The Effect of Objective Knowledge on Consumer Acceptance towards GM Foods in Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Since the middle of the 1990s, when GM food was first developed, genetically modified (GM) foods have been the subject of much discussion. This biotechnology invention enables farmers in various nations to boost output. In this study, we aim to explore the effect of consumer knowledge on attitudes towards GM foods in Ghana. We investigate the association between consumers' attitudes toward GM foods and their level of trust and objective knowledge. We conducted a cross-sectional survey of 509 people in Ghana to look into this connection. Participants were required to respond to a questionnaire that evaluated their general attitude toward GM foods, perceived risk, perceived benefit, trust and objective knowledge of GM foods, with an age range from (20-50 years and higher), and different levels of educational level. Results indicated that PHD consumers had a higher level of objective knowledge, (93%) to be precise, followed by High School Students with a percentage of (87%). We employed multiple regression analysis to investigate the link between the

independent and dependent variables. Data were analyzed through IBM SPSS Statistics for Windows 22.0 and AMOS 18. The structural equation model (SEM) was used in this study to examine the impact of objective knowledge and trust on consumers' attitudes toward genetically modified (GM) foods in Ghana. Results for the model indicated that Knowledge had a stronger correlation with attitude, with a standard regression weight of (.252), but trust had a weaker correlation on attitude amongst Ghanaian consumers. It had a standard regression weight of (-.612). The P-Value for the model indicated that the estimated path coefficients are highly statistically significant, with an extremely low probability of the observed results occurring by chance. Suggesting that the model fits the data well and the estimated coefficients are reliable and robust. The effect of the two constructs on the willingness to accept GM foods was statistically significant.

Overall, the level of education somewhat impacts the level of objective knowledge. Knowledge positively impacted consumers' willingness to accept GM food, whiles trust negatively impacted consumer willingness to accept GM foods.

1. INTRODUCTION

1.1 Research Background

Genetically modified food (GM) foods, according to the World Health Organization (WHO), are foods generated from organisms whose genetic material (DNA) has been transformed in a way that does not normally occur, such as by the introduction of a gene from one organism to the other [1]. The motivation for creating GM crops was to boost farmer profitability through cost savings or increased yields.

The use of GM technology to create food can only be successful if customers accept the ultimate result. In other words, the future growth of gene technology is greatly reliant on public approval [2]. Indeed, public attitudes regarding genetic engineering and the eventual acceptance of items developed from the technique are becoming increasingly essential in deciding the technology's future position in society. If consumer acceptability difficulties are not sufficiently addressed, contemporary biotechnology's potential economic and societal benefits may not be achieved. Clearly, consumer acceptance of GM foods is a significant component that will help define its future, therefore the need to assess consumers' understanding, attitudes, and concerns regarding GM foods, as well as their willingness to accept and utilize them [3].

The Ghanaian parliament has adopted laws allowing the country to sell genetically modified (GM) crops [4]. The regulations pave the way for the commercialization of insect-resistant Bacillus Thuringiensis (BT) cowpea. BT crops are plants genetically engineered/modified to contain the bacterium's endospore or crystal toxins; BT is said to be resistant to certain insect pests), allowing farmers to reduce pesticide use while increasing yields drastically. Researchers are also ready to move on with newest rice, which has been developed to require less nitrogen fertilizer, withstand drought conditions, and grow in salty soils while still producing a high yield [4].

In spite of this positivity, what are Ghanaian's attitudes/acceptance levels toward this kind of food production? There are bound to be some controversies surrounding the use of biotechnology in foods. What is the public's view on the use of said method in food? This study aims to answer the following questions:

- What is the consumer's awareness level, specifically objective knowledge level of genetically modified (GM) foods?
- Does consumers objective knowledge positively or negatively affect their willingness to accept GM food?
- If consumers trust the use of GM technology on food because of government or institutional approval.

Academically, this research will help contribute to the body of information on people's awareness on GM foods in Ghana, as there isn't a lot of research that has been done on said topic, this research will serve as a source of reference materials for students and researchers. By analyzing the results of a thorough survey done to measure Ghanaians' knowledge, trust, and perception of GM food and ascertain if they are

willing to embrace these items, this study seeks to better understand customers' views about these products. This research can also assist the government bodies, and policymakers to better understand consumers' attitudes and implement better policies to gain consumer's trust if it has been tainted by their knowledge level. The objective of this study is to examine consumers level of awareness towards GM foods. It will help to determine the objective knowledge level and how this level influenced their acceptance level of Genetically modified foods, investigate consumers trust in the Government and Governmental institutions like universities to determine their attitude towards GM food as well as to identify factors that influence consumers attitude towards GM foods. One minor limitation faced in this research was getting enough people in the 50 upwards demography to answer the questionnaire (electronic-based questionnaire), as most older generations tend not to be able to navigate their way using technology or prefer not to use technology at all. This problem was tackled by giving a face-to-face interview to as many older consumers as possible. Although it doesn't guarantee a large number of respondents, it proved to be more efficient for them than the electronically based questionnaire).

2. LITERATURE REVIEW

2.1 Literature Review and Theoretical Framework

2.1.1 Background of genetic engineering in food production in developing countries

The world population increased to 6 billion in the previous century. While food production has grown in response, 800 million people, particularly in developing countries, continue to lack adequate food. According to the World Health Organization, the world's population will exceed 9 billion by 2050. The great majority of this rise will occur in developing nations in South East Asia and Sub-Saharan Africa, with more than half of this population expected to reside in cities. Or fulfil this task over the next 50 years, we must double to treble food production on practically the same amount of land, despite dwindling water resources and environmental concerns.

Ultimately, the success of GM foods will be determined by government permission and commercial acceptance, as well as the degree to which the public accepts or rejects either side of the issue. Public opinions can impact not just the consumption of genetically modified foods, but also government policy and legislation governing their creation, manufacturing, and distribution. Understanding public perceptions concerning GM food is therefore critical in order to build appropriate governance structures that will foster confidence and, ultimately, consumption [5].

2.1.2 Objective knowledge

Because of the gap between what consumers believe they know and what they actually know, consumer knowledge is divided into objective and subjective knowledge [6]. Subjective and objective knowledge have previously been established as drivers of consumers' acceptance of genetically modified organisms (GMO) in the medical and food industries [7]. Objective knowledge is defined as actual information, whereas subjective knowledge relates to what consumers believe they know about GM technology and GM food [8].

Certain studies have indicated that in various cases, consumers feel they know more about a topic than they really do, and they may base their judgments on the information they assume is right, whether it is true or not [9]. Zhang and Liu [10] show that objective knowledge influences consumers' benefit perceptions while negatively influencing their risk perceptions.

A study conducted by Eric Worlanyo Deffor [3], indicated a high degree of knowledge among respondents in the Greater Accra Region, with nearly 90% of those polled having heard or read anything about GM foods. Additionally, the findings indicate that 85% of respondents were open to eating GM food. Additionally, those with college and secondary education were more inclined to embrace genetically modified goods.

Consumers' awareness of genetically modified foods, particularly objective knowledge, is a key predictor of their propensity to embrace GM foods [11]. Certain studies have indicated that in various cases, consumers feel they know more about a topic than they really do, and they may base their judgments on the information they assume is right, whether it is true or not [9]. Zhang and Liu [10] show that objective knowledge influences consumers' benefit perceptions while negatively influencing their risk

perceptions. However, Deon Klerk [12] discovered that objective information decreases acceptance of GM food and consumers' subjective risk perception.

2.1.3 The role of knowledge in determining perceived benefits and risks on consumer attitudes towards Genetically Modified (GM) food

Literature on customer attitudes and buying intentions seems to be published on a regular basis. The continuing crises in the globe have made it even more important. The political, social, and economic environment are always shifting. Globally, which has resulted in shifting customer tastes and behavior that is more dynamic than ever before [13].

Consumers' degree of awareness and attitudes regarding the perceived hazards and advantages of GM technology are factors that impact their fears or anxiety about GM foods. Because perceptions of risk and gain are based on an individual's assessment of product qualities, and they can be influenced by raising consumer awareness about GM foods. When consumers lack knowledge regarding GM technology, they are unable to assess the potential hazards and advantages objectively. As a result, the relationship between consumer awareness and attitude toward GM foods based on perceived dangers and advantages must be investigated [6]. Research published in 2021, [6] investigated the effects of customer information on attitudes toward and intentions to purchase genetically modified foods, as well as the implications of these consumer reactions for the long-term sustainability of the food sector. In this study, objective and subjective knowledge were differentiated, and it was shown how an imbalance between the two information types affected consumers' perceptions of and inclinations to buy genetically modified foods. According to the findings of the multinomial regression study, customers with higher education, money, and participation in the food industry and more exposure to information regarding genetically modified foods tend to overestimate their knowledge of these products. The group that overestimated risk saw benefits as being lower and risks as being higher.

Research undertaken by Ampadu-Ameyaw [14] to investigate the status of public knowledge and awareness of GMO's and attitudes toward the NBF in Ghana found that, despite the existence of GMO's and NBF in Ghana for many years, awareness, understanding, and knowledge remain inadequate.

This shows that more widespread public education, participation, and awareness building about GMOs, the NBF, and governmental institutions are needed to address the difficulties caused by disinformation, distrust, and fear, and to increase public confidence in GMOs. Many of these studies have found that while consumers are aware of GM foods, they lack detailed information about them and are heavily impacted by mass media, which emphasizes the negative features of GM foods. As a result, it is vital to assess the link between consumers' understanding of genetically modified foods and their attitudes and actions, which will aid in ensuring consumer safety and providing managerial insights to the food business [6,15,16].

2.1.4 The role of trust in determining attitudes about food-grade GMOs

Trust is a significant predictor of attitudes toward science and technology. According to the researchers, in the lack of extensive understanding about biotechnology, people use social trust as a heuristic to minimize the complexity of science and risk management judgments [17].

A study by Ernest Bonah [18] looked at GM food labeling policy preferences and consumer trust in biotechnology institutions in Ghana. To administer surveys, a cross-sectional study design with simple random selection was adopted. The findings demonstrate high positive linear correlations between acceptance of GM foods and readiness to purchase GM foods (Pearson's $r = 0.52$, $p<0.001$) and weak relationships between Trust in Biotechnology Institutions and willingness to purchase (Pearson's $r = 0.20$, $p<0.001$).

A meta-analysis of 20 impact sizes from 19 research looked into the relationship between trust and customer purchase intent. The findings show that trust has a favorable impact on customers' buying inclinations. Meanwhile, moderation analysis shows that trust in sellers has a greater significant influence than other types of trust. Meanwhile, customers in forums and communities can build trust, which influences their purchasing decisions [19]. As a result, this study investigates social trust in GM food in Ghana

3. MATERIALS AND METHODS

3.1 Location of Study

Ghana is a country on the African continent. It is located in West Africa and is bordered by two bodies of water. The Atlantic Ocean runs immediately beneath Ghana's southern border, while the Gulf of Guinea runs along the country's south-eastern border. In the northern hemisphere, Ghana is located at 7.9465° N and 1.0232° W latitude and longitude. With a current population is 33,722,225 people.

3.2 Study Design

A structured questionnaire was employed as the data-gathering technique in this study. A self-administered questionnaire had mostly closed-ended questions. The questionnaire was created using the findings of the literature study. The questionnaire's items are based on the study objectives and the studied literature. It was developed to gather all important information about the proposed research topic and hypothesis using a range of questions. There are four (4) sections to the questionnaire. Section one (1) gathered demographic information from respondents. This part included inquiries on gender, age, and education. Section two (2) examines biotechnology, genetically modified food awareness, and information sources. Section three (3) examines customers' objective knowledge level with a series of True or False questions. Section four (4) investigates consumers' trust in the government and whether or not the problem of GM foods concerns them.

This study's assessment is based on 3 variables and 11 specific indicators based on multiple scales in relevant research with excellent reliability and validity. Trust and Attitude questions were prepared using Likert's five-scale technique to reduce the bias of submitted replies. For example, the various options for varied consumer approval labelling systems to help consumers to identify GM food were "strongly disagree," "disagree," "neutral," "Agree," and "strongly agree," rated from 1 to 5, with regard to objective knowledge, respondents answered 4 true-or-false questions on GM food related-objective facts, receiving one point for right answer and zero point for wrong one. Another set of 6 true-or-false questions was asked to determine the consumer's level of understanding about the perceived risk and benefit of GM food, these questions were framed in a way to answer and determine consumers' perceived risk and benefit as well as their objective level, also receiving one point for the right answer and zero point for wrong answer.

Participants then indicated their level of certainty (1: uncertain—5: certain) for each true/false response to take into consideration them guessing the answer. For example, an incorrect response with a certainty level of 5 generated a score of 1 (minimum score for a single statement); an incorrect response with a certainty level of 3 generated a score of 2; a correct response with a certainty level of 1 generated a score of 5; and a correct response with a certainty level of 5 generated a score of 9 (maximum score for a single statement). The final score of objective knowledge was computed by adding the scores of the 4 statements that can be between 0 to 36, a similar analysis method done by Tae-Im Han [20]. Standard Equational Modelling was then used to determine the relationships between attitude and the Latent variables.
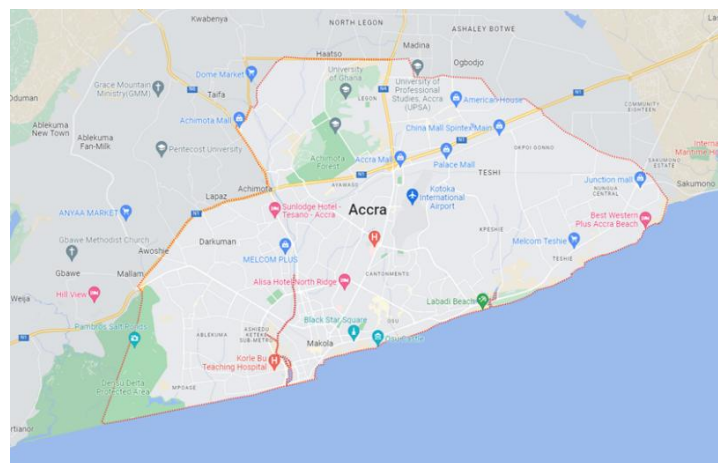

Fig. 1. Location of study

3.3 Statistical Analysis

We employed multiple regression analysis to investigate the link between the independent and dependent variables. Data was analyzed through IBM SPSS Statistics for Windows 22.0 and AMOS 18. IBM SPSS was used to test the data's reliability and to measure the mean and standard deviation of objective knowledge. AMOS 18 was used to determine the correlation and relationship between dependent (Attitude) and independent variables (Knowledge and Trust).

4. RESULTS AND DISCUSSION

4.1 Demographic Characteristics

Demographic statistics of survey respondents are presented in Table 2. 60.8% were male, whiles 39.2% were female. Consumers between the ages of 20-30 were the maximum, with a number of 56.97. Bachelor students were the highest, with a percentage of 35.76% of the total. Most respondents (41.25%) received a monthly income of 501-3000ghc, the average amount of money an average Ghanaian receives monthly. Almost all respondents had, one way or the other, heard about GM food, 90.18% to be precise, with most of them (57%) gaining knowledge from Personal research.

4.2 Consumer Knowledge about GM Foods

Results show most respondents had good knowledge about GM foods based on Table 2.

General knowledge: More than half of the respondents, approximately (93.12%) were aware of what GM food stands for. (6.88%) did not know. 'Genetic engineering is new technology' (17.29%) of the respondents answered True, whiles (82.71%) of respondents answered false. 'GM food can be engineered to have longer shelf life'. (85.66) Some respondents believed that transferring genes from animals to plants is scientifically possible. (14.34) believed that transferring genes from animals to plants is not possible.

Perceived Benefits: 'GMOs decrease infection by bacterial and fungal pathogens'. Most respondents (88.02%) showed a level of understanding by agreeing to this statement. (11.98%) of respondents answered that its false. 'GMOs can help out small-scale farmers' Genetic engineering has mostly been utilized to reduce the use for pesticides and herbicides while increasing farmer yields. (84.87%) of respondents agreed that GMOs can actually help out small scale farmers which is a perceived benefit, only (15.13%) disagreed with this statement, only few believed GMOs doesn't actually help out small scale farmers. 'GM food are good for solving food problems because they increase yields. (83.10%) of respondents believed that GM foods are good for solving food problems, which is more than half of the total respondents. (16.90%) disagreed that GM foods doesn't increase yields. Overall respondents had a much more positive response towards this statement.

Perceived Risks: 'Eating GM foods will modify a person's genes'. More than half (89.39%) of respondents knew this statement to be false. Only (10.61%) answered True. 'Foods with GMO's contain fewer nutrients. (14.73%) of consumers were worried that using GMOs in food contains fewer nutrients. Most respondents (85.27%) knew this statement was false that GMOs don't actually contain fewer nutrients. 'GMOs are bad for the environment'. (15.91%) of respondents answered it to be true that GMOs are indeed bad for the environment, but (84.09%) showed a level of understanding that GMOs are not bad for the environment.

Table 3 indicates that education somewhat has a positive impact on consumers objective knowledge level [21,22]. Results indicated that P.H.D consumers from the ages of 31 upwards gained knowledge from personal research, whiles High School Students gained knowledge from School, with P.H.D consumers ages 31 and upwards having a higher level of objective knowledge. This could be due to perceived risks on health, this might lead them to do more research on the topic hence gaining more objective knowledge. Bachelor and Master Students under the age of 31 had a lower objective knowledge level. This could be because, they are majoring in one particular course at School that doesn't require the knowledge use of GM food, most of their source of information was through friends.

Level of education somewhat has a positive impact on consumers objective knowledge level [21,22]. Results indicated that P.H.D consumers from the ages of 31 upwards gained knowledge from personal research, whiles High School Students gained knowledge from School, with P.H.D consumers with ages from 31 upwards having a higher level of objective

knowledge, this could be due to perceived risks on health, this might lead them to do more research on the topic hence gaining more objective knowledge. Bachelor and Master Students under the ages of 31 had a lower objective knowledge level. This could be due to the fact that, they are majoring in one particular course at School that doesn't require the knowledge use of GM food, most of their source of information was through friends.

Table 1. Demographic description survey

Variable	Characteristic	Sample Number	Sample (%)
Gender	Male	309	60.8%
	Female	200	39.2%
Age Range	20-30	290	56.97%
	31-44	122	23.97%
	45-54	44	8.64%
	55 or older	53	10.41%
Education	PHD	76	14.93%
	Masters	146	28.68%
	Bachelor	182	35.76%
	High School	105	20.63%
Income	10,000>	50	9.82%
	6001-10,000	56	11.00%
	3001-6000	108	21.21%
	501-3000	210	41.25%
	100-500	85	11.39%
Heard?	Yes	459	90.18%
	No	50	9.82%
Source	Personal Research	157	57%
	School	24	9%
	Friends	60	22%
	TV	32	12%

Table 2. True or false questions

Questions	True	False
a. The term GM food stands for Genetically modified Foods.	93.12%*	6.88%
b. Transferring genes from animals to plants is scientifically possible	85.66%*	14.34%
c. Genetic Engineering is new technology	17.29%	82.71%*
d. GM foods can be engineered to have longer shelf life	85.46%*	14.54%
e. GMO's decreases infection by bacterial and fungal pathogens	88.02%*	11.98%
f. Gm food are good for solving food problems because they increase yields	83.10%*	16.90%
g. GMO's can actually help out small farmers	84.87%	15.13%
h. Eating Gm foods will modify a person's genes	10.61%	89.39%*
i. Foods with GMO's contain fewer nutrients	14.73%	85.27%*
j. GMOs are bad for the environment	15.91%	84.09%*

Note that, answers with asterisks (*) are the required answers.

Table 3. Objective knowledge of consumer knowledge groups

Level	Number	Mean	S.D	%Level
High School	105	31.19	5.167	87%
Bachelor	182	30.92	6.381	86%
Masters	146	29.61	7.563	82%
P.H.D	76	33.36	5.520	93%

Note that mean points are calculated based on the four-level scale educational level including High School, Bachelor, Masters and P.H.D

4.3 Reliability Test

Cronbach's Alpha Reliability test was used to test the reliability of the three constructs, Knowledge, Trust and Attitude. Results in Table 4 indicated that they were all at an acceptable and significant level of reliability, as a result all three constructs were kept.

4.4 Proposed Model

According to 1, the model is created to address one eventuality. Modelling without covariance regression on the latent variables is what this scenario entails. In other words, Latent variable covariances must be used in Modelling for the model. In order to assess the significance of modelling covariance correlation between latent variables, this is done.

4.5 Model Fit

This step is based on examining model fitness of the model by assessing model fit Indices.

Based on the Table 5, RMSEA denotes root mean square error of approximation; GFI denotes goodness of fit index; AGFI denotes adjusted goodness of fit index; IFI denotes incremental fit index; CFI denotes comparative fit index; NFI denotes normed fit index; TLI denotes Tucker– Lewis index or non-normed fit index (NNFI); PGFI denotes parsimony goodness of fit index; and CN denotes critical number. Ten out of 11 types of fit measure verified the model fitness. The fit in (Table 6) showed that the model acceptably fits the sample data.

Table 4. Cronbach's reliability test results

Construct	Item	Mean Value	Standard Deviation	Cronbach's Value
Knowledge	Know1	3.73	.774	.709
	Know2	3.66	.745	
	Know3	3.73	.724	
Trust	Trust1	2.55	.874	.712
	Trust2	2.16	.655	
	Trust3	2.45	.608	
	Trust4	2.08	.774	
Attitude	Attitude1	3.55	.992	.789
	Attitude2	3.25	.797	
	Attitude3	3.67	.733	
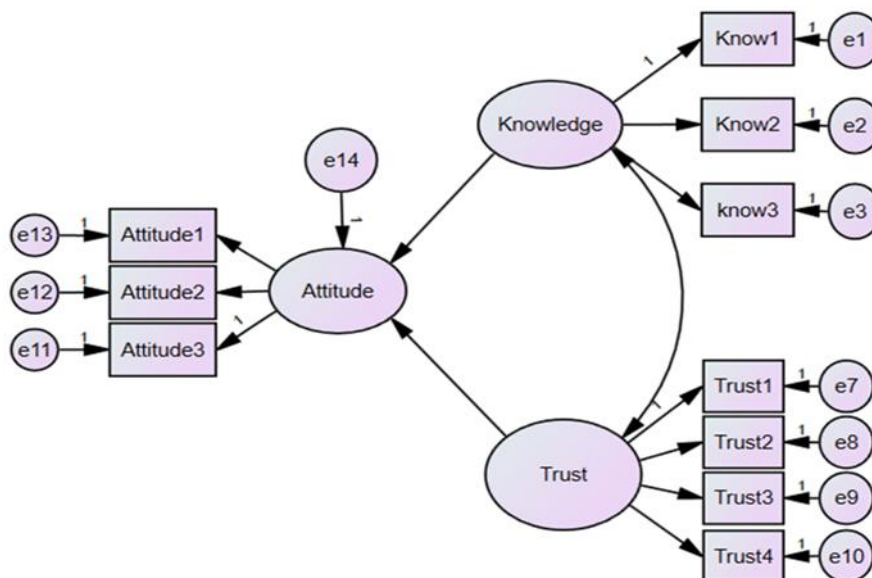
Fig. 2. Proposed structured model

Table 5. Model fit indices

Model Fit Indices	Model Fit Summary	Recommended Values
X^3	.000	>0.05
X^3/df	3.217	<5.0/3.0
RSEA	.066	<.08
GFI	.962	>.90
AGFI	.962	>.90
IFI	.964	>.90
CFI	.964	>.90
NFI	.949	>.90
TLI	.950	>.90
SRMR	.0489	<.09

4.6 Performance of Variances and Covariance among the Exogenous Variables

The variance is the expected squared deviation of a random variable from its population mean in probability theory and statistics. Variance is a measure of dispersion, or how far apart from the mean a group of data are from one another.

SEM analysis in Table 6, showed the parameters with Attitude of GM foods having the largest impact on Knowledge. Trust was found to affect respondents' willingness to accept GM food negatively, which is in line with [18]. "***" indicates that the estimated path coefficients are highly statistically significant, with an extremely low probability of the observed results occurring by chance. This is good news and suggests that the model fits the data well, and the estimates coefficients are reliable and robust. The effect of the two constructs on the willingness to accept GM foods was statistically significant.

Table 6. Regression weights estimates on observes against variables

Variables		Estimate	S.E	C.R	P-Val
Attitude ⬅	Knowledge	.259	.05	5.519	***
Attitude ⬅	Trust	-.651	.06	-11.003	***
Know1 ⬅	Knowledge	1.000			
Know2 ⬅	Knowledge	.912	.06	15.996	***
Know3 ⬅	Knowledge	1.028	.06	16.919	***
Trust1 ⬅	Trust	1.000			
Trust2 ⬅	Trust	1.953	.06	15.220	***
Trust3 ⬅	Trust	1.606	.05	11.643	***
Trust4 ⬅	Trust	.929	.07	13.654	***
Attitude3 ⬅	Attitude	1.000			
Attitude2 ⬅	Attitude	.938	.06	15.812	***
Attitude1 ⬅	Attitude	1.029	.07	15.063	***

Table 7. Standardized regression weight

Variables		Estimate
Attitude ⬅	Knowledge	.252
Attitude ⬅	Trust	-.612
Know1 ⬅	Knowledge	.781
Know2 ⬅	Knowledge	.739
Know3 ⬅	Knowledge	.858
Trust1 ⬅	Trust	.858
Trust2 ⬅	Trust	.861
Trust3 ⬅	Trust	.590
Trust4 ⬅	Trust	.709
Attitude3 ⬅	Attitude	.842
Attitude2 ⬅	Attitude	.732
Attitude1 ⬅	Attitude	.693

In this scenario (Table 7), it is seen that, when Knowledge goes up by 1 standard deviation, attitude goes up by 0.252 standard deviations. When trust goes up by 1 standard deviation, attitude goes down by 0.619 standard deviations, meaning knowledge has a much larger and positive impact on attitude than trust amongst Ghanaian citizens.

5. CONCLUSION

Genetically modified foods are a constant and growing part of our food chain. In Ghana, consumer understanding and awareness of genetically modified foods are progressively rising. SEM analysis that showed the parameters with Attitude of GM foods having the largest impact on Knowledge. Trust was found to affect respondents' willingness to accept GM food negatively. According to our study, the majority of consumers relied much on their knowledge instead of Government or Governmental Institutions. Level of education somewhat has a positive impact on consumers objective knowledge level.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Construct	Indicator	True	False
Knowledge	X1: Transferring genes from animals to plants is scientifically possible X2: Genetic Engineering is new technology. X3: GM foods can be engineered to have longer shelf life.		

Construct	Indicator	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Trust	X4: If GM foods have been investigated and approved by government, it is safe to eat. X5: I trust University Scientist and researchers in biotechnology to give careful and reliable reports about GM food. X6: I trust myself to monitor my diet and avoid GM food. X7: I trust labeling system can help consumers to identify GM food.					
Attitude	X8: The issue about GM foods does not really concern me. X9: Allergies may result from the use of transgenic technologies in food production. X10: The production of genetically modified foods has the potential to improve present and future food security.					