Knowledge and attitude towards genetically modified foods: A quantitative cross-sectional study among the educated subjects in the four largest divisions of Bangladesh

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ABSTRACT

The food consumers and stakeholders of Bangladesh have limited knowledge and perception over genetically modified (GM) foods. As no studies have been done regarding this among the Bangladeshi educated people on a large scale, hence this study aims to determine the level of knowledge and attitude regarding GM foods; and to explore the related factors as well. A cross-sectional survey was done with a close-ended questionnaire in the four largest divisions of Bangladesh where respondents were above 18 years of age and completed at least higher secondary level education. It was observed that among the total 614 respondents, 24.8% had no acquaintance with GM food. Of the remaining 462 respondents, 41.8% had better knowledge and 30.7% had positive attitude. The level of knowledge significantly varied with respondents' gender, occupation, monthly income, educational status, and discipline studied where male, pharmaceutical workers, respondents with monthly income of 50001-100000 BDT, science studied respondents had significantly better knowledge than their counterparts. Similarly, respondents' attitude on GMOs significantly differed with gender, occupation, monthly income, and education in which positive attitude were shown by respondents with better knowledge. Finally, logistic regression analysis showed that female and business studied respondents had significantly less likely to have better knowledge and positive attitude than reference group, while respondents with monthly income between 50001-100000 BDT had more likely to have better knowledge and positive attitude, and NGO workers had more likely to have positive attitude than references. Thus, this study will help the policymakers of Bangladesh to perceive the current scenario of public demands on GM foods.

INTRODUCTION

Genetically modified (GM) foods are derived from crops whose hereditary property is altered by recombinant DNA technology [1]. GM food is procured from crops with genetically engineered herbicide and pesticide resistance properties, drought, and salt tolerance characteristics etc., and a special focus on increasing food quality by developing nutritional ingredients at lower prices than conventional foods [2]. Earliest GM plants, manufactured by three research groups in 1983, were tobacco (antibiotic resistant) and petunias [3-5]; then in the early stage of 1990s, China started trading GM tobacco worldwide [6]. After that in 1994, the Food and Drug Administration (FDA) of USA first approved GM tomato with the characteristics of delayed ripening. Thenceforth, FDA validated various transgenic crops which included canola with improved oil consumption (Calgene), herbicide resistant cotton and soybeans etc. Now-a-days GM potatoes, carrots, strawberries, and soy with their by-products like maize flour and soy oil are available in the market [6, 7].

Nevertheless, this GM food has initiated a controversial argument regarding its acceptability among mass people who are questioning about its production, consumption, and marketing process [8, 9]. Although researchers acclaim that GM

foods have environmental, economic and health benefits, consumers are still skeptical about it [10, 11]. Similarly, stakeholders' attitude towards GM food is prudent because of their thinking on the risks and moral sides of it [12]. For instance, USA being as the biggest manufacturer of GM foods in the world, 24% of their farmers were blind about GM crops in terms of knowledge whereas 53% were unable to note down the beneficial characteristics of GM foods; rather 43% and 38% of them considered GM foods to be harmful for human health and environment, respectively [13]. In parallel, the Dutch people are not that much interested to seek information on GM foods even their attitude towards GM technology is not up to the mark [14]. Besides, another study on Chinese consumers revealed that most of them were either neutral or negative about supporting GM technology [15].

Bangladesh, a country with demanding consumer groups in the world food market, has already commercialized GM products such as insect resistant Bt brinjal (eggplant) in the local market without any reactivity among the consumers, which shows brighter prospects for the expansion of GM technology in future [16]. Into the bargain, several GM products like golden rice, GM cotton and late blight resistant potato are in the pipeline to increase more domestic production through GM technology [18]. Still, the knowledge level on biotech products among the educated group from both the public and private sector of Bangladesh is relatively poor which indicates indifference among the consumers towards GM foods [19]. It is evident that compared to other countries, Bangladeshi consumers and stakeholders have limited knowledge and perception over GM foods [18]. In addition, consumers are confused regarding the day-to-day foods they buy are either GM or hybrid or produced through traditional farming due to the lack of proper food labeling in Bangladesh [18]. However, no studies have been done so far in connection with the knowledge and perception of GM foods among the Bangladeshi educated people in a large scale. Hence, this study aims to determine the level of knowledge and attitude regarding GM foods; and to explore the factors related to these knowledge and attitude among the educated population in the four largest divisions of Bangladesh.

MATERIALS AND METHODS

Study design, site, and time

The present study used a quantitative approach with cross-sectional survey design. It was done in the four largest divisions of Bangladesh (Dhaka, Chittagong, Rajshahi, and Sylhet division) in terms of population according to census 2011 of Bangladesh [20]; covering urban, peri-urban, and rural areas. The study was performed from the period of March 2021 to August 2021.The schematic diagram of the study was shown in Figure 1.

Sampling technique and sample size calculation

Multi-stage cluster random sampling technique was used to select participants for the current study. At first, each of the four divisions was divided into four clusters according to urban, per-urban, and rural areas; and then randomly two clusters were chosen. After that, simple random sampling technique was used to select households from each cluster. Then from each household, respondent was chosen randomly according to age, gender, education, occupation, marital status etc.

Sample size was calculated using the following formula:

$n = z^2 p (1-p) / d^2$

Considering 63% prevalence (p) regarding knowledge and awareness on GM crops according to a previous study [18], 95% Confidence Interval (CI) and margin of error (d) 4%, sample size n became 560. Adding 10% non-response made it to 616. So, based on participants' availability and written consent, we finally got 614 respondents for the present study.
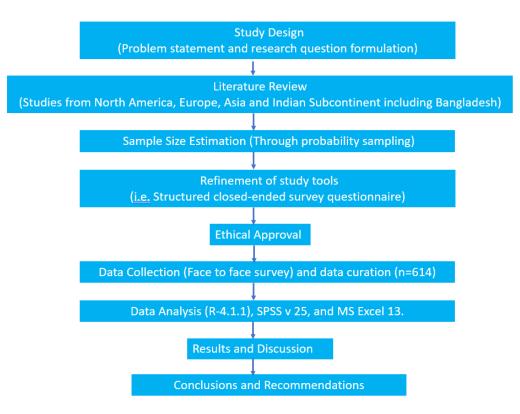

Figure 1. Schematic diagram of the study methodology.

Ethical clearance

The study was approved by the Dhaka University Faculty of Biological Sciences, Dhaka, Bangladesh (Ref.No.106/Biol.Scs.). The respondents were first notified about the purpose of this study and then informed written consent was taken from each of them. Anonymity, confidentiality, and voluntary participation were ensured.

Data collection tools and procedures

A structured close ended survey questionnaire with appropriate response options was developed from previous studies of GM foods [21, 22]. Survey tool was finalized with minor adjustments after pre-testing in the clusters which were not selected for final data collection. The ultimate questionnaire was divided into three sections where the first one consisted of respondents' socio-demographic characteristics; and second and third ones were all about participants' knowledge and attitude regarding GM foods, respectively. Before moving to the second and third section, we asked the participants if they were acquainted with GM foods or not. If the answer was 'no', we had not proceeded to section two and three with them.

Section two was comprised of thirteen questions regarding some basic and slightly advanced knowledge on GM foods such as 'Do GM crops carry foreign genes?', 'Are

GM crops intended to grow faster only?', 'Do GM crops cause harm to the environment?' and many more. For every question, there was only one correct answer for which the participants got one point each. So, the total correct score of knowledge was thirteen. Similarly, section three constituted of eleven questions regarding attitude on GM foods like 'GM food is more costly than non-GM/natural food', 'I think GM food will decrease the natural flavor and taste of food', and so on. Likewise, the total correct score of attitudes was eleven.

Validity of tools and data

The Cronbach's alpha, used to test the reliability and internal consistency of the survey questionnaire were found 0.805 and 0.716 for knowledge and attitude related questions, respectively. And the validity of all data collected was ensured through triangulation – survey findings, literature review and our personal observation in the field.

Statistical analysis

Data were analyzed using 'The R Project for Statistical Computing (R-4.1.1)', 'Statistical Package for the Social Sciences (SPSS version 25)' and MS Excel (2013). Univariate analysis was done by determining frequency with percentage regarding knowledge and attitude on GM foods. Bivariate analysis was done through chi-square test, firstly between socio-demographic factors and the acquaintance of GM foods; and then socio-demographic factors concerning knowledge and attitude level of the participants. Knowledge level was determined as 'better knowledge' and 'poor knowledge' based on the median value (7) of the total correct knowledge score (13); and the attitude level was determined as 'positive attitude' and 'negative attitude' based on the median value (6) of the total correct attitude score (11) according to a previous study [23]. Lastly, binary logistic regression analysis was performed to show the adjusted association of socio-demographic factors with knowledge and attitude level separately. All statistical significance level was set at less than 5% ($p<0.05$).

RESULTS

Characteristics of the respondents

The sample consisted of total 614 respondents to whom 24.8% had no acquaintance with GM food (Table 1). The total sample included slightly higher proportions of younger people (54.2% vs 45.8% in older age group), female (56.5% vs 43.5% in male), and married (54.6% vs 43.3% in single) respondents; and considerably higher percentage of urban (77.3% vs 10.3% peri-urban vs 12.4% rural), student (38% vs 17.4% Govt. Service vs 15.8% non-governmental organization (NGO) service vs 11.4% pharmaceuticals service etc.), graduate (58.1% vs 28.2% post-graduate vs 13.7% higher secondary level), studied in science background respondents (48.4% vs 32.6% business studies vs 19% arts) and monthly income <10,000 BDT (49.7% vs 30% 10,00-50,000 BDT vs 15.4% 50,001-1,00,000 BDT etc.). Respondents' acquaintance of GM food significantly ($p<0.05$) differed with age, gender, educational status, discipline studied, occupation and monthly income level (Table 1).

Table 1. Socio-demographic characteristics of the participants according to their acquaintances of GM food.

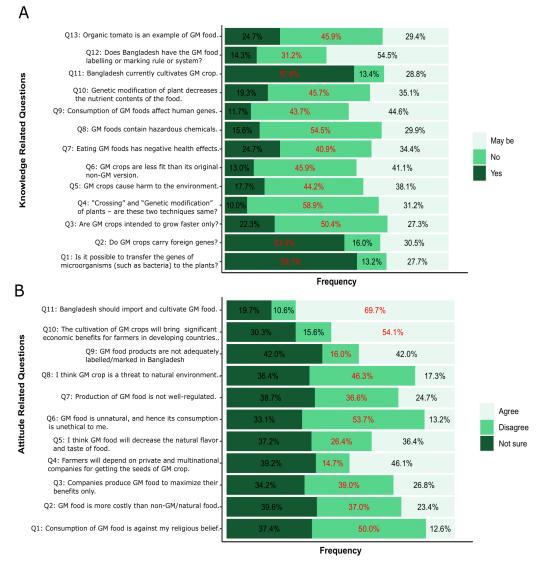| Characteristics of the participants		Acquaintance of GM food (N = 614)				P value
		No 152 (24.8%)	Yes 354 (57.7%)	May be 108 (17.6%)	Total 614 (100%)	
Age[1]	19-28 years	100 (65.8%)	174 (49.2%)	59 (54.6%)	333 (54.2%)	**0.003**
	29-67 years	52 (34.2%)	180 (50.8%)	49 (45.4%)	281 (45.8%)	
Gender	Male	68 (44.7%)	168 (47.5%)	31 (28.7%)	267 (43.5%)	**0.003**
	Female	84 (55.3%)	186 (52.5%)	77 (71.3%)	347 (56.5%)	
Area of Residence	Urban	109 (71.7%)	275 (77.7%)	91 (84.3%)	475 (77.3%)	0.099
	Peri-urban	23 (15.1%)	34 (9.6%)	6 (5.5%)	63 (10.3%)	
	Rural	20 (13.2%)	45 (12.7%)	11 (10.2%)	76 (12.4%)	
Educational Status	Higher secondary level	42 (27.6%)	34 (9.6%)	8 (7.5%)	84 (13.7%)	**0.000**
	Graduate	77 (50.7%)	201 (56.8%)	79 (73.1%)	357 (58.1%)	
	Postgraduate	33 (21.7%)	119 (33.6%)	21 (19.4%)	173 (28.2%)	
Discipline studied in higher secondary level	Science	19 (12.5%)	216 (61.0%)	62 (57.4%)	297 (48.4%)	**0.000**
	Business studies	83 (54.6%)	86 (24.3%)	31 (28.7%)	200 (32.6%)	
	Arts	50 (32.9%)	52 (14.7%)	15 (13.9%)	117 (19.0%)	
Occupation	Student	81 (53.3%)	121 (34.2%)	31 (28.7%)	233 (38.0%)	**0.000**
	Teaching	7 (4.6%)	36 (10.2%)	6 (5.6%)	49 (8.0%)	
	Business	27 (17.8%)	21 (5.9%)	10 (9.3%)	58 (9.4%)	
	Government service	10 (6.6%)	54 (15.2%)	43 (39.8%)	107 (17.4%)	
	NGO service	18 (11.8%)	69 (19.5%)	10 (9.3%)	97 (15.8%)	
	Service in pharmaceutical company	9 (5.9%)	53 (15.0%)	8 (7.4%)	70 (11.4%)	
Monthly Income (BDT[2])	<10,000	107 (70.4%)	162 (45.8%)	36 (33.3%)	305 (49.7%)	**0.000**
	10,000-50,000	22 (14.5%)	109 (30.8%)	53 (49.1%)	184 (30.0%)	
	50,001-1,00,000	11 (7.2%)	68 (19.2%)	16 (14.8%)	95 (15.4%)	
	>1,00,000	12 (7.9%)	15 (4.2%)	3 (2.8%)	30 (4.9%)	
Marital Status	Single	70 (46.0%)	151 (42.6%)	45 (41.7%)	266 (43.3%)	0.927
	Married	79 (52.0%)	196 (55.4%)	60 (55.5%)	335 (54.6%)	
	Divorced	3 (2.0%)	7 (2.0%)	3 (2.8%)	13 (2.1%)	

[1]Age is categorized according to its median value 28. [2]BDT = Bangladesh taka, the currency for Bangladesh. Significant results with P values < 0.05 are shown in bold in the rightmost column.
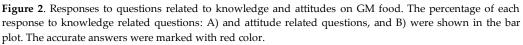
Knowledge and attitude of the respondents towards GM food

Overall, respondents had mixed knowledge on GM food. Among 462 respondents who were somehow familiar with GM foods, 41.8% had better knowledge and 58.2% had poor knowledge. Here, majority of the respondents correctly answered that Bangladesh currently cultivates GM crops (57.8%) and GM foods contain no hazardous chemicals (54.5%) (Figure 2). Besides, majority of the respondents (nearly 53–60%) gave right answers on plant biotechnology related questions such as 'crossing' and 'genetic engineering' of plants are not same, GM crops carry foreign genes and transfer of genes from microorganism to plant is possible. Correspondingly, questions associated with outcomes such as "Does GM food has negative health or environmental effects?" were correctly denied by majority of the respondents (around 40-45%). However, bulk amount of the respondents was skeptic whether Bangladesh has GM food labeling system (54.5%) or eating GM foods affect human genes (44.6%) (Figure 2).

Unlike knowledge related questions, most of the respondents' attitude towards GM foods was pessimistic. Within 462 respondents, only 30.7% had positive attitude whereas 69.3% were negative. Among the respondents, 37% disagreed that GM food is costlier than non-GM food and around 47% agreed that farmers' dependency on private and multinational companies will increase for buying GM seeds (Figure 2). Also, an ample amount of the respondents believed that GM food will decrease the natural flavor and taste of the food (36.4%), and GM food products are not adequately labeled (42%); whereas around 37% of the respondents swallowed that GM foods are produced in a well-regulated manner (Figure 2).

However, still majority of the respondents agreed that Bangladesh should import and cultivate GM foods which will bring significant economic benefits for the farmers accordingly. Besides, respondents' positive attitude was also observed regarding environmental, ethical, and religious perspective of GM foods (Figure 2).

Figure 2. Responses to questions related to knowledge and attitudes on GM food. The percentage of each response to knowledge related questions: A) and attitude related questions, and B) were shown in the bar plot. The accurate answers were marked with red color.

Relationship of socio-demographic variables with the level of knowledge and attitude

The associations of socio-demographic characteristics with the level of knowledge and level of attitude were performed in Table 2. It was observed that both the younger age (19-28 years) and older age (29-67 years) groups had poor knowledge (64.8% and 51.5% respectively) and negative attitude (72.1% and 66.4% respectively) (p>0.05) with no significant difference between them; although older age group had more average knowledge score (6.7±4.3vs 5.9±3.8) and more average attitude score (4.9±2.9 vs 4.5±2.7) than younger age group (p>0.05). In terms of gender, male had significantly (p<0.05) better knowledge and positive attitude on GM foods than female (attitude score 7.6±3.5 vs 5.3±4.2 and 5.7±2.6 vs 3.9±2.6, respectively); and the overall differences between the

percentage of better knowledge and positive attitude were 51.8% vs 34.2% and 43.7% vs 20.9%, accordingly for male and female ($p<0.05$). Regarding educational status, higher secondary education group had the highest knowledge and attitude score (7.9 ± 3.7 and 5.8 ± 2.3 sequentially) compared to graduate and post graduate group ($p<0.05$) even though they were few in numbers. On the other hand, post graduate education group had more knowledge (48.6% vs 36.8%) and positive attitude (32.1% vs 28.6%) than the graduate group and these differences were significant ($p<0.05$) as well (Table 2).

Table 2. Linkage of socio-demographic variables with the level of knowledge and attitude on GM foods.

Variables	Level of knowledge[1]				Level of attitude[2]			
	Poor knowledge	Better knowledge	Average knowledge score	P values	Negative attitude	Positive attitude	Average attitude Score	P values
Age								
19-28 years	151 (64.8%)	82 (35.2%)	5.9± 3.8	0.07	168 (72.1%)	65 (27.9%)	4.5± 2.7	0.2
29-67 years	118 (51.5%)	111 (48.5%)	6.7±4.3		152 (66.4%)	77 (33.6%)	4.9±2.9	
Gender								
Male	96 (48.2%)	103(51.8%)	7.6± 3.5	0.00	112(56.3%)	87 (43.7%)	5.7±2.6	0.00
Female	173 (65.8%)	90 (34.2%)	5.3± 4.2		208 (79.1%)	55 (20.9%)	3.9±2.6	
Educational status								
HSC	20 (47.6%)	22 (52.4%)	7.9±3.7	0.00	25 (59.5%)	17 (40.5%)	5.8±2.3	0.00
Graduate	177 (63.2%)	103 (36.8%)	5.6±4.3		200 (71.4%)	80 (28.6%)	4.3±2.8	
Postgraduate	72 (51.4%)	68 (48.6%)	7.3±3.4		95(67.9%)	45 (32.1%)	5.2±2.6	
Disciplined Studied in HSC								
Arts	156 (56.1%)	122 (43.9%)	6.3±4.4	0.02	197 (70.9%)	81 (29.1%)	4.6±2.7	0.63
Business	80 (68.4%)	37 (31.6%)	5.9±3.2		79 (67.5%)	38 (32.5%)	4.5±2.8	
Science	33 (49.3%)	34 (50.7%)	7.4±3.7		44 (65.7%)	23 (34.3%)	5.3±2.7	
Area of Residence								
Rural	215 (58.7%)	151 (41.3%)	6.3±4.1	0.71	256 (69.9%)	110 (30.1%)	4.6±2.8	0.43
Peri-urban	22 (55%)	18 (45%)	6.8±4.5		28 (70%)	12 (30%)	4.9±2.7	
Urban	32 (57.1%)	24 (42.9%)	6.2±3.5		36 (64.3%)	20 (35.7%)	5.1±2.6	
Monthly Income (BDT)								
<10000	121 (61.1%)	77 (38.9%)	6.6±3.3	0.00	136 (68.7%)	62 (31.3%)	4.9±2.6	0.002
10000-50000	112 (69.1%)	50 (30.9%)	4.9±4.3		127 (78.4%)	35 (21.6%)	3.9±2.6	
50001-100000	28 (33.3%)	56 (66.7%)	8.1±4.3		46 (54.8%)	38 (45.2%)	5.4±3.1	
>100000	8 (44.4%)	10 (55.6%)	7.4±3.6		11 (61.1%)	7 (38.9%)	5.8±2.3	
Marital Status								
Single	100 (51%)	96 (49%)	6.9±4.3	0.08	139 (70.9%)	57 (29.1%)	4.6±2.8	0.3
Married	165 (64.5%)	91 (35.5%)	5.8±3.9		176 (68.8%)	80 (31.3%)	4.7±2.7	
Divorced	4 (40%)	6 (60%)	7.7±4.3		5 (50%)	5 (50%)	5.6±3.1	
Occupation								
Student	86 (56.6%)	66 (43.4%)	6.8±3.6	0.00	104 (68.4%)	48 (31.6%)	4.9±2.7	0.00
Teaching	24 (57.1%)	18 (42.9%)	7.1±3.2		27 (64.3%)	15 (35.7%)	4.9±2.8	
Business	19 (61.3%)	12 (38.7%)	7.3±3		22 (71%)	9 (29%)	4.4±2.6	
Government Service	85 (87.6%)	12 (12.4%)	2.5±3.4		90 (92.8%)	7 (7.2%)	2.6±2.1	
NGO Service	38 (48.1%)	41 (51.9%)	7.4±4.0		40 (50.6%)	39 (49.4%)	5.8±2.5	
Service in pharmaceuticals	17 (27.9%)	44 (72.1%)	8.7±3.2		37 (60.7%)	24 (39.3%)	5.7±2.6	

[1]Level of knowledge was determined as 'better knowledge' and 'poor knowledge' based on the median value (7) of the total correct knowledge score (13), [2]Level of attitude was determined as 'positive attitude' and 'negative attitude' based on the median value (6) of the total correct attitude score (11). Significant results with P values < 0.05 are shown in bold both in the 5th and 9th column.

Following respondents' discipline studied in higher secondary level, only science group possessed more average knowledge and attitude score as opposed to business studies and arts group, while the differences were significant ($p<0.05$) for the level of knowledge only. In response to participants' living areas, most of the rural, peri-urban and urban people had poor knowledge and negative attitude; interestingly, these

differences were insignificant (p>0.05). With reference to their monthly income in BDT, people who earned 50,0001-1,00,000 had the highest knowledge (66.7%) and positive attitude (45.2%) in comparison to people earning <10,000, 10,000-50,000 and >1,00,000 (p<0.05). Significant (p<0.05) results were also obtained in case of respondents' occupation. For example, people working in pharmaceuticals had more average knowledge score (8.7±3.2) than people working in NGO (7.4±4.0), businessmen (7.3±3), teachers (7.1±3.2) and students (6.8±3.6) while all were significant (p<0.05). In a similar way, people working with NGO had the highest average attitude score (5.8±2.5); followed by people working with pharmaceuticals (5.7±2.6), teachers (4.9±2.8), students (4.9±2.7) and businessmen (4.4±2.6) (p<0.05). Concerning marital status, divorced group had the highest knowledge (60%) and positive attitude (50%); although their numbers were very little and insignificant (p>0.05). Nevertheless, single people had more knowledge (49% vs 35.5%), but less positive attitude (29.1% vs 31.3%) than married people (p>0.05) (Table 2).

Binary logistic regression analysis to associate socio-demographic variables with knowledge and attitude level of the participants regarding GM food

Finally, binary logistic regression analysis was performed to ascertain the magnitude of the association of respondents' socio-demographic variables with their level of knowledge and attitude, separately (Table 3). The dependent variables were set as 'Level of Knowledge' (Better knowledge and Poor knowledge) and 'Level of Attitude' (Positive attitude and Negative attitude). Independent variables were Age (Reference: 19-28 years), Gender (Ref: Male), Area of residence (Ref: Rural), Educational status (Ref: Higher secondary level), Discipline studied (Ref: Arts), Occupation (Ref: Student), Monthly income (Ref: <10,000 BDT), Marital status (Ref: Single) and Acquaintance of GM food (Ref: May be). It was obtained that adjusted for age, residence, education, discipline, occupation, monthly income, marital status and acquaintance of GM food, female had (1-0.6) = 0.4 or 40% less likely to have better knowledge and (1-0.3) = 0.7 or 70% less likely to have positive attitude regarding GM foods than male, which were significant (p<0.05). In a similar way, respondents completing post graduate education had (1-0.2) = 0.8 or 80% less likely to have positive attitude significantly (p<0.05) than respondents completing higher secondary level education. In terms of discipline studied in higher secondary level, the business studies group had (1-0.5) = 0.5 or 50% less likely to have better knowledge significantly (p<0.05) than arts group adjusted for other variables. While considering occupation, NGO workers had 3.3 times more likely to develop positive attitude than students significantly (p<0.05) too (Table 3).

In respect of monthly income, respondents earning 50,001 to 1,00,000 BDT per month had 7 times and 3.1 times more chances to possess better knowledge and positive attitude sequentially (p<0.05) than earning <10,000 BDT per month adjusting for other variables. Regarding marital status, adjusted ORs for knowledge level was 0.4 for married people compared to singles (p<0.05). Additionally, respondents acquainted with GM foods were less likely to develop better knowledge (Adjusted ORs: 0.3, p<0.05) and positive attitude (Adjusted ORs: 0.4, p<0.05) compared to those dubious about GM food, consecutively. Conversely, age group of 29-67 years had 2.1 times more chances to have better knowledge and 1.1 times more chances to have positive attitude than 19-28 years, respectively (p>0.05). In the same pattern, respondents living in urban areas had more likelihood of developing better knowledge (Adjusted ORs: 1.4, p>0.05) and positive attitude (Adjusted ORs: 1.3, p>0.05) than rural areas respectively; similar for peri-urban area also (Table 3).

Table 3. Binary logistic regression analysis.

Variables	Category of characteristics (N = 462)	Level of knowledge		Level of attitude	
		Adjusted ORs[1] (95% CI[2])	P value	Adjusted ORs (95% CI)	P value
Age	19-28 years (Reference)	1		1	
	29-67 years	2.1 (0.974-4.689)	0.058	1.1 (0.516-2.310)	0.819
Gender	Male (Reference)	1		1	
	Female	**0.6 (0.376-0.954)**	**0.031**	**0.3 (0.200-0.510)**	**0.000**
Area of Residence	Rural (Reference)	1		1	
	Peri-urban	1.1 (0.518-2.494)	0.749	1.1 (0.493-2.565)	0.781
	Urban	1.4 (0.703-2.872)	0.327	1.3 (0.682-2.782)	0.372
Educational Status	Higher secondary level (Reference)	1		1	
	Graduate	0.8 (0.364-1.689)	0.535	0.6 (0.290-1.378)	0.249
	Postgraduate	0.5 (0.179-1.301)	0.150	**0.2 (0.007-0.581)**	**0.003**
Discipline studied in higher secondary level	Arts (Reference)	1		1	
	Business studies	**0.5 (0.267-0.879)**	**0.017**	1.2 (0.670-2.204)	0.520
	Science	0.8 (0.402-1.537)	0.481	0.6 (0.280-1.099)	0.091
Occupation	Student (Reference)	1		1	
	Teaching	0.6 (0.190-1.788)	0.346	1.9 (0.655-5.378)	0.241
	Business	0.5 (0.139-1.684)	0.253	1.1 (0.338-3.453)	0.896
	NGO service	0.5 (0.174-1.476)	0.212	**3.3 (1.170-9.113)**	**0.024**
	Service in pharmaceutical company	2.0 (0.633-6.396)	0.236	2.1 (0.694-6.289)	0.190
Monthly Income (BDT)	<10,000 (Reference)	1		1	
	10,000-50,000	1.6 (0.768-3.313)	0.211	0.8 (0.371-1.588)	0.476
	50,001-1,00,000	**7.0 (3.058-16.187)**	**0.000**	**3.1 (1.429-6.663)**	**0.004**
	>1,00,000	0.9 (0.269-2.873)	0.831	1.2 (0.375-4.160)	0.717
Marital Status	Single (Reference)	1		1	
	Married	**0.4 (0.265-0.778)**	**0.004**	1.3 (0.792-2.301)	0.269
	Divorced	0.9 (0.195-5.101)	0.998	2.7 (0.547-13.404)	0.222
Acquaintance of GM food	May be (Reference)	1		1	
	Yes	**0.3 (0.152-0.535)**	**0.000**	**0.4 (0.228-0.843)**	**0.013**

[1]ORs = Odds Ratio. [2]CI = Confidence Interval. Significant results with P values < 0.05 are shown in bold both in the 4th and 6th column.

DISCUSSION

The present study illustrated the intensity of knowledge and attitude connected to GM foods with exploring the amplitude of factors associated with it among the educated subjects of Bangladesh. We observed that out of 614 respondents, 24.8% had not even heard the term 'GM food', although our participants had minimum 12th class of education. Interestingly, a study among the food shoppers of USA, Italy and Japan revealed that 40.9%, 28% and 33.3% were at least familiar with GM foods, respectively [24]. Data of the present study also showed that acquaintance of GM foods significantly (p<0.05) differed with gender where female knows more about GM foods than male. However, it confutes with a study in Europe [25], where female had subtractive knowledge on GM products. Thus, it is of utmost importance now to make the Bangladeshi educated class aware of GM crops to tackle food security through knowledge transmission [26].

While different knowledge related questions regarding GM foods were considered, a good percentage of the respondents gave right answers which meant their comprehensive knowledge was good. For example, 45.9% of our respondents said that organic tomato is not a GM food, which is almost like a study among Latvian consumers as 50% of them did not consider organic tomato as GM [27]. On the contrary, 40.9% of the Latvian consumers agreed that consumption of GM food can change human genes [27], but in our study 43.7% disagreed this statement; even in another Bangladeshi study stated above [18], 78% also disaccorded this. In addition, only 24.7% of our respondents considered GM foods as harmful for health whereas 57.4% among 500 participants in Poland considered GM food as unhealthy [28]; which showed a clear

knowledge gap among these two types of consumers. This gap is also supported by another study among Turkish nursing students, where 72.8% (N = 346) agreed GM food as being dangerous due to its hazardous chemical composition [29]. Meanwhile, in our study, only 15.6% confronted this statement. So, proper knowledge conveyance to Bangladeshi educated people has become essential now in terms of the effect of GM food on human health and environment.

In connection with our respondents' attitude towards GM food, there were variations like 36.6% were undoubted about GM food production process, but 36.4% believed that GM food would decrease the natural flavor and taste of food. These findings were in consistent with a previous study conducted among Polish subjects showing that 59.9% believed the production of GM crop to be unregulated [28], and also another study of Bangladesh showed that 57% contemplated GM food regarding the decrease of its natural taste and flavor [18]. Concerning environmental effect of GM food, only 17.3% of our participants perceived GM crops to be a threat to the natural environment. This is not in accord with an Indian study, where 60.7% science teachers and 55.2% 12th class biology students viewed GM foods as unsafe for environment [30]. While talking about GM food production, 26.8% of our respondents thought that companies would be more profitable by manufacturing GM foods rather than thinking about the other sides of it, which has some differences with the other study from Bangladesh [18] as 39% of them agreed on this. Hence it is clear that government authority along with private companies should come forward to bring transparency and accountability of GM foods to the educated people.

Our binary logistic regression illustrated that female were 40% and 70% less likely to have better knowledge and positive attitude respectively than male. Although this finding is similar to a study of India [33], it indicated that female were 18.5% less likely to prefer GM foods than male as they observed female to be more conscious about their children than male regarding food habit; just like another study among US consumers [34]. Besides, the present study portrayed that respondents with post graduate education had less chance to develop positive attitude than higher secondary level education. In contrast, Norwegian consumers found people with higher education to be more interested on GM foods than compulsory education [35]. On that account, although education plays a vital role in dietary choice and habits, there is still scope of research on specific education groups for pursuing their behavior and attitude towards GM foods. Moreover, in terms of discipline studied in higher secondary level, our study discovered the arts group to have more knowledge on GM food than business studies and science group, which is completely opposite to many other studies, like the Arabian study [36]. In terms of occupation, we found NGO workers to have better perceptions on GM foods than students which were opposite to a study done in Poland [37]. The present study also derived that comparatively older people had better knowledge and more positive attitude than younger ones which became apparent in a European study [38].

The present study underwent several limitations. Firstly, data were collected only from four out of eight divisions of Bangladesh due to time and resource constraints underlying the COVID-19 pandemic in Bangladesh. Also, comparatively less data were collected from either rural or peri-urban areas rather than urban areas because of the shortage of transportation caused by COVID-19 lockdown in Bangladesh. Besides, most of the data collected were self-reported; so, there might be a chance of recall bias from the participants. However, our data collectors did some probing questions informally to mitigate this recall bias.

CONCLUSIONS

This study proves that the impact of proper knowledge and right attitude on GM food is crucial for a developing country like Bangladesh to maintain food security, and to implement an appreciated food policy for the consumer groups of Bangladesh. Although stakeholders' knowledge and perceptions are vital for the correct advertising and launching GM foods in Bangladesh, our study could not capture that holistic dimension. As a result, further studies are needed to apprehend the right caricature of both consumers' and policymakers' standpoints to establish a sustainable GM food chain in Bangladesh.

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AUTHOR CONTRIBUTIONS

DA and SAF have equally contributed to the concept, design, methodology development and data analysis of the study. DA prepared the initial manuscript whereas SAF critically revised it. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

There is no conflict of interest among the authors.

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