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Trust, Perceived Risks and Consumers Attitude Towards Genetically Modified (GM) Foods: Evidence from Rwanda.

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Abstract

Since the mid-1990s, Genetically Modified food (GM food) has been developed. This innovation increased commercially and has been available on markets for nearly 25 years now. This biotechnology innovation allows farmers in different countries to increase productivity through bioengineering that lowers the amount of pesticide and herbicide used on plants. However, there's still a limited acceptance by consumers probably because consumers' knowledge toward GM food has not relatively increased, generally, consumers present some misconception on benefits and risks toward GM food. Most consumers' sources of information on GM food are from the internet and media, the sources that are considered to give less reliable information compared to report with more facts mostly from university scientists and biotechnology researchers or the government that carefully monitor the use of GM food and regulates its use. This study will essentially identify factors that could influence consumers' acceptance of GM food, as one way to increase Agriculture productivity in Rwanda. This study would assist leaders, policymakers, and other governmental agencies in understanding the significance of attributes that influence consumers' attitudes toward the acceptance of GM food. The study conducted an online survey among which 417 qualified samples were analyzed through a logit statistic model in SPSS. The result of the empirical analysis found that consumers *Trust* more the government, university scientists as well as biotechnology researchers for balanced and trustworthy reports regarding genetically modified food, also that consumers who perceive more benefits toward GM food positively form an attitude toward the acceptance of Genetically Modified food. It is recommended that consumers should be more educated to diminish the misconception toward genetically modified food. A high number of consumers trust the government to give trustworthy information, it is suggested that the government could use this occasion to communicate effectively about the benefits and risks toward genetically modified food (GM food) for consumers' better perception. According to the findings of this study, the perception of more benefits will lead to high acceptance of genetically modified food.

Keywords: Trust, perceived risk and benefit, consumer's acceptance, Attitude, Genetically modified food (GM food).

1.0 INTRODUCTION

1.1 Research Background

Consumers are very concerned about what they consume (Hossain et al., 2016). (Hossain et al.; BJAST, 14(5): 1-12, 2016; Article no. BJAST.22873). Consumers Scientists say: "We are what we eat." Though recently consumers have been eating food with some of the unknown ingredients. Consumers are concerned with where the new food comes from and what it is made of when it's processed (Rollin et al., 2011). Every day, consumers need to make choices, from the time to get up in the morning, deciding what to wear, eat, and do, to take difficult decisions with far-reaching consequences. Making choices is a result of weighing the alternatives that go in hand with knowledge, trust, and trade-offs between perceived benefits and risks. Scientists work restlessly to improve the production of food to solve the challenge of ensuring food security for the teeming population particularly those of developing regions of the world. This includes innovating new agriculture means considering the climate change and declining access to agriculture land. In recent decades some food innovations have been suggested to tackle the growing challenges of food security in most developing countries (Boratyńska & Huseynov, 2017). Among these, there are Genetically modified organisms (GMO), defined by the World Health Organization as "Plants, animals or microorganisms in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and /or natural recombination."

These GMO food products are produced by using biotechnological techniques specifically genetic engineering to introduce a foreign gene of interest in an organism (Lucht, 2015), Food product created in this way they are mainly labeled as GM foods or GMO foods (World health organization, 2014) (World Health Organization (WHO), 2020).

Looking on the positive side, on one hand, it is proved that genetically modified plants and animals are used to enhance the food supply, mostly related to nutrition, shell life, taste, and quality of food. Different people claim that the new biotechnology provides more food resources to feed the swiftly growing world population where GM crops are more resistant to adverse environmental conditions such as frost, drought, and saline soil. They

use a low amount of pesticide and herbicide too. therefore, this results in an increase in farming productivity and lower crop costs which leads to lower market food prices and higher income for farmers (Lucht, 2015).
Over the last two decades, multiple studies have been conducted around the world to investigate consumer attitudes and purchase behavior regarding GM food. Most of that research includes a question about consumers' socio-demographic background, how aware they are, and how they view the benefits and risks of GM food. The trust of consumers in the information sources such as the science community, health professionals, government and media are among the topics studied.
Recently, over 100 Nobel laureates signed a petition to support the positive role of GM foods in achieving sustainable food security for the poorest people in Africa and Southeast Asia (Chen & Li, 2007; Cui & Shoemaker, 2018). However, in Africa, few countries in the continent have accepted it thus far. The political and economic elite in Africa tends to share the aversion of European consumer groups for GM food based on health and environmental concerns despite the high potential of Technology for increasing food production in Africa (De Groote et al., 2016).
To our knowledge, in Africa it is only In Nigeria, two-thirds of respondents disapproved of the use of GM technology (Kushwaha et al., 2008), but in Kenya, most respondents had a positive attitude towards GM maize (Bett et al., 2013). Several factors have been shown to affect the acceptance of GM food by consumers (Akter et al., 2016), however, the most hesitant consumers of GM foods are typically relatively more risk-conscious (Costa-Font et al., 2008).
The Rwandan government is considering permitting the cultivation of GM potato variety "Victoria" which will be the first-ever genetically modified crop to be grown in the country. However, there is no conducted study to analyze the consumer's knowledge, trust, and perception toward GM food in Rwanda.
Therefore, this study aims to enhance the understanding of consumers' attitudes toward GM food by evaluating responses from a comprehensive survey conducted to measure the knowledge, trust, and perception of Rwandans about GM food and determine if they are willing to accept these products.
One of the main challenges of introducing GM foods into the Rwandan market is their acceptance by the public. Our main contribution to the existing literature centers on exploring some "conventional" variables that have typically influenced consumer attitudes around the world toward genetically modified foods to hold for Rwandans.

2.0 LITERATURE REVIEW

According to the most accepted theory of the formation of consumer attitude which is based on Fischbein's (1963) multi-attribute attitude model, attitude toward the product is based on knowledge about the product itself as well as its attributes. From there, Bredahl et al. (1998) developed a more detailed model for the consumer attitude explanation regarding GM food, which suggests that Attitude toward genetically modified food technology is defined overall by weighting perceived risks and benefits associated with both the product and the process. Costa-Font et al., (2008) confirmed this theory with an explanatory process of GM food acceptance that states consumer decision making as a multi- stage process. In their model, the attitude toward acceptance is driven by the risk perception associated with GM food, where knowledge is considered as a predictor of risk perception.
Figure 1 describes a conceptual model for exploring consumers' attitudes toward the acceptance of GM food, where perceived risk and benefit influenced by knowledge and trust and subsequently influence consumers' attitude to accept genetically modified food.

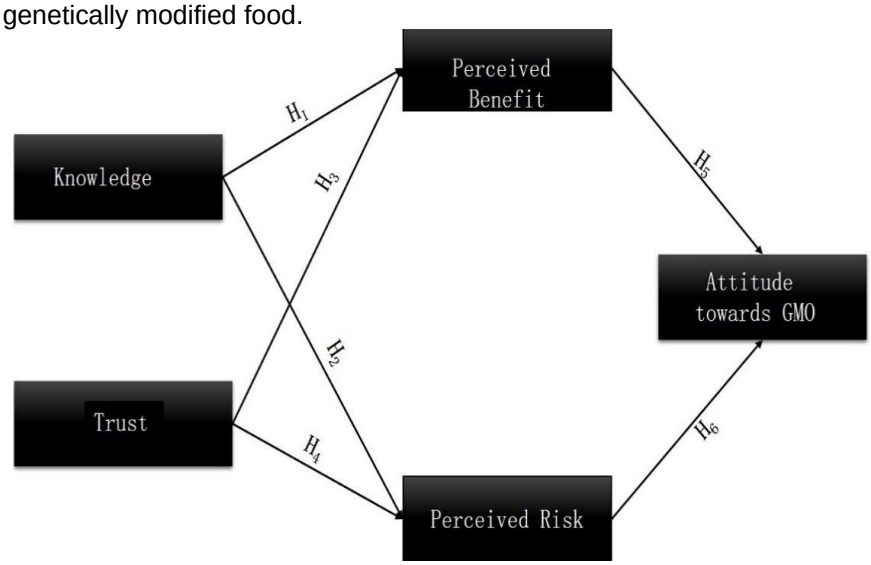

Figure 1: Proposed framework of the study

2.1 Theoretical framework and Research Hypothesis

2.1.1. Consumers' Knowledge

Consumers' knowledge of GM technology and foods plays an essential function to predict how consumers perceive the benefits and risks that are associated with GM food and consequently affects the decision making of its acceptance (De Steur et al., 2010; Frewer et al., 2013). In general, consumers knowledge about genetically modified technology and foods is low (Chen & Li, 2007), and this is the main problem that leads to uncertainty toward GM food. Literature suggests that mere improvement in consumer knowledge would decrease the confusion and help consumers make a good decision under the condition of being fully aware (Muhammad Asim Nawaz et al., 2019; S. M. Wunderlich et al., 2016)

However, consumption choices are a set of diverse factors such as sensorial, social, cognitive, situational, cultural, and demographic characteristics therefore, some research gives a shred of evidence that indicates that knowledge about GM food cannot positively affect consumers' acceptance. (Verdurme & Viaene, 2003). Some studies note that the more knowledge consumers receive about GM food the more it stimulates the initial attitude than changing these attitudes, in other words, consumers' opposition toward this new technology remains rather than being diminished by new information that has been provided for them. (Grunert et al., 2000; Vecchione et al., 2015; S. Wunderlich & Gatto, 2015) Another study suggests that consumers educated with objective knowledge might guide them to weigh risks and benefits rationally and thereby increase their positive attitude toward Acceptance of GM food (Frewer et al., 2003). Therefore, consumer perceived knowledge might play a key role in determining consumers' attitude towards GM food (Aleksejeva, 2014; Muhammad Amjad Nawaz et al., 2019)

Hence, we propose that:

H_1. Perceived benefit offered by GM foods increases according to consumers' knowledge

H_2. Perceived risk offered by GM foods decreases according to consumers' knowledge

2.1.2 Consumers' Trust

Consumers acquire insufficient knowledge regarding Genetic engineering, this results in being unable to decide for themselves whether GM food carries risks and to weigh that against possible benefits (Lucht, 2015). For that reason, consumers' trust relies on people they regard as trustworthy experts to be informed. This is also called: "social trust" (Trevathan-Tackett et al., 2018). Here, Scientists and trusted companies researching biotechnology strongly affect how consumers perceive risks and benefits associated with these new technologies (Siergriest 1999-2000) (Sierka, 2011). Public risks and benefit perception plays a significant role in the acceptance of GM food (Chen & Li, 2007). It was explained that perceived risks and benefits associated with biotechnology were used by Siegrist & Cvetkovich, (2000) and found that social trust is positively related to perceived benefit (explaining 19% of the variance) and negatively related to perceived risk (explaining 34% of the variance). Trust has been the center of controversies regarding the returns and drawbacks of GM products. On one hand, Some Scholars argue that trust does not directly influence consumer Attitude toward GM food (Chen & Li, 2007; Costa-Font et al., 2008; Prati et al., 2012). Also, psychological factors such as the strength of prior attitudes toward a particular technology have been shown to limit the impact of trust on attitude change following information interventions (Frewer et al., 2003).

On the other hand, as the study mentioned before, scientists declare that consumers often employ social trust to cope with the lack of knowledge about new technology (Earle & Cvetkovich, 1995). Therefore, this study examines social trust toward GM food in Rwanda. The following hypotheses are proposed

H3: Perceived benefits offered by GM food increase according to consumer's trust in Government, scientists, and the labeling system.

H4: Perceived risk offered by GM food decrease according to consumer's trust in Government, scientist, and the labeling system

2.1.3 Consumers' benefit and risk perception toward Attitude.

Consumer's perception of risks and benefits associated with GM technology highly influence consumer's attitude toward GM food (author, year) (Montesinos et al., 2016). GM food is seen as an unforeseen risk; it is only embraced when GM food shows clear benefits (Krystallis & Ness, 2005). The literature has shown that personal values and ethics deeply offset consumers' risks and benefit perception. It has been also claimed that values held by a certain society are overall shaped by ethical beliefs, their concerns about new kinds of food, food security, climate change, and increasing in environmental regulations which consequently affect their attitude toward the acceptance of Genetically modified food (Frewer et al., 2014).

Generally, consumers' benefit perception influences positively the attitude toward genetically modified food whereas perceived risk negatively impacts. When it comes to the trigger of benefits and risks perception, perceived benefits are based on environmental concerns, especially the depletion of energy and chemical inputs, which consequences in healthier food, high yields, abundance, and lower food prices. However, risk perception includes unknown long-term effects, allergies, environmental and social problems (Amin et al., 2014).

New technology, new product, all require consumers' acceptance, where the consumer's attitude toward the acceptance of Gm food is critically affected by how they positively or negatively perceive GM food.
Some studies suggest that perceived benefits affect more consumers' attitude toward acceptance (Bredahl et al., 1998; Chen & Li, 2007; Prati et al., 2012) where as some argued that consumers perceive more risk than benefits (Amin et al., 2013; Gaskell et al., 2004).
However, the conclusion cannot be generalized because of cross-county differences. This calls for further examination, therefore the following hypotheses are proposed:
H5: Attitude toward GM foods increases according to consumers' perceived benefits.
H6: Attitude toward GM food decreases according to consumers' perceived risks.

2.4 Problem statement

Efficient food systems begin and end with health-positive nutrition outcomes. Given the high level of poverty, malnutrition, hunger, low agricultural productivity in Africa, and future shortage of food which could occur due to climate change (Godfray et al., 2010), advanced technology like GM technology seems to have the potential to offer solutions. Moreover, considering current environmental problems that are increasingly jeopardizing the earth's life support system such as the high amount of pollution, excessive land use, and resource depletion it is important that GM food will be considered as a solution (Rockstrom et al., 2009). However, the controversy over the use of GM technology remains one of the biggest threats in adopting this new technology.
There is an urgent need to improve agricultural production and GM technology can be a part of the solutions in cases where traditional methods of farming have been less efficient. The adoption of GM technology would play a significant role in the Rwandan economy in terms of gross domestic product (GDP), promoting international trade, industrial development, and the creation of job opportunities. It is, therefore, important to witness that consumers' perception and Attitude toward genetically modified food needs to be determined. It is on this account that the present study seeks to denote the major factors that influence consumer's perception and attitude toward genetically modified food in Rwanda.

2.5 Research Objectives

This study focuses on the identification of the relationship of Rwandans' trust, risk perception, and attitude toward Genetically Modified food. It is with that motive that this research is intending to evaluate what drives Rwandans' Attitude toward Genetically modified food. The specific research objectives of this study are as follows:

i. To examine the influence of knowledge on perceived benefit and risks and how it affects decision making and attitude toward genetically modified food.
ii. To evaluate the consumers 'perception toward Acceptance of Genetically Modified Food.
iii. To evaluate whether the consumer's trust toward the government, scientist or labeling as the source of information influence the consumers' perception toward Genetically Modified Food.

2.6 Research Significance

It is of great importance that this study consults Rwandans consumers' attitudes toward Genetically Modified Food from a varied perspective which could assist the government, scientists, and policymakers to better understand consumers' attitudes and intentions and enact efficient biotechnology policy. By using the logistic statistical model to analyze Rwandans' consumers' attitudes, we will have an overall picture of the consumers' decision process which includes individual attributes and values, knowledge about genetically modified food, consumer's trust, and their perception of both risk and benefits.
The research will give Rwandans a place to express their feelings and expectation about the adoption of GM food in Rwanda. The research will also serve as a reference for further studies in consumer's attitude analysis toward GM food. This research will contribute and surely convince policymakers to review plans and policies towards the adoption of GM food.

3.0 METHODOLOGY

The chapter begins with a description of the study area. The research design and population are also discussed. This chapter also presents the design and administration of the choice experiment survey. The chapter ends with a description of the method of data collection.

3.1 Study area

This research is designed to study and solicit information from Rwandan residents. Rwanda also Known as the "Land of a Thousand Hills," Rwanda rests just below the equator and its small size has a rich geography with mountains, savannas, and many lakes. This landlocked country is at a high altitude of 4,800 feet (1,463 m). The country is divided by great peaks of up to 3, 000m (9,842ft) which run across the country from north to south.

The capital city is Kigali – one of East Africa's fastest-growing cities with an estimated population of over 12 million people.
Rwandan economy is based on subsistence agriculture and the people grow enough food to feed their families. To feed the people, almost every available piece of land which is not designed for the population habitation is under cultivation, except where there's Akagera park (along the border with Tanzania) and the higher slopes of the Virunga volcanoes. Rwanda is a country with high altitude located in East Africa, where rainfall is the most important climate variable.

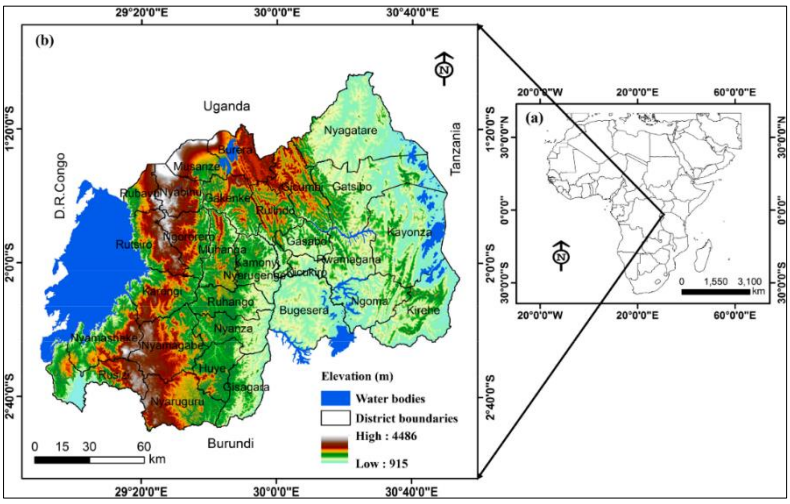

Figure 2: Location of Rwanda on (a) map of Africa (b) Physical map of Rwanda.
Source: Adapted from Nsengimana et al. 2018, The elevation (shaded in meters), lakes, and district boundaries

The Rwandan country was chosen as the study area primarily selected after concluding no research has specifically studied the consumer's perception and attitude toward GM food though such forms of research exist for different African countries(D. Zhang & Guo, 2011). Tianjin (Jia et al., 2018) and Suzhou (Wang et al., 2016). Furthermore, Rwanda is considering permitting the cultivation of GM potato Variety "Victoria" which will be the first-ever genetically modified crop to be grown in the country. However, no study was conducted to analyze the consumer's knowledge, trust, and perception toward GM food.

3.2. Sample size

According to Kearl et al. (1994), a sample is the preferred group of elements or units taken from a greater whole of all the elements or community that the study attempts to infer.
The selection of the sample size is the key importance if the research indeed wants to ensure representativeness of the population under analysis. Marshall and Rossman (2014) point out that, for a sample size to be considered as optimum for a study or research, it should fulfill some basic assumptions and requirements such as representativeness, efficiency, flexibility, and consistency. Even though it has been opined in earlier discussions and commentaries that the best method of determining a sample size is by the use of confidence interval approach, Bradley and Henseler, (2007) argue that researchers on what is feasible within time or money available decide many sample sizes for research studies. The sample size for this study was made up of 417 respondents;
All 417 were in the best position to provide the information that was needed by the research. The participants were Rwandans from various neighborhoods in five cities that geographically cover a substantial portion of Rwanda.

3.3. Data collection

Survey: The data collection tool that was used in this study was a structured questionnaire. A self-administered questionnaire was made up of predominantly closed-ended questions. The study adopted an internet-administered questionnaire because it is a simpler, faster, and cheaper source of soliciting information for subsequent processing. Such questionnaires can be administered to many respondents simultaneously. Respondents only need to be connected to the internet, read the questions, and fills in the answers by themselves without any form of influence whatsoever.
The questionnaire was designed based on the literature review. The items in the questionnaire are based on the research objectives and reviewed literature and it was designed to capture all the relevant information regarding the proposed research topic and the proposed hypothesis using a variety of question types. The

questionnaire is divided into four (4) sections. Section one (1) collected data on respondents' demographic information. This section asked questions about Gender, age, living area, education level, income level, and whether there is any child who is less than 18 years living in the respondent's household. Section two (2) looks at biotechnology and genetically modified food awareness. Section three (3) focuses on consumers' perception and attitude toward GM food. Section four (4) also looks at the consumers' trust toward the government, university scientists, and labeling when it comes to GM food.

Table 1: Construct and Indicators

Construct	Indicator	Source
Knowledge	X1: I understand very well the meaning of GM food	Author
	X2: I know biotechnology and GM food	
	X3: I feel informed about the use of biotechnology in foods	
Trust	X4: I trust University scientists and researchers in biotechnology to give carefully reports about GM food.	(Y. Zhang et al., 2018)
	X5: I trust the government has monitored carefully the use of GM food	
	X6: I trust labeling system can help consumers to identify GM food.	
	X7: I trust myself to avoid eating GM food	
	X8: I trust myself to monitor my diet and avoid GM food	
Perceived benefit	X9: GM food increase crop yields and is useful to fight against hunger	(Prati et al., 2012)
	X10: GM food can solve environmental problems	
	X11: GM food industry in a long run will be good for the economy	
Perceived risk	X12: Eating GM food will be harmful to me and my Family's health	
	X13: Growing GM food will be harmful to the environment	
	X14: Application of transgenic technology in food production can cause allergies	
Attitude	X15: Production of GM food can improve current and future food security	(G. M. Rodriguez, 2013)
	X16: For the whole society, the benefits of GM food are greater than the risks	
	X17: Application of transgenic technology in food production can cause allergies	Author

Source: Researcher's survey response, December 2020

3.4 Data Quality

Reliability and Validity help not only to establish the trustworthiness of any study but also to constitute the credibility of the research (Saunders et al., 2009). They are, therefore, a very important part of the measurement process of research. Neuman, (2005) argued that once a concept has been operationalized by proposing a way to measure such a concept, the measurement device should be both valid and reliable.

Reliability: Refers to the consistency to attain the same results again using the research instrument (Neuman, 2014) Peterson, 2001). Reliability assessment of the research instrument is very important because it determines the inconsistencies that exist in the items or questions used in the measurement of the results. (Neuman, 2014) stated that though reliability can be indirectly inferred by validity, the reverse is not true.

Deducing from Neumann's argument, it could be stated that if a measure is valid, it is reliable; and if it is not reliable, it cannot be valid. However, if a measure is reliable, it cannot automatically infer validity even though it is a very good indicator of obtaining measurement validity.

Measurement of the reliability (internal consistency) of the instrument can be done by computing the Cronbach's coefficient alpha for each variable. Cronbach's alpha is one of the most commonly used metrics in evaluating the internal consistency reliability related to scores derived from a scale or set of questions.

In this study, the question items used had been confirmed reliable. Hundleby (1968) recommended that the corrected item-total correlations that have a reliability of 0.7 or higher for the early stage of the research of regarded as acceptable, reliable, and good for analysis. Consequently, this study remained with the four constructs (Trust, Attitude, perceived benefits, perceived risks) having Cronbach values ranging from 0.717 to 0.736 and dropped the variable of knowledge which had Cronbach's alpha of 0.494 for further analysis**.**

Table 2: Cronbach's Alpha reliability test results

Variables	Cronbach's Alpha
Knowledge	.494
Trust	.735
Perceived benefits	.736
Perceived risks	.717
Attitude	.726

Source: Researcher's survey response, December 2020

3.5 Data Analyses

Data collected was subject to both descriptive and inferential statistics. Data on knowledge, trust, risk and benefit perception, as well as consumer's attitude toward GM food were downloaded from the survey platform and were generated using Statistical Package for Social Science (SPSS) for analysis and interpretation of the information. Hypothetical statements were estimated, and analysis was done using SPSS statistics 26.

3.5.1Variables and Measurement Procedures

There are two types of variables; dependent and independent variables. A dependent variable change in response to changes in other variables. An independent variable causes change in a dependent variable. This study measurement is based on 5 variables and 17 specific indicators (Table 2), which are based on several scales in relevant studies that have high reliability and validity. To minimize the bias of submitted responses, most questions were designed using Likert' five-scale method. Such as the possible options for the variable *consumer acceptance of the production of GM food to improve current and future food security* were "strongly disagree," "disagree," "neutral," "Agree," "strongly agree," coded from 1 to 5. Meanwhile, the variable is categorical with an unequal interval between any two categories, the variable could not be analyzed using the ordered logit model. We recoded a binary variable with "Agree=1" for "Agree" and "strongly agree," and "otherwise=0" for "strongly disagree," "disagree," and "neutral." Dummy variables were also created for reliable independent variables. Moreover, the binary variable similarly accelerates an easy understanding of the economic meaning of the variable. This method has been widely employed in agricultural economics, such as Yu et al. (2020).

Table 3: Description of survey Question

Variable	Description of survey Question	Mean	Standard deviation
Attitude	Do you believe that the Production of GM food in Rwanda can improve current and future food security? (Agree =1, otherwise =0)	.60	.491
Trust	Do you trust University scientists and researchers in biotechnology to give careful reports about GM food? (Agree=1, otherwise=0)	.49	.500
	Do you trust the government to give carefully reports about GM food? (Agree=1, otherwise=0)	.29	.457
	Do you trust that labelling system can help consumers to identify GM food (Agree=1, otherwise=0)	.22	.412
	Do you trust yourself to avoid eating GM food? (Most certain =1, impossible=0)	.27	.444
	Do you trust yourself to monitor your diet and avoid GM food (most certain =1, impossible=0)	.33	.471
Perceived benefits	Do you believe that GM food can increase crop yields and be useful to fight hunger? (Agree=1, otherwise=0)	.72	.450
	Do you believe that GM food can solve environmental problems? (Agree=1, otherwise=0)	.40	.491
	Do you believe that the GM food industry in a long run will be good for the economy? (Agree=1, otherwise=0)	.62	.485
Perceived risks	Do you think that eating GM food will be harmful to you and your Family's health? (Agree=1, otherwise=0)	.54	.499
	Do you think that Growing GM food will be harmful to the environment? (Agree=1, otherwise=0)	.37	.483
	Do you think that the Application of transgenic technology in food production can cause allergies (Agree=1, otherwise=0)	.45	.498

Source: Researcher's survey response, December 2020

3.5.2 Binary logistic regression

Considering the previous studies that have done empirical research on consumer attitude and its correlation with different explanatory variables such as consumer perception and consumer knowledge using Binary logistic analysis (Teng & Jusoh, 2018) we run a logit model to explore consumer attitude toward the acceptance of GM food. This study used (dichotomous) binary logistic regression equation with *I* independent variable.

A logistic regression model allows us to establish a relationship between a binary dependent variable and a group of predictor variables. It models the logit-transformed probability as a linear relationship with the predictor variables. To start, Let Y be the binary dependent variable indicating whether consumers attitude agreeing that the production of GM food in Rwanda can improve current and future food security or otherwise with$\{0,1\}$, and (p) be the probability of (y) to be 1,$p = P(y = 1)$. let $x_{1,}$…….,x_k be a set of predictor variables. Then the logistic regression of y on $x_{i,}$…….$x_k$estimates parameter values for β_0+β_1+……+β_k, and ε the random error term (assumed to follow a standard normal distribution). Here below the binary logistic regression equation with l independent variable is given by:

$$\log \mathrm{p} = \beta_0+\beta_1 \mathrm{x}_1+\beta_2\mathrm{x}_2+\ldots\ldots\ldots+\beta_k \mathrm{x}_\mathrm{k} + \varepsilon \ (1)$$

Where $\mathrm{Logit(P)} = \ln[\frac{P}{1-P}]$

This will give us

$$\mathrm{Logit(P)} = \ln[\frac{P}{1-P}] = \beta_0+\beta_1 \mathrm{x}_1+\beta_2\mathrm{x}_2+\ldots\ldots\ldots+\beta_k \mathrm{x}_\mathrm{k} + \varepsilon \quad (2)$$

We have to consider the antilogarithm of the above formula as we convert the formula to represent the probability:

P $(y = 1)$, we get:

$$e^{log(p)}=[\frac{P}{1-P}]\, e^{\beta_0+\beta_1 \mathrm{x}_1+\beta_2\mathrm{x}_2+\ldots\ldots\ldots+\beta_k \mathrm{x}_\mathrm{k}+ \varepsilon} \ (3)$$

That is a formulation that helps us to remove the impact of the independent variable on the odds of P $(y = 1)$ in respect to its reciprocal [1-P $(y = 1)$]. In the case of dummy independent variables (which are coded with values 1 and 0). The exponents of coefficients illustrate the odds ratio between the odds of an event happening $(y = 1)$ when the same variable changes from 0 to 1, while the remaining independent variables assume the value 0. If we include the variable x_1 we obtain:

$$\frac{[\frac{P}{1-P}]\mathrm{x}_1=1}{[\frac{P}{1-P}]\mathrm{x}_1=0}=\frac{e^{\beta_0+\beta_1 (1)}}{e^{\beta_0+\beta_1 (0)}}=e^{\beta_1 (1)-\beta_1 (0)}=e^{\beta_1} \ (4)$$

Beginning with P $(y = 1)$:

$$[\frac{P}{1-P}]=e^{\beta_0+\beta_1 \mathrm{x}_1+\beta_2\mathrm{x}_2+\ldots\ldots\ldots+\beta_k \mathrm{x}_\mathrm{k}+ \varepsilon},$$

We can isolate the expected probability P $(y = 1)$:

P $=e^a[1 - P]$, with a=$\beta_0+\beta_1 \mathrm{x}_1+\beta_2\mathrm{x}_2+\ldots\ldots\ldots+\beta_k \mathrm{x}_\mathrm{k} + \varepsilon$,

This gives us:

$\mathrm{P} +e^a[1 - P]=e^a$

$(1 + e^a)\mathrm{P}=e^a$

$\mathrm{P}=\frac{e^a}{(1+e^a)}$ (5)

This formula above, like linear regression, includes testing the effects of each independent variable's variance regarded as the Dummy variables (as in this study, shift from 0 to 1) on the dependent variable. In this study P $(y = 1)$ stands for the probability of consumers agreeing that, the production of GM food in Rwanda can improve current and future food security.

The probability where P $(y = 0) = [1 - P]$ is equal to:

$$\mathrm{P}\ (y = 0)=\frac{\frac{e^a}{1+e^a}}{e^a}=\frac{1}{1+e^a} (6)$$

4.0 Analysis, Interpretation, And Discussion Of Results

This chapter presents the findings of the study also analyses and discusses the results by comparing them with reviewed literature. Findings include measurements of the correlations between explanatory variables and the dependent variable as well as the analysis and discussions of hypotheses. This chapter is divided into two main sections. Section 4.1 deals with the descriptive analysis of the demographics together with the set of variables used in this study while 4.2 analyses the data set quantitatively. The descriptive analysis uses tables and graphs while the quantitative method using the logistic model analysis to analyses data. The data gathered are analyzed using the computer software- Statistical Package for Social Services (SPSS) statistic 26 packages.

4.1 Demographic descriptive analysis

The Demographic descriptive aspect represents respondents' frequency, mean, and percentage in terms of the question evaluated. Also, it deals with the use of tables and histograms to show results in consideration of the sample size used. The variables used include gender, the age range of respondents, living area in Rwanda, level of education, employment status, the monthly personal income range in Rwandan Francs (RWF), and also if the respondents' households have any child under 18 years old. The study also evaluates the number of respondents who are aware of GM food. The table below represents the responses of the 417 respondents who answered the questionnaire.

4.1.1 Gender

The Gender demographic information obtained showed that male and female respondents of the survey were 65.9% and 34.1 % respectively.

4.1.2 Age range of respondents

The age data as shown in table 4 it was realized that the age group 20-30 years old dominated the distribution with 254 respondents constituting 60.9% followed by the age group of respondents ranging from 30 to 40 years old with 138 respondents also constituting 33.1%, which is keenly followed by respondents aged between 40 to 49 years old and the age group under 20 years with 3.6% and 2.2 % respectively. The least year group was those above 50 with 1 respondent, which constitute 0.2% of the total respondents

4.1.3 Living area of respondents

The study had Rwandans respondents from different living areas. Out of the 417 respondents, 335 (80.3%) were living in the Urban area, 63 (15.1%) living in a rural area, the remaining 19 (4.6%) are in the suburb

4.1.4 Educational Background of Respondents

Bachelor and Master level of education were the two dominants among respondents. They constituted 49.2% and 26.1%, respectively, of the total respondents. High school respondents with only 17% and those with PhD. or above were 7.6%. The probability is that since most respondents are educated, they will be very much concerned about their attitude toward the acceptance of genetically modified food.

4.1.5 Other demographics of respondents

Approximately 47.7 % of participants are students, whereas 30.2 % are hired, employees. Few numbers respondents were individual entrepreneurs with 9.4 %, and respondents who are currently not employed constituted 10.3 % of the total respondents, and respondents that were classified in another part called "other" were just 2.4 % of the total respondents. Among the respondents, people who earn less than RWF 100,000 per month are the majority with 167 (40%) of the total respondents. Also, 20.9 % earns from 200000 to 300000 of RWF, whereas respondents whose earning income range between 300000 and 400000 RWF are 12.7% in total. The respondents whose monthly income ranges from 400000 to 500000 and those who make more than 500000 are 8.4% and 18% respectively. The data from the survey also reported about 47% of Families with a child less than 18 years old and 53% don't. The findings also reveal that 236 (56.6%) respondents are aware and understand genetically modified food, 157 constituting 37.6 % of the total respondents somehow understands, where 24 respondents with 5.8% don't know and don't understand the meaning of GM food even after being given the definition.

Considering the dependent variable, the findings show that 60% of the respondents believe that the production of GM Food in Rwanda can improve current and future food security, 49 % trust university scientist and researcher in biotechnology to give carefully reports about GM foods and 72 % of respondents perceived the benefit of GM food increasing crop yields and be useful to fight against hunger. A majority (62 %) of consumers perceive GM food to be good for the economy in a long run and about 54% of consumers think that eating GM food will be harmful to them and their Family's health.

Table 4: Demographics of respondents

	Frequency	Percent
Gender		
Male	275	65.9
Female	142	34.1
Total	**417**	**100**
Age Group		
Under 20	9	2.2
20 to 29 years	254	60.9
30 to 39 years	138	33.1
40 to 49 years	15	3.6
over 50 years	1	0.2
Total	**417**	**100**
Living Area		
Urban Area	335	80.3
Rural Area	63	15.1
Suburb	19	4.6
Total	**417**	**100**
Education		
High school	71	17
Bachelor's degree	205	49.2
Master's degree	109	26.1
Doctoral degree	32	7.7
Total	**417**	**100**
Employment status		
Student	199	47.7
Hired employee	126	30.2
Individual entrepreneur	39	9.4
Currently not employed	43	10.3
Other	10	2.4
Total	**417**	**100**
	Frequency	**Percent**
Income		
less than 100,000	167	40
from 200,000 to 300,000	87	20.9
from 300,000 to 400,000	53	12.7
from 400,000 to 500,000	35	8.4
more than 500,000	75	18
Total	**417**	**100**
Child in a family		
Yes	196	47
No	221	53
Total	**417**	**100**
Knowledge toward GM food definition		
Sure, I understand	236	56.6
Somehow yes	157	37.6
No, I don't understand	24	5.8
Total	**417**	**100**

Source: Researcher's survey response, December 2020

A x^2(chi-square) tests were tested to see if there is a relationship between variables. According to the results of the Pearson chi-square test (in Table 7) implies that consumer attitude toward the acceptance of GM food is associated with most variables including trust toward university researchers in biotechnology, trust towards labeling, trust of consumers to monitor their diet and avoid GM food, perceived benefit to reduce hunger and increase crop yield, benefit to the environment and the economy in a long run.

Table 5: Definition and descriptive statistics of variables.

Variable	Description of survey Question	Mean	Standard deviation
Attitude	Do you believe that the Production of GM food in Rwanda can improve current and future food security? (Agree =1, otherwise =0)	.60	.491
Trust	Do you trust University scientists and researchers in biotechnology to give careful reports about GM food? (Agree=1, otherwise=0)	.49	.500
	Do you trust the government to give carefully reports about GM food? (Agree=1, otherwise=0)	.29	.457
	Do you trust that labelling system can help consumers to identify GM food (Agree=1, otherwise=0)	.22	.412
	Do you trust yourself to avoid eating GM food? (most certain =1, impossible=0)	.27	.444
	Do you trust yourself to monitor your diet and avoid GM food (most certain =1, impossible=0)	.33	.471
Perceived benefits	Do you believe that GM food can increase crop yields and be useful to fight hunger? (Agree=1, otherwise=0)	.72	.450
	Do you believe that GM food can solve environmental problems? (Agree=1, otherwise=0)	.40	.491
	Do you believe that the GM food industry in a long run will be good for the economy? (Agree=1, otherwise=0)	.62	.485
Perceived risks	Do you think that eating GM food will be harmful to you and your Family's health? (Agree=1, otherwise=0)	.54	.499
	Do you think that Growing GM food will be harmful to the environment? (Agree=1, otherwise=0)	.37	.483
	Do you think that the Application of transgenic technology in food production can cause allergies (Agree=1, otherwise=0)	.45	.498

Source: Researcher's survey response, December 2020

4.2 Empirical results and discussion

The dependent variable was coded as a binary to one if the respondent expressed a positive attitude agreeing that the production of GM food in Rwanda can improve current and future food security, and zero for expression of otherwise. The Model was developed to determine the best estimation among chosen and valid variables. The omnibus test of the model was calculated to establish the best fit for the model. The chi-square$x^2 = (136.690), p < 0.001$. Also, the model summary implies that the variance between 27.9% and 37.8% in the independent variable is explained by this model. The Hosmer and Lemeshow test was conducted to determine the goodness-of-fit for the selected model. Odds Ratio (OR) and 95% Confidence Intervals (CI) for OR were calculated. The percentage of classification accuracy was also calculated. A p-value < 0. 05 was considered statistically significant at 5% level while 0.05 <p-value < 0.1 was also considered significant at 10% level.

Table 6: Omnibus Tests of Model Coefficients

		Chi-square	Df.	Sig.
Step 1	Step	136.69	11	0
	Block	136.69	11	0
	Model	136.69	11	0

Source: Researcher's survey response, December 2020

These study findings confirm the variable that stands for the perceived benefit of GM food to increase crop yields and be useful to fight against hunger, perceived benefit of GM food to solve environmental problems and perceived benefit of GM food industry in a long run will be good for the economy were statistically significant at the level of $(0.000, 0.067 and\ 0.000)\ at\ p\ value\ of(\ 0.05 < p < 0.1\ )$ respectively and show a positive effect on consumers' attitude to accept Genetically modified food (Table7).

Table 7: Pearson chi-square test of independent variables

		The Production of GM food in Rwanda can improve current and future food security		
Variable		Agree =1	Otherwise=0	Pearson correlation
Do you trust University scientists and researchers in biotechnology to give careful reports about GM food?	Agree =1	134	70	5.470[a]
	otherwise =0	116	97	
Do you trust the government to give careful reports about GM food?	Agree =1	76	47	.245[a]
	otherwise =0	174	120	
Do you trust that a labeling system can help consumers to identify GM food	Agree =1	40	50	11.496[a]
	otherwise =0	210	117	
Do you trust yourself to avoid eating GM food?	Most certain =1	78	34	5.990[a]
	Impossible=0	172	133	
Do you trust yourself to monitor your diet and avoid GM food	Most certain =1	88	50	1.251[a]
	Impossible=0	162	117	
Do you believe that GM food can increase crop yields and be useful to fight hunger?	Agree =1	220	80	79.741[a]
	otherwise =0	30	87	
Do you believe that GM food can solve environmental problems?	Agree =1	130	37	37.141[a]
	otherwise =0	120	130	
Do you believe that the GM food industry in a long run will be good for the economy?	Agree =1	201	59	86.638[a]
	otherwise =0	49	108	
Do you think that eating GM food will be harmful to you and your Family's health?	Agree =1	126	98	2.763[a]
	otherwise =0	124	69	
Do you think that Growing GM food will be harmful to the environment?	Agree =1	88	66	.803[a]
	otherwise =0	162	101	
Do you think that the Application of transgenic technology in food production can cause allergies?	Agree =1	117	71	.743[a]
	otherwise =0	133	96	

Source: Researcher's survey response, December 2020

The results specify a positive relationship between consumers' Accepting that the production of GM food in Rwanda can improve current and future food security, and their perceived benefit toward the economy, solving environmental problems, and food security. The more consumers perceive benefit toward GM food the stronger their attitude toward the acceptance of GM food. The findings indicate that consumers who perceive that GM food can increase crop yield and fight against hunger are 14.9% more likely to accept that the production of GM food in Rwanda, considering that it can improve current and future food security.

Additionally, the more consumers perceive the benefit of GM food to the economy in the long run the greater likelihood of consumers' acceptance toward GM food, the findings show that this likelihood is 12.88 % with a 99% of the confidence interval. Consequently, the odds ratio implies that the odds of consumers accepting that the production of GM food can improve current and future food security is nearly 4.5 times greater for people who perceive the benefit of GM food to increase crop yield and fight against hunger as opposed to those perceive otherwise. Furthermore, the odds of consumers' acceptance of GM food is 3.6 times higher for consumers with a great perception toward the benefit of GM food to the economy in a long run compared to consumers who don't. under this model, Perceived benefit toward consumers' attitude is significant and supports *hypothesis 5.* These results suggest that the more consumers perceive the benefits of genetically modified food the more likely their attitude toward GM food becomes positive. This goes in hand with the results from previous research (Zhang, Y et al 2017, Hormoz movassaghi 2017). However, the perception of GM food to be harmful to consumer's and their family's health, to be harmful to the environment, and to cause allergies were statistically

insignificant toward the acceptance of GM food. This infers that perception of risk toward genetically modified food doesn't factor the attitude toward the acceptance of GM food, which rejects Hypothesis 6.
The results also specify a positive relationship between consumers' Accepting that the production of GM food in Rwanda can improve current and future food security, and their perceived benefit toward solving environmental problems. The more consumers perceive benefit toward GM food the stronger their attitude toward the acceptance of GM food. The findings indicate that consumers who perceive that GM food can solve environmental problems are 4.9% more likely to accept that the production of GM food in Rwanda, considering that it can protect the environment and solve the problems brought by the use of pesticides.

Table *8*: The estimation of empirical results

Variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Step 1[a] Trust to avoid GMO	0.676	0.323	4.374	1	0.036	1.966	1.043	3.706
Trust to monitor diet and GM food (1)	-0.068	0.297	0.052	1	0.82	0.935	0.522	1.673
Trust university to give reports (1)	0.628	0.313	4.028	1	0.045	1.874	1.015	3.462
Trust labelling	-0.808	0.241	11.199	1	0.001	0.446	0.278	0.715
Trust government	0.744	0.34	4.783	1	0.029	2.104	1.08	4.096
Perceived Benefit to fight hunger and increase crop yield (1)	1.487	0.284	27.421	1	0.000	4.423	2.535	7.715
Perceived the benefit to environment (1)	0.49	0.266	3.386	1	0.066	1.632	0.969	2.748
Perceive the benefit to economy in a long run (1)	1.288	0.262	24.21	1	0.000	3.624	2.17	6.052
Perceive risk to health (1)	-0.376	0.274	1.879	1	0.171	0.687	0.401	1.176
Perceive risk to the environment (1)	-0.101	0.279	0.13	1	0.719	0.904	0.524	1.562
Risk to cause allergies (1)	0.268	0.27	0.982	1	0.322	1.307	0.769	2.221
Constant	-2.145	0.389	30.428	1	0.000	0.117		

Source: Researcher's survey response, December 2020.

Consumers perception toward GM food is also promoted by the trust that consumers have for their source of information. Considering how this technology (GM food biotechnology) has created a lot of controversies and uncertainties since it's development "social trust" is regarded as one of the solutions (Trevathan-Tackett et al., 2018), therefore, the findings reveal that consumer who trust university scientist and biotechnology researchers to give trustworthy report about GM food are 6.29% more likely to support that the production of GM food in Rwanda can improve short and long-term food security. This shows that's the odds of consumer to accept that the production of GM food can increase current and future food security is about 1.876 times larger for consumers who trust the university scientist and biotechnology researchers than those who thinks otherwise. This variable is statistically significant at the level of (0.045) with a p value of ($0.05 < p < 0.1$). This finding is consistent with (Frewer et al., 2014),(Frewer et al., 2003) (Chen & Li, 2007)
Whereas the odds ratio of consumers' attitude toward acceptance of GM food is 2 times bigger for consumers who trust the government to monitor carefully the use of biotechnology and the reports regarding its use than for the consumer who perceive otherwise. This variable is statistically significant at the level of $(0.03)\ with\ (p\ value = 0.05)$. Based on the findings of this study Rwandan consumers have trust more the government, university scientist as well as biotechnology researchers on reports and information regarding GM food technology.
The estimation results indicates that the consumers' significance toward trust labelling is at the level of $(0.01)\ with\ (p\ value = 0.05)$. However, the consumers who trust labelling as the source of information and trustworthy reports are nearly 8% less likely to accept GM food. This is probably because the consumers have little knowledge toward GM food labelling. The study also investigates the level of consumers to trust avoid GM food, the findings indicates that this variable is statically significant at the level of $(0.036)\ with\ (p\ value = 0.05)$.The consumers who trust themselves to avoid GM food are 6.76% more likely to accept the production of GM food in Rwanda, considering that it can improve current and future food security. (……Zhang, Y et al 2017) Also, the odds of consumer to accept that the production of GM food can increase current and future food security is about 1.966 times larger for consumers who trust the themselves to avoid GM food than those who don't.

5.0 CONCLUSION AND RECOMMENDATION

The purpose of the study was to focuses on the identification of the relationship of Rwandans' trust, risks and benefit perception, and attitude toward Genetically Modified food. The study examined the knowledge, Trust, risk, and benefit perception toward genetically modified food in addition to the demographics of the respondents. This study obtained the data through a survey distributed online which resulted in 417 qualified samples. The study used SPSS Statistics 26 to analyze the sample using the logistic model. Based on an objective analysis of data using appropriate test statistics, findings were made, and the results were discussed. The proceeding constitutes a summary of the major findings of the study.

The findings of this study confirm that perceived benefit to increase crop yields and be useful to fight against hunger, perceived benefit of GM food to solve environmental problems and perception of benefits toward GM food industry in long run to be good for the economy had a strong statistical significance toward consumer acceptance of GM food. Therefore, the study suggests that the more consumers perceive the benefits of genetically modified food the more likely their attitude toward GM food becomes positive. The findings also show that Rwandan consumers trust more the government, university scientists as well as biotechnology researchers on reports and information regarding GM food technology.

This study provides new insight into the influence of Trust, perceived benefit, and risks to Rwandan consumers' acceptance toward Gm food. Studying the consumer attitude not only supports the commercial nature of GM food but assist in the determination of the development of transgenic technology and the future of GM food. Being able to understand the driving factors of consumer's concerns is critical in policy making. The findings of this study show that the more consumers perceive the benefits of genetically modified food the more likely positive they are toward Acceptance of GM food. This implies that the odds ratio of consumers' acceptance becomes greater as people perceive more benefit towards GM food. Perceived risk toward risk, environment, and allergies was statistically insignificant toward the acceptance of GM food, it infers that perception of risk toward genetically modified food doesn't factor the acceptance of GM food. The study results also estimate that consumers whose trust relies more on Government, university scientists, and biotechnology researchers to give a trustworthy report about GM food are more likely to support the production of GM food in Rwanda than consumers who trust labeling. Therefore, Because of the strong effect that consumer trust has on benefits perception, the government, university scientists, biotechnology researchers, performing research on this new technology to be adopted should take the responsibility of giving balanced reports and verified information to consumers. Also, the Rwandan government should communicate with consumers more effectively and provide educative knowledge about genetically modified food. Intensive research is the essence to forbid harmful effects from GM food technology. To conclude, this study, it is expected that consumers will rely more on government, university scientists as well as biotechnology researchers for balanced and trustworthy reports and information regarding genetically modified food, perceive more benefits, and positively form an attitude toward the acceptance of Genetically Modified food.

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