079	2.133	.917	4.964
Preference of the source of information	.400	.173	.021	1.492	1.062	2.097
Government responsibilities	-.533	.248	.032	.587	.361	.954
Main benefits of GM food based on different factors	.347	.172	.044	1.414	1.009	1.983
Seeks more information on GM food	.270	.260	.299	1.310	.787	2.178

Table 3. Backward stepwise logistic regression analysis of the willingness to consume GM food

Variables in the equation	β	S.E.	p	Exp (β)	95% C.I. for Exp (β)	
					Lower	Upper
Can classify GM food in the market?	.600	.203	.003	1.822	1.223	2.713
Is enough information available on GM food?	.789	.413	.056	2.201	.980	4.946
Preference of the source of information	.396	.170	.020	1.486	1.064	2.075
Government responsibilities	-.565	.234	.016	.568	.359	.899
Main benefits of GM food based on different factors	.393	.168	.019	1.482	1.067	2.059

Table 4. Contingency table for Hosmer and Lemeshow test of model 2

Step	Chi-square	df	p
1	13.531	8	.095

4. CONCLUSIONS

In this study, a survey was conducted to examine the awareness and willingness of Bahraini public to purchase genetically modified food. To the best of our knowledge this is the first study that uses a random sample of participants representing the Kingdom of Bahrain. A logit model was also developed to examine the possible determinants that significantly affect GM food consumption. The results indicate that a majority of the consumers have little knowledge about GM food and are unable to identify them in the market. The results also show that the consumers are not ready to buy GM food due to the lack of information about them, indicating that the provision of information by media and the government can play an important role. The Bahraini public expect labeling as well as proper monitoring of the market by the government, especially the Ministry of Health. The conclusions of this study are in agreement with the results of previous studies. Future studies are expected to expand the scope of the survey both in terms of the size of the samples and the questions, providing more insight into policymaking and thereby helping decision makers decide on how to proceed with the future GM food policy of the Kingdom of Bahrain.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX A

Questionnaire on awareness, acceptance, and willingness to consume genetically modified food

Introduction:

Genetically modified (GM) food are food derived from organisms/plants whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism/plant. This questionnaire aims to measure peoples' awareness, acceptance and willingness to buy GM food.

Instructions:

- Your participation in this study is completely voluntary. It will take approximately 4-5 minutes to complete. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point.
- Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact me.
- Please do not discuss or help the person(s) filling the questionnaire, and delay the discussions until after the questionnaire is submitted. The aim of the questionnaire is to measure peoples' current background about this topic.
- There are no correct or incorrect answers, the aim as mentioned previously is to see peoples' opinions.

1. Where are you living?

- City:
- Neighborhood:

2. Which category below includes your age?

- 16-20
- 21- 25
- 26-30
- 31 or above

3. What is your Gender?

- Male
- Female

4. What is the highest level of education you have completed?

- High school or less
- Bachelors
- MS
- PhD

5. What is your current level of understanding about GM food?

- Low
- Medium
- High

6. Can you classify GM food in Bahrain market?

- No
- Not sure
- Yes

7. Are you aware of the labeling of GM food in Bahrain market?
 - No
 - Yes
8. Do you agree GM food should require labeling in the Kingdom of Bahrain?
 - Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
9. Do you read the producers' label when you buy food?
 - Never
 - Sometimes
 - Always
10. Do you think there is enough information openly available about GM food?
 - No
 - Yes
11. Where would you prefer to get information of GM food development from?
 - TV
 - Lectures/Seminars
 - Publications/Newspapers/Magazines
12. What level of responsibility do Government have to ensure GM food are safe?
 - Low
 - Medium
 - High
13. What do you think is the main benefit of GM food?
 - Price
 - Taste
 - Health
14. Are you seeking more information on GM food?
 - No
 - May be
 - Yes

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