

Understanding Saudi Public's Awareness, Perception, and Attitudes towards Genetically Modified Foods

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Abstract

Introduction: Recent technological developments have enabled many scientists to produce a wide variety of foods that meet consumers' desires for diversity and quality. Genetically modified (GM) foods have long been a controversial topic, and consumer reliance on these foods depends on their trust in biotechnology institutions due to their lack of knowledge about the risks and benefits. This study aimed to assess the awareness, attitude, and perception of GM foods among the Saudi population, as well as to identify the association between age, gender, and education level in the studied population and their awareness level towards genetically modified foods. **Method:** Data was collected using a structured, pretested questionnaire drawn from previous studies, after obtaining written consent. The questionnaire included three sections focusing on personal data, general knowledge of GM foods, and perception, attitudes, and beliefs towards GM foods. Our study included 500 responses. **Results:** The majority of the participants were female, located in the central region, and had a university education. Most participants provided a correct definition of GM foods and indicated that they had heard about them, but were unsure if they had eaten these foods in the past. Their knowledge of these foods was good. Regarding opinions and attitudes towards these foods, the majority of participants were neutral. They approved of using GM foods because it produces more food, tastes better, and can be stored for a long time. In conclusion, the study highlights the urgent necessity to raise awareness and knowledge regarding genetically modified foods among the Saudi population. It emphasizes the importance of educating consumers about the potential advantages and risks associated with consuming such foods, enabling them to make informed decisions. It is crucial to integrate awareness and education about genetically modified foods into the technological and agricultural advancements in Saudi Arabia.

Keywords

Genetically Modified Foods, Biotechnology, Food Quality, Knowledge and Beliefs

1. Introduction

Many scientists have been able to improve the sustainability of our society through the development of science and technology, which has effectively influenced the food industry. These technological developments help improve food production, increase nutritional content, and meet consumer desires in terms of variety [1]. Therefore, deliberate modification of the genetic configuration of living organisms is now possible thanks to modern biotechnology. Nonetheless, genetically modified foods have long been a controversial topic. Although many food crops have been mass-produced using this technology, consumer adoption of genetically modified foods has been rather slow [2].

Consumers' desire to buy genetically modified foods depends on their trust in biotechnology organizations because of their lack of knowledge about the risks and benefits associated with genetically modified technology [3]. In addition to companies responsible for creating and marketing genetically modified seeds, consumers' opinions influence how suspicious they are about the technology [4]. Consumers are still mostly unaware of the risks and benefits of genetically modified foods, although there is information available to help them assess these risks and make informed decisions, which are necessary for consumer acceptance and risk management [1]. The science used to create genetically modified organisms is biotechnology or genetic engineering. A genetically modified organism (GMO) is a living organism whose DNA undergoes alterations that do not occur normally (transgenic). Therefore, foods that are created using genetic engineering or genetically modified ingredients are referred to as genetically modified foods [5]. According to scientific opinion, eating genetically modified foods does not endanger consumers, but there is a difference between feeling the risk and the risk determined by science [6]. The description of any risk arising when using these products, especially the effects of molecular biology techniques that enter the natural recombination process and disrupt its ability to reproduce, are both of concern to the consumer [7]. The increase in the availability of transgenic food products on the market reinforces the myth that genetically modifying plants and animals yields financial gain. The potential for agronomic, technological, or utilitarian trait improvement drives food producers to adopt genetic engineering innovations more frequently. Every alteration starts with a difficult process of changing the genome structure, which is responsible for producing the desired utilitarian attribute [7]. A study by Amin *et al.* showed the importance of the biotechnology sector in focusing on creating foods with clear benefits to the consumer and effectively communicating these benefits to poten-

tial consumers [8]. In addition, it is important to understand how different religions view and the ethical implications of genetic modification, and to look at real reality [9]. Reasons for criticism by media critics discussed by Wunderlich *et al.* in his published paper showed that a large percentage of consumers are unaware and do not understand the effects and recipes of genetically modified products and are not satisfied with their self-rating, which indicates the need to increase consumer awareness. In addition, there is a need for accurate educational materials that contain scientifically supported information [10].

The public perception of genetically modified (GM) foods has been a topic of discussion and research for many years. While some studies have shown that the public is becoming more positive towards GM foods, others have found that public concerns remain over the safety of GM foods [11]. The debate around GM foods has involved individuals from all different backgrounds, ranging from farmers to biotechnology companies and government regulators [11]. The main international and national scientific organizations accept the scientific consensus that food produced from genetically modified (GM) crops is safe [12]. However, there are still controversies and public concerns surrounding GM foods and crops, including human and environmental safety, labelling and consumer choice, intellectual property, market dynamics, and environmental effects of GM crops [13]. Most research effort has been devoted to assessing people's attitudes towards GM foods as a technology [13]. Numerous surveys have been conducted on national and cross-national levels, and there are differences in the demographic characteristics associated with the gap between science and public opinion concerning GM food safety [14].

In this study, we aimed to assess the awareness, attitude, and perception of Saudi population towards genetically modified foods.

2. Methodology

Our study was a cross-sectional analytic study to measure the level of knowledge, awareness, and practice towards genetically modified foods in Saudi Arabia. The data were collected using a valid pretested structured questionnaire taken from previous studies after obtaining written approval, which included three sections focusing on personal data; general knowledge on genetically modified foods; and perception, attitude, and beliefs towards genetically modified foods [5]. After reviewing similar studies, the sample size was estimated to be approximately 500. Our study included 500 responses from various regions of Saudi Arabia at a rate of 99.2%. The criteria for the questionnaire that was applied in this study were as follows: we included any person more than 18 years of age who was willing to enroll in the study. Anyone who refused to participate in the study, had a mental and physical illness, was younger than 18 years, or did not answer the whole questionnaire was excluded. We chose a small sample from the target population and conducted a survey. Data were analyzed afterwards to ensure the clarity of the questionnaire and to discover any shortages of

the project plan. Data from the pilot study were excluded from the final project analysis.

2.1. Statistical Analysis Plan

Data are expressed as frequency (%) for categorized data and as mean \pm standard deviation (minimum - maximum) for parametric data. Analyses were performed using IBM SPSS Statistics for Windows version 23 (IBM SPSS, IBM Corp., Armonk, N.Y., USA). The correct answer was given 1 and the incorrect answer was given 0, and the total answers of the 16 questions were summed. The total score ranged from 0 to 16. Good score corrected answers ranged from 75% to 100% (12 - 16); medium score corrected answers ranged from 25 - 75 to (4 - <12), and poor score corrected answers < 25 (<4). Pearson's Chi-square test was used for comparisons between the categorized data groups. For parametric data, one-way analysis of variance (ANOVA) followed by Tukey's test was used for comparison between groups. Statistical significance was set at $p < 0.05$.

2.2. Ethics and Confidentiality

Ethical approval for this study was obtained from the Qassim Research Committee. The participants were informed about the purpose of the research, and their electronic consent was obtained prior to completing the questionnaire. Data were initially identified and then coded in a database Excel sheet using a unique identification number. The data were stored on a password-protected laptop with PI and CI, and all data were kept confidential. Only the research team had access to the database for analysis. The publication only presented a summary of the statistics, and no identifying information was used.

3. Results

The demographic characteristics of the participants are presented in **Table 1**. The participated female were significantly higher than that of male (61.6% vs. 38.4%, $p < 0.001$). Most participants were age group 18 - 30 years (34.0%), followed by >30 - 40 years (28.4%), >40 - 50 years (23.6%), >50 - 60 years (9.4%), and >60 years (4.6%), with a significant difference between them ($p < 0.001$). Most of the participants were from the middle region (69.8%), followed by the western region (10.6%), eastern region (9.2%), southern region (6.0%), and northern region (4.4%), with a significant difference between them ($p < 0.001$). Most of the participants had a university education (65.6%), followed by secondary education (19.4%), higher education (8.2%), intermediate education (3.8%), and elementary education (3.0%), with a significant difference between them ($p < 0.001$).

Participants' knowledge about genetically modified food is shown in **Table 2** and **Figures 1-3**. Of the participants, 78.8% had heard about genetically modified food (**Figure 1**). Approximately 70.2% understand that foods whose genetic material has been modified to obtain new properties (**Table 2**). Regarding the

type of genetically modified food sold locally, most answers were wheat products (30.4%), followed by chickens (25.0%), potatoes (16.6%), maize (15.0%), dairy products (8.0%), and eggs (5.0%) (Figure 2). Approximately 32.4% of the participants ate genetically modified foods (Figure 3).

Table 1. Demographic characteristics of participants (n = 500).

Characteristics	Frequency (%)	Significance
Gender		p < 0.001
Male	192 (38.4%)	
Female	308 (61.6%)	
Age groups		p < 0.001
18 - 30 years	170 (34.0%)	
>30 - 40 years	142 (28.4%)	
>40 - 50 years	118 (23.6%)	
>50 - 60 years	47 (9.4%)	
>60 years	23 (4.6%)	
Residential areas		p < 0.001
Middle region	349 (69.8%)	
Eastern region	46 (9.2%)	
Western region	53 (10.6%)	
South region	30 (6.0%)	
Northern region	22 (4.4%)	
Education levels		p < 0.001
Elementary education	15 (3.0%)	
Intermediate education	19 (3.8%)	
Secondary education	97 (19.4%)	
University education	328 (65.6%)	
Higher education	41 (8.2%)	

Table 2. Knowledge about genetically modified food (n = 500).

Items	Frequency (%)
What is your understanding of genetically modified foods?	
Foods whose genetic material has been modified to obtain new properties.	351 (70.2%)
They are foods that have been genetically modified and cause a genetic change in humans, which causes cancer.	85 (17.0%)
Foods that have been modified to remove unwanted taste.	64 (12.8%)

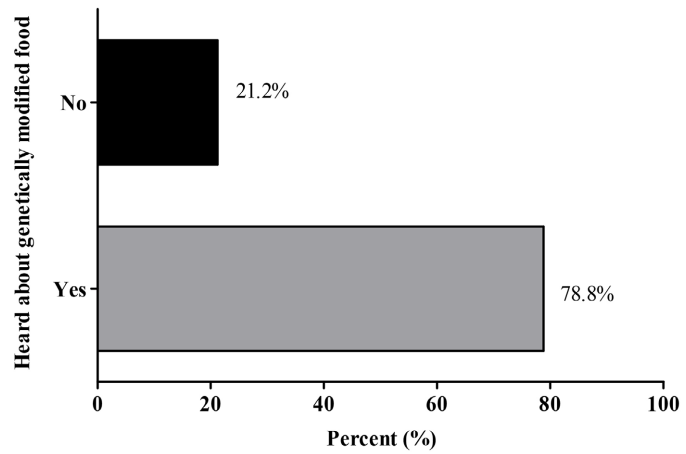


Figure 1. Percentage (%) of participants heard about genetically modified food (n = 500).

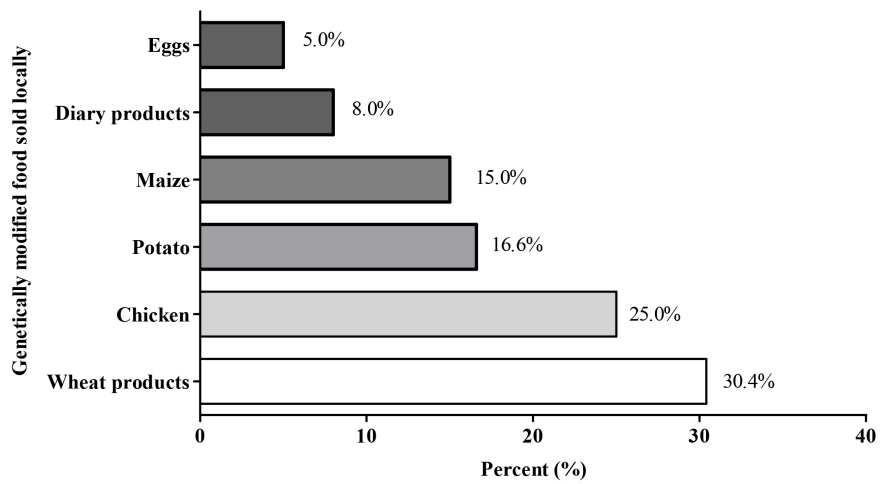


Figure 2. Type of genetically modified food that is sold locally (n = 500).

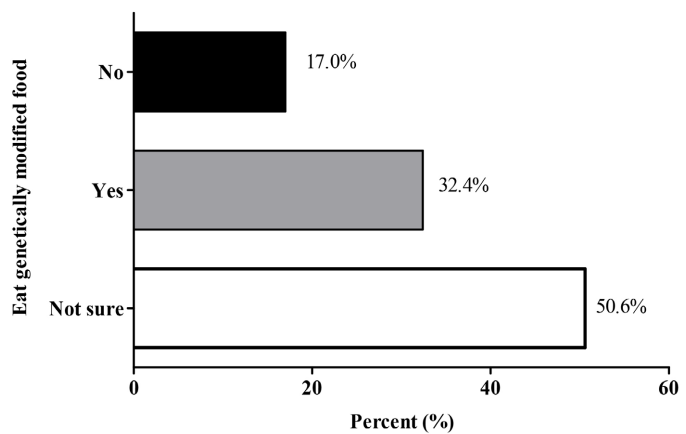


Figure 3. Participants (%) ever eaten genetically modified foods (n = 500).

The perceptions of the participants about genetically modified food are shown in **Table 3**. Regarding the statement that genetic modification of the plant can increase its nutritional quality and add more flavor to the fruits, 53.8% answered

Table 3. Perception about genetically modified food (n = 500).

Statement	True	False	Not sure
Genetic modification of the plant can increase its nutritional quality and add more flavor to the fruits.	269 (53.8%)	74 (14.8%)	157 (31.4%)
Practical application of transgenic plants to increase plant productivity and disease resistance.	293 (58.6%)	61 (12.2%)	146 (29.2%)
In the event of consumption of genetically modified foods, it can lead to the destruction of human genes.	175 (35.0%)	115 (23.0%)	210 (42.0%)
Genetically modified foods contain many dangerous chemicals.	174 (34.8%)	113 (22.6%)	213 (42.6%)
Genetically modified crops are sterile.	157 (31.4%)	92 (18.4%)	251 (50.2%)

correctly. The statement that the practical application of transgenic plants to increase plant productivity and disease resistance was answered correctly by 58.6%. Meanwhile, the statement that consumption of genetically modified foods can lead to the destruction of human genes was answered correctly by 23.0%. The statement that genetically modified foods contain many dangerous chemicals was answered correctly by 22.6% of the participants. The statement that genetically modified crops were sterile was answered correctly by 18.4% of the respondents.

Attitudes and beliefs towards genetically modified foods are shown in **Table 4**. Only 46.0% agreed to eat genetically modified food products (**Figure 4**). Only 9.8% strongly disagreed with the statement that genetically modified food technology conflicted with religious beliefs. A total of 33.4% answered that Genetically Modified Foods (GMF) technology was unnatural and unacceptable. About 28.6% answered neutral that GMF technology is mainly driven by private companies and that they desire to increase profits. 11.8% disagree that the consequences of using GMFs are very complex, and we cannot acquire knowledge to reduce the potential risks. Of the respondents, 29.6% agreed that the aim of GMF was to produce cheaper food, 43.6% agreed that it aimed to produce more food, 36.8% agreed that it aimed to produce food with tastes better, and 41.2% agreed that it aimed to produce products with extended shelf life.

The corrected and incorrect responses of the participants regarding knowledge, perception, attitudes, and beliefs about GMFs are shown in **Table 5**. The correct answers were significantly higher than the incorrect answers in terms of hearing about GMFs, understanding of GMFs, practical application of transgenic plants to increase plant productivity and disease resistance ($p < 0.001$ for all). While, the incorrect answers were significantly higher than the correct answers in the followings. In the event of consumption of GMFs, it can lead to the destruction of human genes ($p < 0.001$), GMFs contain many dangerous chemicals ($p < 0.001$), genetically modified crops are sterile ($p < 0.001$), accept to eat a

Table 4. Attitudes and beliefs towards genetically modified foods (GMFs) (n = 500).

Attitudes and beliefs	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Statements about genetically modified foods (GMFs)					
Genetically modified food technology conflicts with religious belief.	48 (9.6%)	70 (14.0%)	220 (44.0%)	113 (22.6%)	49 (9.8%)
Genetically modified food technology is therefore unnatural and therefore unacceptable.	93 (18.6%)	128 (25.6%)	167 (33.4%)	93 (18.6%)	19 (3.8%)
Genetically modified food technology is mainly driven by private companies and their desire to increase profits.	142 (28.4%)	158 (31.6%)	143 (28.6%)	49 (9.8%)	8 (1.6%)
The consequences of using genetically modified foods are very complex and we cannot acquire the knowledge to reduce the potential risks.	111 (22.2%)	150 (30.0%)	167 (33.4%)	59 (11.8%)	13 (2.6%)
Purposes of used GMFs					
The aim of genetic modification is to produce cheaper food.	67 (13.4%)	148 (29.6%)	149 (29.8%)	115 (23.0%)	21 (4.2%)
The aim of genetic modification is to produce more foods.	108 (21.6%)	218 (43.6%)	121 (24.2%)	45 (9.0%)	8 (1.6%)
The aim of genetic modification is to produce food that tastes better.	90 (18.0%)	184 (36.8%)	142 (28.4%)	71 (14.2%)	13 (2.6%)
The aim of genetic modification is to produce products with extended shelf life.	131 (26.2%)	206 (41.2%)	121 (24.2%)	34 (6.8%)	8 (1.6%)

Table 5. Response of participants about knowledge, perception, attitudes and beliefs about genetically modified food (n = 500).

Items	Correct answers	Incorrect answer	Significance
Knowledge			
1) Have you heard about genetically modified food?	394 (78.8%)	106 (21.2%)	p < 0.001
2) What is your understanding of genetically modified foods?	351 (70.2%)	149 (29.8%)	p < 0.001
Perception			
3) Genetic modification of the plant can increase its nutritional quality and add more flavor to the fruits.	269 (53.8%)	231 (46.2%)	p = 0.089
4) Practical application of transgenic plants to increase plant productivity and disease resistance.	293 (58.6%)	207 (41.4%)	p < 0.001
5) In the event of consumption of genetically modified foods, it can lead to the destruction of human genes.	115 (22.8%)	385 (77.0%)	p < 0.001
6) Genetically modified foods contain many dangerous chemicals.	113 (22.6%)	387 (77.4%)	p < 0.001
7) Genetically modified crops are sterile.	92 (18.4%)	408 (81.6%)	p < 0.001

Continued

Attitudes and beliefs			
8) Accept to eat a genetically modified food product.	230 (46.0%)	270 (54.0%)	p = 0.074
9) Genetically modified food technology conflicts with religious belief	49 (9.8%)	451 (90.2%)	p < 0.001
10) Genetically modified food technology is therefore unnatural and therefore unacceptable.	167 (33.4%)	333 (66.6%)	p < 0.001
11) Genetically modified food technology is mainly driven by private companies and their desire to increase profits.	143 (28.6%)	357 (71.4%)	p < 0.001
12) The consequences of using genetically modified foods are very complex and we cannot acquire the knowledge to reduce the potential risks.	59 (11.8%)	441 (88.2%)	p < 0.001
13) The aim of genetic modification is to produce cheaper food.	148 (29.6%)	352 (70.4%)	p < 0.001
14) The aim of genetic modification is to produce more foods.	218 (43.6%)	282 (56.4%)	p = 0.004
15) The aim of genetic modification is to produce food that tastes better.	184 (36.8%)	316 (63.2%)	p < 0.001
16) The aim of genetic modification is to produce products with extended shelf life.	206 (41.2%)	294 (58.8%)	p < 0.001
Total score (0 - 16)	6.06 ± 2.58 (0 - 13)		
Total score category			
Good (12 - 16)	8 (1.6%)		
Medium (4 - <12)	407 (81.4%)		
Poor (<4)	85 (17.0%)		

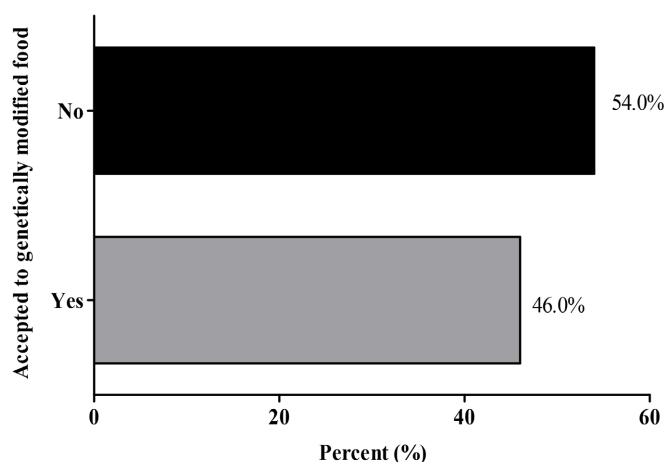


Figure 4. Percentage (%) of participants accepted to eat genetically modified food (n = 500).

GMF product (p < 0.001), GMF technology conflicts with religious belief (p < 0.001), GMF technology is therefore unnatural and therefore unacceptable (p < 0.001), GMF technology is mainly driven by private companies and their desire to increase profits (p < 0.001), the consequences of using genetically modified foods are very complex and we cannot acquire the knowledge to reduce the potential risks (p < 0.001), the aim of genetic modification is to produce cheaper food (p < 0.001), to produce more foods (p = 0.004), to produce food that tastes

better ($p < 0.001$), to produce products with extended shelf life ($p < 0.001$). The total score ranges from 0 to 13, with a mean of 6.06. Most participants had a medium score (81.4%), followed by a poor score (17.0%); only 1.6% had a good score (Figure 5).

The corrected and incorrect responses of the participants regarding knowledge, perception, attitudes, and beliefs about GMFs are shown in Table 5.

There were insignificant changes in the mean total scores between male and female ($p = 0.918$). Among the different age group, the mean total score was highest in age group 18 - 30 years and lowest in the >60 years, with an insignificant difference between the groups ($p = 0.744$). In the different residential areas, the mean total score was highest in the northern region and lowest in the western region, with an insignificant difference between the groups ($p = 0.420$).

There were significant differences in the mean total score at different education levels, with the highest score in elementary education and the lowest score in intermediate education ($p < 0.001$) (Table 6).

Table 6. Total score of knowledge, perception, attitudes and beliefs about genetically modified food according to demographic characteristics of participants.

Characteristics	Frequency (%)	Significance
Gender		$p = 0.918$
Male	6.05 ± 2.76	
Female	6.07 ± 2.46	
Age groups		$p = 0.744$
18 - 30 years	6.24 ± 2.73	
>30 - 40 years	6.04 ± 2.40	
>40 - 50 years	5.84 ± 2.38	
>50 - 60 years	6.15 ± 2.88	
>60 years	5.83 ± 2.86	
Residential areas		$p = 0.420$
Middle region	6.13 ± 2.68	
Eastern region	6.28 ± 1.93	
Western region	5.45 ± 2.37	
South region	5.87 ± 2.60	
Northern region	6.32 ± 2.57	
Education levels		$p < 0.001$
Elementary education	7.80 ± 2.62	
Intermediate education	4.89 ± 2.58	
Secondary education	5.90 ± 2.41	
University education	5.94 ± 2.52	
Higher education	7.32 ± 2.79	

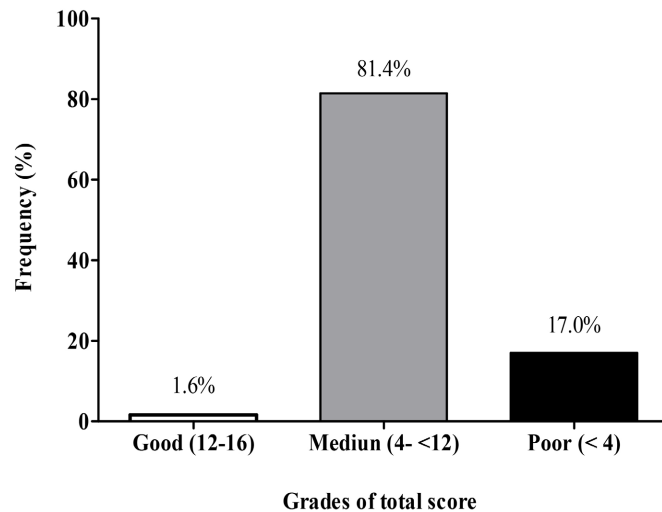


Figure 5. Total score grading among participants (n = 500).

4. Discussion

In this study, we evaluated awareness and knowledge of genetically modified foods in Saudi Arabia. The majority of participants had a university education, and most of them were within the 18 - 30 years age range. The study participants were primarily from the central region of Saudi Arabia. Our findings indicate that a large majority (78.8%) of the participants had heard of genetically modified foods, and a significant proportion (70.2%) provided an accurate definition of these foods. This high level of awareness can be attributed to the cultural knowledge present in Saudi society, particularly among the younger generations. Interestingly, approximately half of the participants (50.6%) were unsure whether they had consumed genetically modified foods in the past. This uncertainty may be owing to a lack of labeling regulations and limited transparency in the food industry. Previous research supports the notion that genetically modified foods are a topic of controversy despite their widespread production in the form of food crops [2]. Regarding their perceptions of genetically modified foods, most participants expressed the belief that genetic modification enhances nutritional quality and confers increased disease resistance to plants. These findings align with previous research that highlights the positive impact of these technological developments in food quality and nutritional content [1]. However, some participants held the impartial belief that genetically modified foods contain chemicals and have the potential to alter human genes.

This concern likely stems from the perception that any risks associated with these products, particularly the effects of molecular biology techniques and the potential disruption of normal recombination processes, may pose a threat to consumers [7]. Additionally, a considerable proportion of participants (44.0%) believed that genetically modified foods might conflict with religious beliefs. As highlighted in prior studies, it is crucial to explore how different religions perceive the ethical implications of genetic modification and understand their actual attitudes. perspectives within specific religious contexts [9].

The agreement among the participants in the study reflects their belief that genetically modified foods are influenced by private companies driven by profit motives. Additionally, the results show that consumers desire to purchase. These foods depend on their trust in biotechnology organizations, likely because of their lack of knowledge about the risks and benefits associated with this technology [3]. The participants in our study agreed that the use of genetically modified foods could lead to increased food production, improved taste, and longer shelf life. Previous research has also shown that this technology contributes to consumer desire for food variety and enhances productivity [1].

In terms of consumer acceptance, 46.0% of the participants accepted genetically modified foods, while 54.0% did not. It is noteworthy that scientific consensus suggests that consuming these foods does not pose a risk to consumers. However, there can be a difference between the perceived risk and the risk determined by scientific evidence [6]. In conclusion, our study reveals the awareness and knowledge levels of the Saudi public towards genetically modified foods. The findings indicate relatively high awareness among respondents, with variations in perceptions and beliefs. Further research is needed to explore the underlying factors influencing these perceptions and develop effective strategies for disseminating accurate information about genetically modified foods to the public.

5. Conclusion

The study concluded that there is an urgent need to increase awareness and knowledge about genetically modified foods among the Saudi population, especially with the increasing use of these foods in the market. The study also showed the need to educate consumers about the potential benefits and risks of consuming genetically modified foods, and to encourage them to make informed decisions about their consumption. Awareness and education about these foods should be an essential part of technological and agricultural development in the Kingdom of Saudi Arabia. Additionally, future research should focus on understanding the factors influencing consumer attitudes and perceptions towards GM foods, and on developing effective educational interventions to address any misconceptions or concerns. Overall, this study provides valuable insights into the current state of awareness and attitudes towards GM foods in Saudi Arabia, and highlights the importance of addressing this issue in order to ensure informed decision-making and food security in the country.

Author Contributions

Noorah Al-Sowayan and Afrah A Aldhaishy contributed to the design, conceptualization, and implementation of the research. Afrah A Aldhaishy contributed to data collection, analysis, and interpretation of results, resources, and writing of the original draft preparation. Noorah Al-Sowayan Authentication, editorial review, supervision, and project management conceived the original manuscript

and edited it. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data presented in this study are available upon request from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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Ethics Approval

This study was conducted in accordance with the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Regional Research Ethics Committee, Qassim Province, KSA. Review Board Number: 10043/44/607, on Jan. 23, 2023.

Informed Consent

The authors consented to the submission of this manuscript for publication.

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