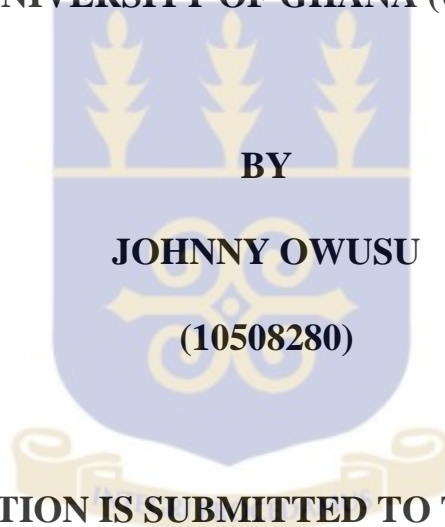


**SCHOOL OF PUBLIC HEALTH
COLLEGE OF HEALTH SCIENCES
UNIVERSITY OF GHANA**

**PERCEPTIONS OF GENETICALLY MODIFIED FOODS (GMFS)
AND ITS PERCEIVED RISKS AND BENEFITS ON HEALTH
AMONG UNIVERSITY OF GHANA (UG) STUDENTS**




**THIS DISSERTATION IS SUBMITTED TO THE UNIVERSITY OF
GHANA, LEGON IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE
IN APPLIED HEALTH SOCIAL SCIENCE DEGREE**

JULY, 2015

DECLARATION

I, Johnny Owusu, do hereby declare that, with the exception of other people’s works which have been duly acknowledged, this dissertation is my own work under the supervision of Dr. Emmanuel Asampong, and that this work, either whole or in part, has not been presented elsewhere for another degree.

.....	
Johnny Owusu (Student)		Date
.....	
Dr. Emmanuel Asampong (Supervisor)		Date

DEDICATION

I dedicate this work to my Parents, Georgina Owusuaa and Joseph Mensah Atta, and my siblings who have been my source of encouragement.



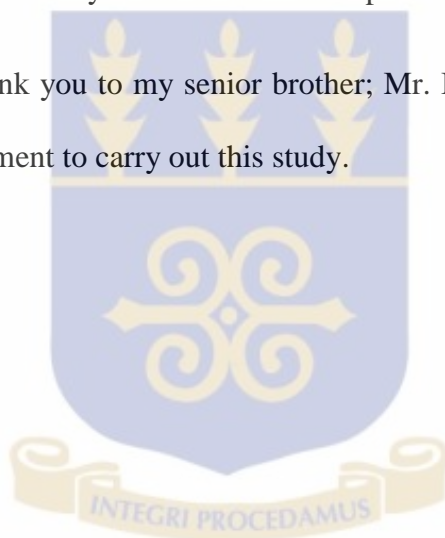
ACKNOWLEDGEMENT

I am highly grateful to the almighty God for His grace and mercy upon my life throughout this study.

I am deeply thankful to my academic supervisor, Dr. Emmanuel Asampong for his guidance and support throughout this study. Many thanks go to Mr. Dwomo of the Department of Biostatistics, School of Public Health for his support to have this work done.

I am also thankful to all lecturers who supported me, especially Dr. Collins Ahorlu and to all students of the University of Ghana who took part in the study.

Finally, I say a big thank you to my senior brother; Mr. Benson Atta, for his financial support and encouragement to carry out this study.



ABSTRACT

Introduction -Genetically modified foods (GMFs) are foods containing Genetically Modified (GM) ingredients produced by using modern molecular and cellular biology techniques. People are widely exposed to GM foods through either direct or indirect consumption of processed foods produced using GM ingredients. After the inception of the first commercial GMFs in the early 90s, contentions arose with regards to the potential benefits and risks to human health and the environment.

Method -This cross sectional descriptive study examined the perceptions of students of the University of Ghana about GMFs effects on health. A total of 194 students from different colleges of the University participated in the study. Data entry and analysis was done using STATA 13. Chi square was used to assess the association between the outcome variables and explanatory variables. $P < 0.05$ was used to denote statistical significance.

Results -The study revealed that the students had high awareness of GMOs and GMFs. The study also found television and radio as the students' major source of information on GM issues. Generally, many of the students believed that consumption of GMFs could be harmful to health with cancer and allergy as their major concern. However, others also thought enhanced nutrient content of GMFs as a major health benefit.

Conclusion - There should be awareness creation and educational campaigns of GMFs to help the general public to make well informed decisions and become actively involved in the decision making process. Finally, studies tracking public opinion should be conducted regularly, in order to determine awareness levels, capture the impact of awareness activities, the perceptions and reveal trends to inform policy and practice.

TABLE OF CONTENTS

DECLARATION.....	i
DEDICATION	ii
ACKNOWLEDGEMENT.....	iii
ABSTRACT	iv
TABLE OF CONTENTS	v
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ABBREVIATIONS	xi
CHAPTER ONE.....	1
INTRODUCTION.....	1
1.1 Background	1
1.2 Problem Statement	5
1.3 Conceptual Framework	6
1.4 Justification of the study	9
1.5 Research Questions	10
1.6 Objectives.....	10
1.6.1 General Objective.....	10
1.6.2 Specific Objectives	10
CHAPTER TWO.....	11
LITERATURE REVIEW	11
2.1 Introduction	11

2.1.1 Brief History of GMOs.....	11
2.1.2 Awareness and Interest of GMOs/GMFs	12
2.1.3 The Effects of Information on Perception	14
2.2.0 Perception on Potential Benefits and Risks of GMO/GMFs	17
CHAPTER THREE.....	22
METHODOLOGY	22
3.1 Introduction	22
3.2 Study Design	22
3.3 Study Area (additional information must be added)	22
3.4 Variables.....	23
3.5 Study Population	23
3.5.1 Inclusion and exclusion criteria.....	23
3.6 Sampling.....	23
3.6.1 Sample Size Calculation.....	23
3.6.2 Sampling Method	24
3.7 Data Collection Techniques	24
3.8 Quality Control.....	25
3.9 Pre-test.....	25
3.10 Data Analysis	26
3.11 Ethical Considerations and issues	27

CHAPTER FOUR.....	28
RESULTS.....	28
4.1 Introduction	28
4.2 Socio-Demographic Characteristics of Respondents	28
4.3: Awareness of GMOs and GMFs	29
4.4 Sources of Information.....	31
4.5 Relationships between socio-demographics variables and awareness level of respondents.....	32
4.6 Risk and benefits Perceptions about GMFs effects on health	33
4.6.1 Association between socio-demographic characteristics and perception of GMFs effects on health.....	35
4.7 Other perceptions about GMOs and GMFs.....	36
4.7.1 Perception of GMOs on the environment.....	36
4.7.2 Preferred Food production Source and the acceptability of GMFs if they were cheaper.....	37
4.7.3 Association of socio-demographics and acceptability of GMFs if they were cheaper	38
CHAPTER FIVE.....	40
DISCUSSION.....	40
5.1 Introduction	40
5.2 Awareness level and Knowledge	40
5.3 Sources of information on biotechnology and GMFs	41
5.4 Risk and benefits Perceptions about GMFs effects on health	42
5.5 Other perceptions about GMOs and GMFs.....	45

5.6 The Relationship between Gender and Perception	45
5.7 Application of the Conceptual Framework to Perception about GMFs	46
CHAPTER SIX	48
CONCLUSIONS AND RECOMMENDATIONS	48
6.1 Conclusions	48
6.2 Recommendations	49
6.2.1 Education	49
6.2.2 Policy	49
6.2.3 Research	50
REFERENCES	51
APPENDICES	59
Appendix 1: Consent Form	59
Appendix 2: Questionnaire	61

LIST OF TABLES

Table 1: Socio-Demographics characteristics of Study Respondents	29
Table 2: Awareness on GMOs and GMFs	30
Table 3: Source of information and level of trust of source.....	31
Table 4: Relationships between Socio-demographic characteristics and level of awareness of GMOs and GMFs (N=194)	32
Table 5: Perceptions about the effect of GMFs on health and perceptions about the use of GMT	34
Table 6: Association between socio-demographics and perceptions of GMFs on health (N=194)	36
Table 7: Participants perception about the impact of GMOs on the environment	37
Table 8: Respondents' preferred food production sources.....	37
Table 9: Association between socio-demographics and acceptability of GMFs if they were cheaper.....	39

LIST OF FIGURES

Figure 1: Conceptual Framework Diagram..... 7

Figure 2: Sources of information on GMOs and GMFs.....30

LIST OF ABBREVIATIONS

Bt corn-Bacillus thuringiensis corn

EKB Model- Kollat and Blackwell Model

GE- Genetic Engineering

GM crops- Genetically Modified Crops

GM- Genetic Modification

GMFs- Genetically Modified Foods

GMOs-Genetically Modified Foods

GMT-Genetic Modification Technology

GMVs- Genetically Modified Vectors

IFPRI-International Food policy Research Institute

ISAAA - International Service for the Acquisition of Agriculture-Biotechnology

Applications

rDNAT – Recombinant DNA Techniques

WHO-TDR- World Health Organization Training in Tropical Disease

CHAPTER ONE

INTRODUCTION

1.1 Background

The ongoing debate on Genetically Modified Foods (GMFs) and the information on the diffusion of innovations of Genetic Modification Technology (GMT) are filled with examples of individuals, groups and or organizations rising up, either against or for the introduction of the technology (Quaye, Yawson, Yawson, & Williams, 2009). There is growing public discussion about the potential benefits and risks of Genetically Modified Organisms (GMOs), especially concerning GMF which is the most publicized product of biotechnology. Before the introduction of modern biotechnology or Genetic Engineering (GE) in agriculture, farmers in livestock and crops had sought to improve upon their practices and adapt to the environment (Wieczorek, 2003). This had been done through purposive selection of crops and animals with the best and preferred characteristics for further replanting. Thus, farmers have since time immemorial kept seeds with a preferred character for reproduction (Ruttan, 1999). This technique of maintaining and improving particular desired characteristics of a crop or animal is known as selective breeding or traditional biotechnology (Ploeg, 2000). After Mendel in 1866 proved scientifically that characters or traits are carried from parental genome to their offspring with the explanation that trait is the character of interest to the farmers. This could be expressed in terms of colour, height, taste, yield etc.(Matthen & Stephens, 2007). This Mendelian concept led to the introduction of modern biotechnology or genetic engineering with the intention of speeding up the breeding techniques used by farmers and also to obtain result devoid of unintended traits.

The term GMF can be referred to as crop plants that are created for consumption by introducing a desirable set of genes into the crop plants using recombinant DNA

Techniques (rDNAT). Genes are transferred from a plant to another plant. In other cases, genes are transferred from animal to plants, such as from bacteria to plants, for example Bt. Corn (Swiatkiewicz, Swiatkiewicz, Arczewska-Wlosek, & Jozefiak, 2014). This method provides the modified plant or animal with the desired characteristics faster than the classical cross breeding methods. At certain times, the process is called bio-engineering, biotechnology or genetic engineering (Anderson, Wachenheim, & Lesch, 2005). In simple terms, GMFs are foods containing Genetically Modified (GM) ingredients. People are widely exposed to GM foods through either direct or indirect consumption of processed foods produced using GM ingredients (Jae-Hwan, 1995).

The emergence of biotechnology is viewed by advocates as the next revolution which has the potential to fundamentally change the way society organises production and distribution of food (Hallman, Hebden, Aquino, & Cuite, 2003). Biotechnology is a powerful tool that presents benefits such as potential health, environmental, social and economic benefits and demands rigorous oversight (Quaye et al., 2009). However, in recent years, biotechnology has been under public scrutiny. Many supporters of the technology are concerned that the benefits of the technology may be overshadowed by the potential risks magnified by the media and opponents of the technology (Blaine, Kamaldeen, 2002).

A 2014 report by the International Service for the Acquisition of Agriculture-Biotechnology Applications (ISAAA) indicated that, the global hectareage of biotech crops has increased more than 100-fold; from 1.7 million hectares in 1996 to 181.5 million hectares in 2014. This empirical evidence implies that biotech crops are the fastest adopted crop technology in recent time. According to the report, the impressive adoption rate of GM crops speaks for itself; in terms of its sustainability, resilience and the significant benefits it delivers to both small and large farmers as well as consumers

(James, 2014). This had led to increase in commercially grown GM plants, more foods and feeds which were produced from GMOs are available on the market of many countries (Upsaliensis, 2004). Various GM foods such as Zea mays (corn), tomato, potato, wheat, pumpkin, sunflower, peanut, some fish, colza, cassava, and papaya are consumed by people in the world (Paper, Hallman, Ph, Cuite, & Morin, 2013). It is possible that biscuits, vegetable oils, baby foods, chocolate, corn products, soy products, chips, cookies, snack foods and ready soups may have certain GM ingredients (Kaya, Poyrazoglu, Artik, & Konar, 2013). The concerns about GMFs are widespread. Yet many of us may be eating food containing GM ingredients without realizing it (Dean & Shepherd, 2007a).

Many GM products for example rice with enhanced vitamin A, long lasting fruits and vegetables have already entered the world's food distribution networks (Quaye et al., 2009). The development and commercialization of GMFs have become a great concern. Advocates believe that GM products have inherent capacity not only to meet our basic need, but to also bring to bear the wide range of economic, environment and health benefits. They also accentuate the potential benefits to society through reduction of hunger and malnutrition prevention, cure of disease and promotion of health and general well-being (Isserman, 2001; Fukuda-Parr & Birdsall, 2001). More recently the US Food and Drug Authority approved a new biotech crops and planned for commercialization in 2015 and beyond. This includes brinjal (eggplant) and potato. The potato was modified to reduce the amount of acrylamide it produced when exposed to high temperature to a negligible amount in order to prevent cancer (US FDA, 2014). A meta-analysis conducted by Gruissem (2015) on 147 published biotech crop studies during the last 20 years, using primary data from farm surveys or field trials world-wide and reporting impacts of GM soybean, maize, or cotton on crop yields, pesticide use, and/or farmer

profits substantiate the significant and multiple benefits that biotech crops had generated over the past 20 years (1995 to 2014).

In spite of the significant benefits GM technology brings to society, public acceptance to GM foods or food biotechnology has been with mixed feelings (Sophia & Powell, 2000; Tenbült, De Vries, van Breukelen, Dreezens & Martijn, 2008).

Africa is emerging as one of the Frontlines in the battle for acceptance (or otherwise) of agricultural biotechnology. For Africa, the discussion is occurring at a critical period when occurrence of food insecurity, poverty and malnutrition are particularly upsetting (Sheeran, 2008; FAO, 2014).

According to a 2014 report by the ISAAA stated that Africa continued to make progress in 2014. Sudan has increased its Bt cotton hectare substantially to 90,000 hectares which represents 46%, with South Africa and Burkina Faso marginally lower mainly because of uncertainty of planting conditions of the Bt cotton. However, it is important to note that South Africa is one of the five lead biotech developing countries in the three continents of the south. Currently, an additional seven African countries such as Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria, and Uganda have conducted field trials on the following broad range of staple and orphan crops: rice, maize, wheat, sorghum, banana, cassava, and sweet potato. The first biotech stacked drought tolerant maize with insect control (Bt) would be expected to delivered by Water Efficient Maize for Africa (WEMA) to South Africa as early as 2017, followed by Kenya and Uganda and then by Mozambique and Tanzania, subject to regulatory approval (James, 2014). In Ghana some legislation had been put in place, for example, the Government of Ghana in 2011 passed the biosafety Act 831, 2011, which will enable Ghana to allow the

application of biotechnology including GMOs, in food crop production (Souza, Brown, Ahorlu, & Suzuki, 2013; Tuffour et al., 2013).

1.2 Problem Statement

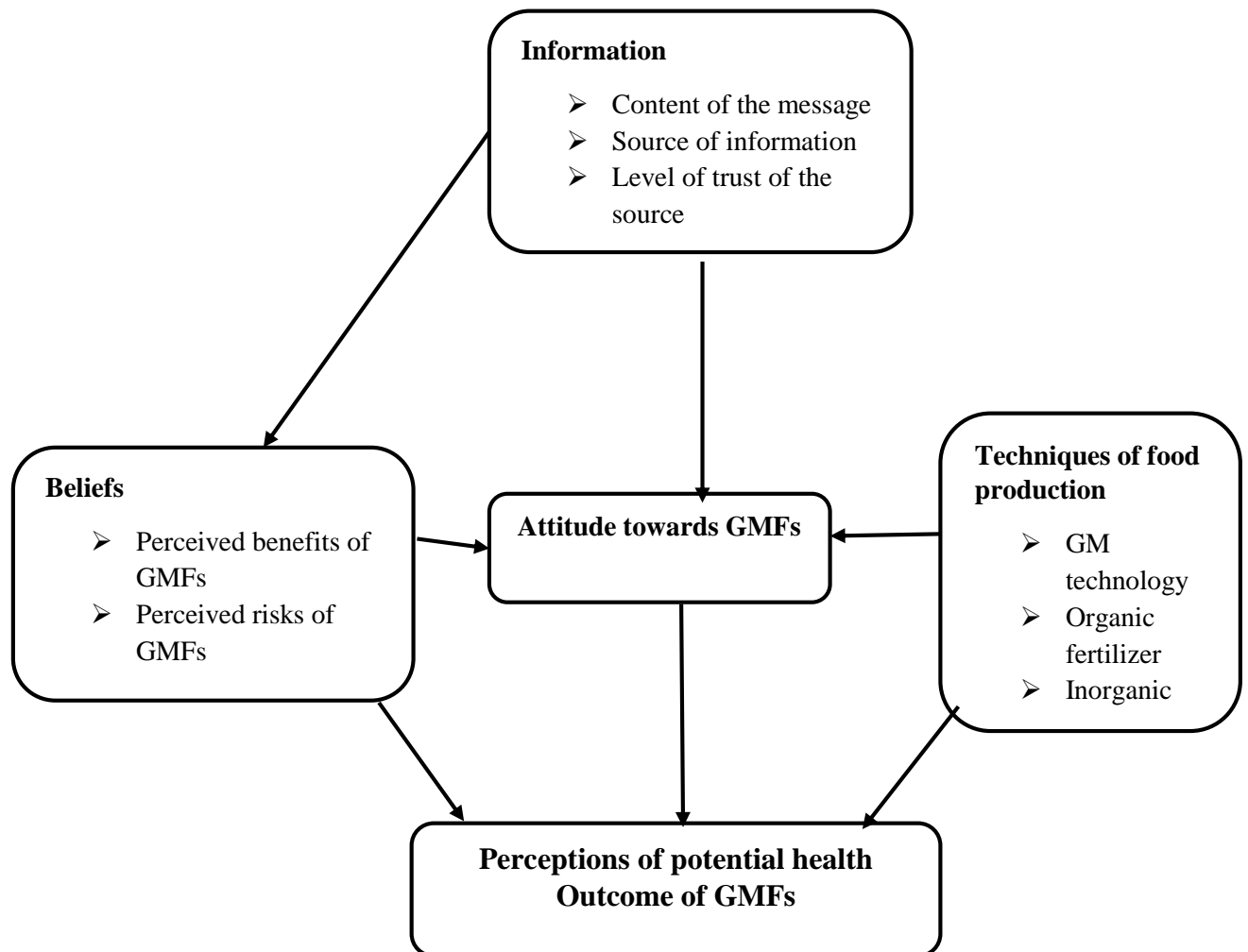
In democratic societies, public perceptions can both promote and impede the commercial introduction and adoption of new technologies. Public perceptions of biotechnology have received extensive attention in recent years in most Western countries (Rimal, Moon, & Balasubramanian, 2005; Bonny, 2003), including publications (Blaine, Kamaldeen, 2002; Morris & Adley, 2000), book chapters (Morris & Adley, 2000), conferences (Sophia & Powell, 2000; Hollingworth & Meade, 2003), studies of social implications and public concerns about biotechnology (Gaps et al., 2000; Blaine, Kamaldeen, 2002). There had been several surveys on public perceptions of genetic engineering or biotechnology in developed countries (Bonny, 2003; Hallman et al., 2003; Hoban, 2001; Ganieri, Wen & Chern, 2004; Curtis, McCluskey, & Wahl, 2004; Gaskell, 2000; Moon & Balasubramanian, 2003). However, the consuming publics in the developing countries are left in the state of uncertainty. There is little or no literature concerning the public perceptions of potential benefits and risks of GM products because little investigation has been conducted in developing world where the technology is not yet practiced on a large scale (Anderson et al., 2005). For instance, in Ghana, the paucity of GMOs/GMFs research on public perceptions has left the people in the country with uncertainty. It is, therefore, important that the people of this country are made aware of the critical issues of the GMFs, the benefits and the threats associated with it in order to make informed decisions. However, this could not be done effectively without the knowledge of the public perception about GMOs/GMFs. It is explicit that the views of the people are very

important which must also be considered to make informed decisions, especially with regards to educating the public.

The study sought to investigate the perceptions about GMFs and its perceived potential risks and benefits in relation to health. The knowledge from this study would bridge the gap on public perceptions on GMFs and will inform policy-makers with regards to GM policy since it of great public health concern not only in Ghana but the world as well.

1.3 Conceptual Framework

Figure 1 below illustrates the relationship between the outcome and independent variables associated with perceptions of GMFs. The diagram shows the various factors that influence people's perception of GMFs, especially with the perceived health outcome of GMFs. The perception of the health outcome of GMFs which is the outcome variable is affected by the independent variables (information, beliefs, sensory and non-sensory characteristics, techniques of production and attitudes towards GMFs). The information includes content of the message, source of information and the level of trust of the source. Beliefs consist of perceived benefits and perceived risks of GMFs. Also techniques of food production are made up of GM technology, organic fertilizer and inorganic fertilizer

Figure 1: Conceptual Framework Diagram

Source: Author's own construct

The above diagram also indicates that information received by people forms their perception of GMFs which could easily influence a person's attitude towards GM products. Research had found that while provision of information is likely to influence perceptions and attitude, the social context in which the information is received is likely to determine public reaction as the content of the information itself (Costa-Font, Gil, & Trull, 2008). Credibility and trusted information source and regulators are likely to play a major part in the determination of individual reactions to products (Frewer, Howard, Hedderley & Shepherd, 1996)

Also, it shows a direct link between the beliefs/perceptions of GMFs and perceptions of potential health outcome of GMFs. When exploring consumer perceptions, an important question is which factors are responsible for attitude development. The presumption is that beliefs are key elements in forming attitudes and eventually influence behaviour. Beliefs characterize the base set of information that a consumer has about an object or concept (Albert, Aschenbrenner, & Schmalhofer, 1989). Individual perceptions and thought about GM foods is a dictate of one's beliefs in conjunction with other factors. Also beliefs play a significant role in forming attitude mediation intentions (Moon & Balasubramanian 2004; Hallman & Aquino, 2005; Han & Harrison, 2007). According to Fishbein's multi-attribute model, a person's attitude toward any object is a function of his/her beliefs about the subject or the object and the implicit evaluative responses associated with those beliefs (Costa-Font et al., 2008). Engel, Blackwell, and Kollat defined attitude as "a learned predisposition to respond consistently in a favourable manner with respect to a given alternative"(Jae-Hwan, 1995). Consequently, attitude refers to an individual's favourable or unfavourable evaluation of GM foods, and attitude formation is closely related to the consumer's evaluation of GM foods. Fishbein Multi-attribute Model (Fishbein, 1963) states that an attitude towards a product is based on knowledge about the product itself as well as its attributes, which is referred to as the so-called 'bottom-up' formation of attitudes (Costa-Font et al., 2008). This theory explains that consumer attitudes towards GM foods depends on his or her subjective thinking that GM foods are related to positive or negative evaluation of attributes and that the strength of belief associate to a given attitude, either positive or negative attribute determines an individual's intention about GMFs. This implies that attitudes towards GMFs are defined by means of a weighted sum of attitudes towards each product and its corresponding process. Therefore, each attitude also depends on the overall perceived risks and benefits

associated with the product and process, respectively. The implication therefore is that, techniques of the method used in food production have a strong influence on people's perceptions of the potential health outcome of the GMFs. Information, beliefs and techniques in food production all exert a level influence on attitude towards GMFs products. The importance of understanding individuals' attitude toward GMFs is not only to decision makers, but also to the food manufacturers, biotechnology industry, research institutes and food retailers. Findings from research had shown that individual resistance to GMFs has changed the trend of food industry behaviour and has led to substantial segmentation of GMFs from non-GMFs (Huang, Qiu, Bai, & Pray, 2006).

1.4 Justification of the study

The outcome of this study would have both theoretical and organizational relevance. Theoretically, issue on GMFs largely remains an unexplored area of research in Ghana. Additionally, the level of awareness of GMOs/GMFs and the perceived effects on the health of the people of this country has been ignored, when it comes to investigations on how the public feels and views about the pros and cons of GMFs. This study is geared towards narrowing research gap existing in the area of GMFs, and to provide a solid foundation on which other research works can be done in Ghana. The study is also relevant for policy making and implementation. In the first place, it will inform the biotechnology companies about the views of the people. The findings of the study will inform policy-makers to create the right regulatory policies with regard to GMFs.

1.5 Research Questions

1. What is the level of awareness of the University of Ghana students on GMOs and GMFs?
2. What are the sources of information about GMFs?
3. What are the potential perceived-health effects of using GMFs?

1.6 Objectives

1.6.1 General Objective

To find out the perceptions about genetically modified foods (GMFs) and its perceived effects on health among University of Ghana students

1.6.2 Specific Objectives

1. To determine the level of awareness of students of the University of Ghana on GMOs and GMFs
2. To explore the sources of information about genetically modified foods
3. To investigate the perceived health effects of using GM Foods among University of Ghana students

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section provides a review of existing literature to understand the extent to which earlier studies have documented key issues in people's perception of GMOs and GMFs. The literature review covers the following areas: awareness, information and perception of the potential benefits and risks of GMFs.

2.1.1 Brief History of GMOs

The introduction of GM foods in the USA and Europe has a long and complex history. During the 1970s and 1980s, the debate was led by scientists with little divergence between Europe and the USA. The commencement gene technology or recombinant DNA technology started 1973, when a US laboratory first managed the in vitro transfer of a gene from one species to another (Scholderer, 2004). This scientific sensation caused much euphoria around the world. In 1974, the geneticist Paul Berg and a number of colleagues published a letter to the editor of *Science*, calling for a moratorium on the use of the new technique until potential biohazards had been evaluated (Peterson, 2010). However, 1975, the scientists lifted the self-imposed moratorium concluding that the technology did not pose any inherent dangers that were beyond conventional risk assessment procedures. In 1976, the US National Institutes of Health issued technical guidelines for laboratory safety, which were adopted in similar form throughout the world. In the 1980s, the technology began to yield industrial applications on a massive scale (Scholderer, 2004). It was adopted widely throughout the pharmaceutical industry, followed by certain sectors of the industrial chemicals industry, including those involved in the production of enzymes, vitamins and other food additives for use in food

processing. The first deliberate release of a GM organism (GMO) into the environment in 1986 prompted widespread attention (Anne Ingeborg Myhr, 1999). After years of litigation, the US released the first transgenic microorganism into the environment (a microbe resistant to low temperatures). This provoked a shift in the public debate, both in terms of the actors involved and in terms of the frames of reference of the debate (Scholderer, 2004).

2.1.2 Awareness and Interest of GMOs/GMFs

Angus Reid World Poll result indicate that consumer awareness is fairly high on the global scale with understanding being the greatest in Germany, Australia and the U.K. In North America, 65 percent Americans and 79 percent Canadians are aware of the issue but understanding remains low (Sophia & Powell, 2000) . Furthermore, on the global scale, more than four in ten consumers (ranging from 44 per cent to 58 per cent) said that they only have "little" understanding about GMFs (Sophia & Powell, 2000). With 54 percent of Americans and 64 percent of Canadians expressing willingness to learn more about GMFs shows that individuals want to learn more about GMFs(Sophia & Powell, 2000). Suggestion from a study states that increased awareness of GM technology will also increase consumer demand for choice between GM and non-GMFs (Viljoen, Dajee, & Botha, 2006). Similarly, a study was conducted on consumers' awareness of GMFs regarding three terms relating to modern biotechnology. The results showed that the highest level of awareness was hybrid breeding technology (91%), followed by gene (85%) and biotechnology (77%). Additionally, the result of a study conducted among students of Turkish secondary schools indicated that most of the students (87%) had high awareness regarding GM product (Suleyman & Tuna, 2011).

Anderson et al. (2005) further worked on a study of Hallman and Metcalfe (2003). They studied North Dakota shoppers' perceptions of GM foods. Their findings were similar to Hallman et al. (2003) albeit, the population surveyed by Wachenheim and Lesch was considerably more rural. However, they found awareness and general knowledge of GMF products to be very low even in the largely agrarian state. Shoppers' knowledge about the existence of GM ingredient in their food product was low and they also viewed biotechnology much favorable when applied in plants as compared to animals. They inclined to agree that the use of genetic modification would be appropriate to feed the over-growing population of the world (Hallman et al., 2003).

Despite the contradictory debate about GMFs, a study in Europe showed that people are fairly interested in this issue. The result of the study revealed that majority (56%) of the respondents fairly or very interested in the issue of GM Food (Poortinga & Pidgeon, 2004).

South Africa has been very active in terms of growing commercial GMOs on the African continent. Some GMOs available in South Africa include insect resistant and herbicide tolerant maize, insect and herbicide tolerant cotton and herbicide tolerant soybean (South Africa Department of Agriculture, 2005). In South Africa 24% of yellow maize, 10% of white maize, 50% of soybean and 85% of cotton account for biotech crops production (James & Isa, 2009). The suggestion here is that GMOs being grown commercially in South Africa since 1997, however, the level of awareness is very little; albeit, government and non-government organization (NGOs) making information on GMOs available (Viljoen et al., 2006).

A perception study in Ghana with a sample size of one thousand two hundred participants; was conducted among four different categories of participants (academia,

research institute, government ministries and ordinary Ghanaian) revealed that 50% or more from all categories were interested in GMOs and GMFs. Additionally, the level of interest was high among academia (82%) and those from research institutes (68%) (Buah, 2011).

2.1.3 The Effects of Information on Perception

Generally, Public information is acknowledged to be more credible and more influential than company-controlled communication (Dean, 2004). By implication negative publicity has the potential to damage the image of an innovation and vice versa. This could be linked to high credibility, negative effect, a tendency for negative information to outweigh positive information in the evaluation of people, objects and innovation (Mizerski, 1982). According to Dean, (2004), because the media has a preference for reporting bad news. Therefore, companies are more likely to receive bad press rather than positive press. The perceptions of the public with regards to GMFs are the influence of the context information received from media or other sources. Mostly information submitted by both proponents and opponents about GMFs to the public is filled with contradictory messages and contested claims. It has been suggested that conflicting information from different sources would lead to social uncertainty (Tuffour, Sedegah, Nana, & Akyiaa, 2013; Ekici & Sancak, 2011).

Genetic Modification and GMFs had become one of the most opposed innovations in recent years (Bonny, 2003). Usually, biotechnology institutions and government organizations are seen as the proponents of this technology whilst consumer organization, NGOs and environmental pressure groups are viewed as cautious opponents (Dean & Shepherd, 2007a) . Information from these sources to the public is predominant with contradictory messages and contested claims. Research shows that general reading of conflicting information from different sources would lead to social

uncertainty (Dean & Shepherd, 2007a). In addition receiving conflicting information reduced the credibility of information presented. The implication of this may cause people to perceive greater risks of GMFs (Dean & Shepherd, 2007a). Again, Frewer & Shepherd, (1994) attributed information relating GM to different sources of varying credibility. They found that regardless of the identity of the information source, the information increased the perceived risk of the participants' regarding the technology. Therefore, this suggests that the source is not responsible for the increased risk perception but rather the information. However, under the same experimental model, Frewer and colleagues indicated that public perceptions of risks were higher from a distrusted source and lower from a trusted source.

Trust in risk information about food-related dangers may be as important a determinant of consumer reactions as the content of the risk information (Frewer, Howard, Hedderley, & Shepherd, 1996). Information and perception literature have indicated the role of trust as being of critical importance. An individual's perception (risks/benefits) is influenced by the content of the message received. (Frewer et al., 1996). This suggests the content of the information has strong effect on people's perception. Similarly, a study on people's preference for consensus ambiguous information or precise but conflicting information from different sources, concluded that contradictory sources are considered as less credible as compared to consensus ones. In addition the total view of the people in the study suggested that conflicting sources are less knowledgeable, less believable and less reliable than consensus source. The implication therefore, is that people prefer consensus information in their decision making because they view these source as more credible (Smithson, 1999).

Viscusi (1997) studied the effects of receiving conflicting high/low risk assessments from one or two sources, the government and/or industry. Viscusi's concept suggest a

conflict between two different sources (as opposed to two different estimates given by the same source) there is a tendency for a higher estimator to be regarded as compared to lower estimator due to the influence by the higher estimator. The possibility of this is regardless of whether higher risk estimator was from the government or industry. However, both estimators were taken into consideration when it sources were the same. Viscusi argues that it is the conflict between the sources of the information that affects the risk perception rather than the two pieces of evidence. Furthermore, He concludes that source's credibility rating is influenced by one's high or low risk estimator. It is essential to accentuate that Viscusi's study attributed the same information to two different sources (government and industry) and assumed that the government would be considered to be more trustworthy than industry, which may not be the case. However, his study suggested that conflicting information from experts increases people's risk perception and reduces the credibility of some of the sources. Whereas, risk information from a government agency among other conflicting information did not alter the way the public viewed the agency message but rather enhanced the image of the government agency. However information from the government agency in the midst of other conflicting information did affect people's perceptions of GM food technology.

Also, Dean (2000) investigated the distinctive influence of conflicting information by juxtaposing participants' perceptions when they read either a single message or conflicting messages. Suggestion from his result indicated that reading conflicting information does not affect the way people see the content of the message, but rather affects their perception of the source involved. Information given amidst other conflicting information, made the source appear more positive than when they gave the same information on their own. This was true for both trusted and distrusted sources. In addition people's perception of the risk was only affected by the content of the risk

message and the identity of the source giving the message and not by conflict (Markon & Lemyre, 2013).

According to Frewer et al. (1996) some identified source of information on GMFs were television, newspapers, magazines, radio, industry (a definition which includes supermarket information and manufacturer label on the packets), friends and medical source. The result of the study indicated the media as the most important and frequent source of information about GMF-related information, with 65% of the respondents' source being media-related. Similarly, in the work of Frewer et al. (2000), the use of television, radio, newspapers and public lectures were the main sources of information for Chinese respondents. However, a study in Ghana indicated that workshops (60%) and friends (40%) were the major sources of GMFs and biotechnology information for respondents from researchers and academia. Whereas, the electronic media had not been a source of information for any of the respondents (Buah, 2011).

In summary, most studies show that conflicting messages increase risk perceptions, especially when these estimates are given by identifying sources. Also the content of the information and its source credibility has effects on a person's perception of benefits or risks of GMFs technology. However the studies do not give a clear image as to how the credibility of the sources is affected.

2.2.0 Perception on Potential Benefits and Risks of GMO/GMFs

The decisions of individuals regarding the use of biotechnology in food production are becoming very important due to recent biotechnological research and the seemingly growth in the world's population. As seen in almost all emerging technology the public associate both benefits and risks with technological processes applied to food production (Frewer, Shepherd, & Sparks, 1994). An individual's reaction to the use of biotechnology

and subsequent acceptance of the products may be largely influenced by perception of both benefits and risks associated with the technology and its applications (Onyango, Jr, & Schilling, 2005; Hossain et al., 2002). The case where perceived risks outweigh perceived benefits associated with the technology and its application, and then acceptance may be very low. Some factors that may affect risks perceptions may originate from health related and technological hazards(Sjöberg, 2008).

Social risks could be defined as risks which may be perceived as having the tendency of widespread and generalized consequences if they should occur. Social risks are perceived to have relatively low threat for self, greater for people, and greatest for society (Joffe, 2003). This phenomenon could be explained as individual's belief that negative events are relatively unlikely to happen to them, this is referred as "optimistic bias" (Frewer et al., 1994). It has been debated that social risks could be better explained as the need by an individual to have control over a situation. The illusion of control theory states that one's perception of his personal control over potential hazards reduces the subjective probability of potential risk associate with hazard (Hosking, Liu & Bayly, 2010; Sj, Moen, & Rundmo, 2004). This theory would predict that, when individuals are in a position where they perceive that they have some level of control over risk, then judgments of invulnerability become equal to those made when people are in control. Research has shown that biotechnology as applied to food production represents more threat at the societal level than at the individual level (Frewer et al., 2002). The societal level is where control of the technology is seen (Frewer et al., 2002) and it would be predicted that personal threat associated with the technology is equal to that of the people.

2.2.1 Perceived Benefits

Biotechnology advocates indicate the potential benefits to the society through reduction of hunger and malnutrition, prevention and cure of diseases and production of general wellbeing (Isserman, 2001;UNDP, 2001)

According to Angus Reid World Poll consumers believed that the main benefits of agricultural biotechnology consist of yield in production, followed by better food quality and pesticides. However, some of the said GMFs provide no benefits. The findings from this poll indicated that the overall support of GM technology is influenced by the perception of benefits. Canadians were more likely to associate biotechnology benefits to nutrient and the quality of the food (Blaine, Kamaldeen, 2002). Also many studies had shown that individuals are very selective about which benefits outweigh the risks of the biotechnology. It was revealed that health related and environmental benefits very important as compared to taste or cost benefits (Henseleit, Kubitzki, & Herrmann, 2009; Cormick, 2005; Blaine, Kamaldeen, 2002).

Americans being at the top level in terms of support for biotechnology and its applications, were more likely to think biotechnology as beneficial to them and their family (Finucane & Holup, 2005; Iposos-Reid 2000; IFIC 2001).

Again proponents emphasize the benefits of GMO to mankind in the form of improve supply of food, fuel, and medicine as well as the reduction of insecticide and labour cost which provide economic benefits to the adopters (Isserman, 2001). In addition, GM crops have contributed significantly to reducing the release of green gas emission from agricultural practices. This result from less fuel use and carbon storage from reduced tillage with GM crops. In 2012, thus equivalent of 27 billion kg of carbon dioxide was removed from the atmosphere by GM crops (Brookes & Barfoot, 2014).

Food and Agriculture Organization of the United Nations estimates that about 805 million people of the 7.3 billion people in the world were suffering from chronic undernourishment in 2012-2014. Almost all the hungry people, 791 million, live in developing countries, representing 13.5 percent, of the population of developing countries. There are 11 million people undernourished in developing countries (FAO, 2014). The use of biotechnology and its application in agriculture could address the issue of food security and malnutrition. Ghana can benefit from this tremendously to curb the incidences of anaemia; vitamin A and iodine deficiency across the country.

2.2.2 Perceived Risks

Biotechnology has caused significant advance in agriculture production and other industries such as the pharmaceutical industry to improve the quality of life for citizens in the United States and other countries (Malcolm & Sinnett, 2015). However the advancements were not made without initial risk. Despite the advancement in biotechnology aims to improve the quality and productivity, uncertain consequences categorize such innovations as risky (Malcolm & Sinnett, 2015). “Agricultural production is a risky endeavour”, (Pruitt, 2014). Agricultural production risks can range from environmental issues, technology experiments, and food safety matters. Uncertain repercussions cause high opposition from the public because they “are usually associated with large-scale, long-term, and trans-boundary hazards with which society has no or only limited experience” (Pruitt, 2014). Many European policy makers’ and public consumers are concerned about GMO effects on the environment, economy and human health (Marris, 2001). Opponents of biotechnology/GMFs insist that these new technologies have threat to human life, to existing plant, to animal species and to the environment. Even though opponents of GMFs agreed that GM crops produce better

yields, however, they stress that devastating risks to public health, safety and environment are inherent in GM research, production and commercialization (Buah, 2011). They further view the use of biotechnology as a needless interference with nature that may lead to unknown and potentially disastrous consequences (Sajeev et al., 2011). Some oppose the use of genetic technologies in agricultural production, alleging the perceived risks to human health and environment, also others oppose it citing moral, ethical and social concerns (Hossain, Onyango, Adelaja, Schilling, & Hallman, 2002; Linacre et al., 2005). A study conducted in the southwestern zone of Nigeria which consists of 6 states (Lagos, Ogun, Osun, Oyo, Ekiti and Ondo) among scientists in the faculties of Agriculture and Biological Sciences from nine universities. The findings of the study revealed that 45 percent of the study participants agreed that GMFs with a higher content of digestible iron are likely to benefit consumers. However, forty-eight percent (47.8%) of the study participants agreed that GM food with possible allergy risk should be fully labelled (Oladele & Akinsorotan, 2007).

Another argument from the opponent is that most testing of GMFs is carried out by biotech companies. The most potential threat among GM food is to create new allergies or harmful toxins that may cause sickness or death in vulnerable populations (Buah, 2011).

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the methodology of the study. This includes the study design, the study area, variables, study population, sampling, data collection techniques, quality control, data processing and analysis, ethical consideration and pretesting of the questionnaire.

3.2 Study Design

This was a cross sectional survey using a structured questionnaire, which included demographic information, knowledge on GMOs, and perceived effects of GMFs on health. The questionnaire was made up of both closed and open ended questions which allowed respondents to present their own perspective beyond the coded category provided.

3.3 Study Area (additional information must be added)

The study took place at the University of Ghana, Legon campus. The University of Ghana is located on the Legon hill about twelve kilometres north-west of the centre of Accra on the Accra- Dodowa road. It is located on longitude 50 38'3"N and latitude 00 11'13"W (UG website, 2008). University of Ghana operates on collegiate system and comprises of the following: College of Basic and Applied Sciences, College of Education, College of Health Sciences, College of Humanities. Each college is made up of different schools and under each school has departments.

3.4 Variables

The dependent variable was perception of potential health outcome of GMFs whilst the independent variables were information (content of message, source of information and credibility of source), beliefs (perceived benefits of GMFs and perceived risks of GMFs), sensory and non-sensory characteristics (taste, texture, nutrient content), techniques in food production (GM technology, organic fertilizer, inorganic fertilizer) and attitude towards GMFs.

3.5 Study Population

The study population was the students of the University of Ghana. University of Ghana had an estimated number of the 30,000 student population (undergraduates and postgraduates). The study involved male and female students who were 18 years and above. This study population is selected because it is an educational institution and they were expected to be knowledgeable about the study topic.

3.5.1 Inclusion and exclusion criteria

The inclusion criteria were that the respondent must be a male or female student, aged 18 years and above, and a student in the University of Ghana. The study excluded teachers and other staffs of the University of Ghana.

3.6 Sampling

3.6.1 Sample Size Calculation

Epi info was used to calculate the sample size. The student population was estimated at 30,000. Based on an expected frequency of 85%, 95% confidence level and a design

effect of 1.0, the total sample size was calculated to be 218 with 10% non-response rate included.

3.6.2 Sampling Method

Stratified sampling method was used to stratify the target population into levels for the study to obtain a representative sample. To cover UG population thoroughly as possible, and avoid sampling only those people from a particular location. The population was classified into level 100, 200, 300, 400, Master's degree and PhD. Averagely 34 participants were selected from each category. Study participants in all the different classifications were selected by simple random sampling generated by computer-based programs, in Microsoft Excel. For example, a generated sampling frame of 1,3,4,8, etc. determined that the views of the first, third, fourth and eighth person encountered by the survey were sampled. This continues until the average number for each class was reached. Individuals of 18 years and above were selected for the study.

3.7 Data Collection Techniques

The study was quantitative, which employed the use of questionnaires. The questionnaire was developed based on the objectives of the study and literature reviewed. The questionnaire was made up of both closed and open ended questions to allow respondents to present their own perspective beyond the coded category provided. Because the university community is a literate population, the questionnaire was self-administered. Adequate instructions and information were provided to aid respondents fill the questionnaire correctly. The time spanned for the data collection was one month.

3.8 Quality Control

The data collected was checked to ensure that all information have been properly collected, completeness was also checked. The case where the questionnaire is not properly filled, the respondent was given a new questionnaire to answer. However, in a situation where the respondent wishes to discontinue answering the questionnaire, that respondent was replaced and the corresponding questionnaire was discarded. Computer data entry and analysis was done. The data were entered into an excel spreadsheet and exported into STATA 13. Double data entry and cleaning was done to reduce data entry errors and validated authenticity.

3.9 Pre-test

The questionnaire was pre-tested on a sample of 20 students (both male and Female) of Central University, Accra. Central University students were used of because they share some similarities in the socio-demographic features with the University of Ghana student. This allowed a few modifications in the questionnaire such as making the sentences clearer and reliable for the study respondents.

3.9.1 Validity and Reliability

There was no research assistance so the researcher. The data was collected properly. All questionnaires returned were checked for mistakes and completeness. Questionnaires with unclear responses or which had missing information that could not be clarified was excluded. The data was entered in an excel spreadsheet and exported into STATA 13 (StataCorp LP, College Station, TX, USA). Double data entry and cleaning was done to reduce data entry errors and validated authenticity

3.10 Data Analysis

The statistical analysis was done using STATA 13. Preliminary analysis was carried out to summarize the data on socio-demographic characteristics of respondents, awareness of GMOs and GMFs, sources of information on GMOs and GMFs, perceptions of GMFs into percentages and frequencies for descriptive purposes.

The level of awareness of the study respondents was measured based on the following set of questions; whether a respondent has heard of GMOs and GMFs, the interest of the respondent on GMOs and GMFs issues, the idea about GM Technology (GMT) and what genetically modified foods are. The overall awareness level was examined using 4 questions. With the maximum accumulated score of 9, respondents who scored 0 to 4 were classified as low awareness level whilst those who scored 5 to 9 were classified as high awareness.

The perceptions of the study respondents about GMOs and GMFs were examined by a total of 12 questions consist of both closed and opened ended questions. The questions asked could be categorized into four main themes, thus the preferred food source, the perceived effect of GMFs on health, perceived effect of biotechnology and GMFs on the environment and perceived potential risks or benefits associated with it.

The Pearson's Chi square (χ^2) and Fisher's exact test analysis was used to determine the association between the variables; the associations between socio-demographic characteristics and level of awareness, socio-demographic characteristics and perception, and socio-demographic characteristics and level of acceptability of GMFs. The significant level of 5% was set for all statistical procedures.

3.11 Ethical Considerations and issues

The researcher sought for ethical clearance from the Ghana Health Service. Consent was sought from the Dean of students. The objective and rationale for the study was explained to respondents and consent obtained.

The privacy and confidentiality of the respondents was secured. All information provided by the respondents was kept confidential and data were locked in a cabinet and on computers protected by passwords. The name and identity of the respondent were not needed for the study. The information provided was only identified by a code number and was treated strictly confidential. Respondent's name did not appear or was not mentioned in any part of the report of this study.

The respondents' involvement in this study was only through an interview and was not exposed to any form of risks. The subjects' participation in the study was voluntary and was not given any money or any kind of reward. All the information provided by the respondents was used for the study.

3.12 Limitations of the study

As there are some form of limitations in all studies. This study also had a limitation: the study relied on self-report from the respondents and the information given by the respondents could not be verified, there may therefore be information bias.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents the results to address the objectives of the study. It begins with a description of the demographic characteristics of participants in the study area. It also shows the results of students' awareness of genetically modified foods and their sources of information. It further presents the perceptions of students in terms of potential benefits and risks associated with GMOs and GMFs and its perceived potential health effects.

4.2 Socio-Demographic Characteristics of Respondents

A total of 194 participants took part in the study. They were made up of 51% males and 49% were females. The majority (59.3%) of the participants were between the ages of 18 to 27 years. The mean age of the study respondents was 26.84 ($SD = \pm 3.75$). Most of the respondents (88.8%) were single. Again, Majority of the study respondents (93.2%) were Christians. On the educational status of the study participants, the majority of the participants, 74.2% were undergraduate students and 24.8% were enrolled in post-graduate programmes. (Table 1)

Table 1: Socio-Demographics characteristics of Study Respondents

Attribute	Frequency (N)	Percentage (%)
Gender		
Male	99	51
Female	95	49
Age Group		
18-27	115	59.3
28-37	53	27.3
38-47	26	13.4
Marital status		
Single	167	88.8
Married	27	13.2
Religion		
Christian	144	93.3
Muslim	50	6.7
Education Level		
Undergraduate	144	74.2
Postgraduate	50	25.8

4.3: Awareness of GMOs and GMFs

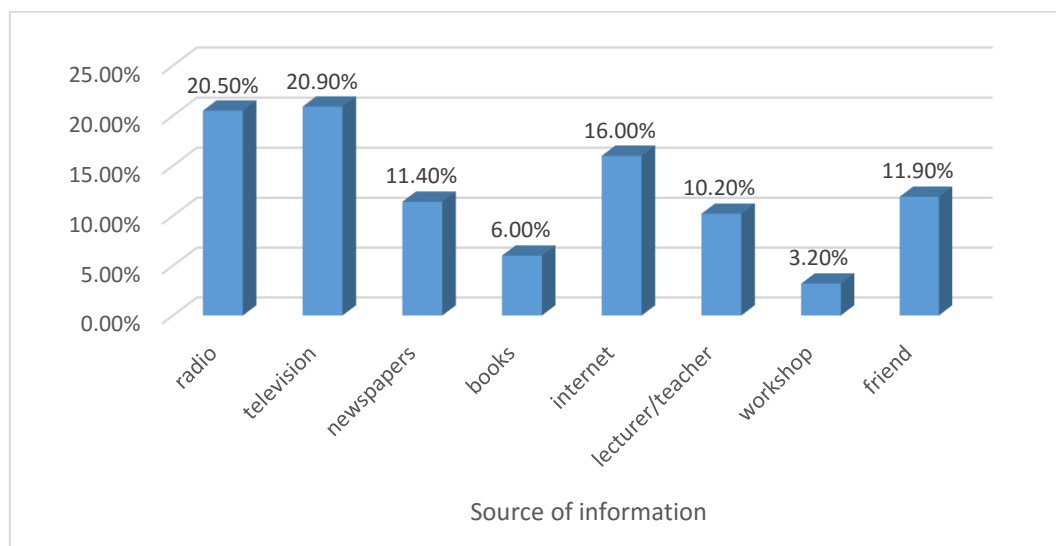
The level of awareness of the study respondents was measured based on the following set of questions; whether a respondent have heard of GMOs and GMFs, the interest of the respondent on GMOs and GMFs issues, the idea about GM technology and what genetically modified foods are. The overall awareness level was examined using 4 questions. With the maximum accumulated score of 9, respondents who scored 0 to 4 were classified as low awareness level whilst those who scored 5 to 9 were classified as high awareness. The result of the study revealed that majority of study respondents (90.7%) is aware of GMOs and GMFs whereas 9.3% of them had a low awareness level

(Table 2). This was confirmed in their knowledge regarding what GMFs mean; it was revealed in result that 73.7% of the study participants had better knowledge of what GMFs mean and understanding of its technology. Since this study is mainly centred on GMFs the study respondents were asked to state their view on the availability of GMFs in Ghana; 73.2% of them believed GMFs are present in Ghana while 26.8% said that GMFs could not be found in Ghana. Those who indicated that GMFs are presented in Ghana stated the supermarkets, markets and grocery as the major source of GMFs in Ghana.

Table 2: Awareness on GMOs and GMFs

Awareness level on GMOS/GMFs	Frequency	Percentage
Low	18	9.3
High	176	90.7
Total	194	100

Figure 2: Sources of information on GMOs and GMFs



4.4 Sources of Information

Responses as provided in Figure 1 indicate that television is the major source of information to respondents representing 20.90%, followed by radio representing 20.50%. Workshops were the least source of information concerning GMOs and GMFs. The internet, peer groups, books and newspapers were also part of the source of information, but were not a major source of information for respondents (Figure 2). Since the target population is made up highly educated respondents, the study further determines the extent to which they trust the various information sources with regards to credibility. The table 2 below is a cross tabulation of the information source by the extent of trust. It can be deduced that radio and television were the most trusted sources followed by internet, lecturers, friends and newspapers

Table 3: Source of information and level of trust of source

Sources of information	Highly Trusted (N)	Lowly Trusted (N)	Not Sure (N)	Total
Radio	72	11	27	110
Television	71	19	22	112
Newspapers	40	9	12	61
Books	20	7	5	32
Internet	59	12	15	86
Lecturer/Teacher	42	5	8	65
Workshop	14	3	0	17
Friends	41	9	14	64

A * Multiple choice allowed

4.5 Relationships between socio-demographics variables and awareness level of respondents

The associations between the socio-demographics and the level of awareness of the study respondents was determined by running a bivariate (chi-square test) and (Fisher exact test) analysis between them at 5% significance level.

The results from the bivariate analysis shows that there were no significant associations between age, gender, marital status, educational level, religious affiliation, programme of study and awareness levels (Table 4)

Table 4: Relationships between Socio-demographic characteristics and level of awareness of GMOs and GMFs (N=194)

Characteristics	Awareness level		Chi-square	P-value
	N	(%)		
Age	Low	High		
18-27	10(8.7)	105(91.30)		
28-37	8(15.1)	45(23.2)		
38-47	0(0.0)	26(100)		**0.086
Sex				
Male	8(8.1)	91(91.9)		
Female	10(10.5)	85(89.5)	0.3444	0.557
Marital status				
Single	18(10.8)	149(89.2)		**0.082
Married	0(0.0)	27(100.0)		
Educational level				
Undergraduate	16(11.1)	128(88.9)		
Postgraduate	2(4.0)	48(96.0)		**0.109
Religion				
Christian	18(9.9)	163(90.1)		
Muslim	0(0.0)	11(13.0)		**0.615

Data are presented in frequency (N) and proportions (%); *p-value < 0.05; **p-value of fisher's exact test

4.6 Risk and benefits Perceptions about GMFs effects on health

The result of the study shows that 42.2% of the study respondents perceived consumption of GMFs to be harmful to health; 32.0% indicated GMFs are not harmful to health and 25.8% reported that they are not sure of GMFs effects on health (Table 5).

On perceived risks of GMFs effect on health, the study respondents indicated that consumption of GMFs poses some health related risks such as allergy and cancer in humans. Other perceived side effects of GMFs indicated includes antibiotic resistance, genetic mutation, unknown long term effects, deformity at birth, high blood pressure, infertility, heart related disease and chemical related diseases.

However, concerning health benefits associated with GMFs, the study participants held the perception that, the consumption of GMFs has the potential to cure malnutrition; enhanced nutrient content of foods with a specific example of GMF used to develop rice with enhanced vitamin A. Additionally, some respondents opined that GMF is used to develop insulin for diabetic patient. Others indicated that some GMFs are used as vaccines to confer immunity in humans against invading pathogens. Albeit, high yield has no direct correlation with health, however the majority of the study respondents indicated high yield as one of the health benefits of GMFs.

On the risks and benefits perception of Genetic Modification Technology (GMT), 51.0% of the respondents indicated the use of modern biotechnology in the production of GMFs to make them higher in protein, nice taste and longer storage to be risky while 49.0% of the respondents believed the technology was useful. The majority of the respondent (43.3%), therefore, held the view that GMT should not be encouraged in the production of food to enhance nutrients, taste and the shelf-life of foods (Table 5) with the reason that is not safe to health. However, 65.5% of the participants indicated that the use of

GMT to make plant crops more resistant to insects and pest in order to increase yield as useful and this was reflected in the majority of the participants (52.0%) indicating that GMT in making crop plants resistant to insect and pests should be encouraged (Table 5).

Table 5: Perceptions about the effect of GMFs on health and perceptions about the use of GMT

Perceptions	Frequency (N)	Percentage (%)
GMFs effect on health		
Harmful to health	82	42.2
Not harmful	62	32.0
Not sure	50	25.8
GM improved food nutrient		
Useful	95	49.0
Risky	99	51.0
GM pest resistant crops		
Useful	127	65.5
Risky	67	34.5
The use of GMT to increase food nutrient		
Yes	67	34.5
No	84	43.3
Not sure	43	22.2
The use of GMT to make crops resistant to pests		
Yes	101	52.0
No	62	32.0
Not sure	31	16.0

4.6.1 Association between socio-demographic characteristics and perception of GMFs effects on health

The association between socio-demographics characteristics and perception of GMFs effects on health were determined by running a bivariate (chi-square test) and (Fisher exact test) analysis between them at 5% significance level.

The results of the bivariate analysis revealed that there were no significant association between age, marital status, educational level, religious affiliation and the perception of GMFs effect on health. However, there was a significant association between gender ($p=0.021$) and perception of GMFs effect on health; 49.0% of females indicated that consumption of GMFs is harmful to health as compared to 34% of males who indicated that consumption of GMFs is harmful to health. Similarly, 41% of the male study respondents indicated that consumption of GMFs is not harmful to health while 23% of the females indicated are harmful to health (Table 6).

Table 6: Association between socio-demographics and perceptions of GMFs on health (N=194)

Characteristics	Harmful to health	Not harmful to Health	Not Sure	Chi square	P value
Age group					
>18	53 (46.1)	38(33.0)	24 (20.9)		
28-37	19(35.9)	15 (28.3)	19 (35.9)		
<47	11(42.31)	11(42.31)	4(15.4)		**0.206
Sex					
Male	34 (34.4)	41(41.4)	24 (24.2)		
Female	49 (51.6)	23 (24.2)	23 (24.2)	7.7154	*0.021
Edu. Level					
Undergraduate	62 (40.0)	44 (30.6)	38 (26.4)		
Postgraduate	21 (42)	20 (40.0)	9 (18.0)	2.0912	0.351
Marital status					
Single	72 (43.1)	56 33.5)	39 (23.4)		
Married	11(40.8)	8 (29.6)	8 (29.6)	0.5158	0.773
Religion					
Christian	80 (44.2)	59 (32.60)	42 (23.20)		
Muslim	3 (23.08)	5 (38.46)	5 (38.46)		*0.229

Data are presented in frequency (N) and proportions (%); χ^2 , Pearson's chi-square value; *p-value < 0.05; **p-value of fisher's exact test!

4.7 Other perceptions about GMOs and GMFs

Other perceptions about GMOs and GMFs of the study respondents covered the area of the environment, preferred food production source and their level of acceptability of GMFs.

4.7.1 Perception of GMOs on the environment

Table 6 summarizes the perceptions held about the impact of GMOs (GM crops) on the environment. It was observed that 37.1% of the study participants held the perception that GMOs have a negative impact of on the environment whilst 28.4% perceived GMOs to have a positive impact on the environment. However, 34.5% of the respondents were not sure about the impact of GMOs on the environment (Table 7).

Table 7: Participants perception about the impact of GMOs on the environment

Response	Frequency	Percentage
Positive	59	28.4
Negative	81	37.1
Not Sure	54	34.5
Total	194	100.0

4.7.2 Preferred Food production Source and the acceptability of GMFs if they were cheaper

On the preferred source of food production, the majority of the respondents (73.7%) preferred foods produced by organic means; 17.0% preferred foods produced using inorganic fertilizer while only 9.3% of the respondents preferred foods produced using GM technology (Table 8). The majority of the participants preferred organic foods because they believe organic foods are safe for consumption, good for health and contain no harmful chemicals which could be dangerous to the human health. They also indicated that foods produced from organic sources nourish to grow nutritious foods.

The study respondents accentuated their opinion concerning the acceptability of GMFs if they were cheaper

Table 8: Respondents' preferred food production sources

Technique	Frequency (N)	Percentage (%)
GM Technology	18	9.3
Organic Fertilizer	143	73.7
Inorganic Fertilizer	33	17.0

4.7.3 Association of socio-demographics and acceptability of GMFs if they were cheaper

A bivariate analysis was carried out between the socio-demographic characteristics of the study respondents, level of awareness of the study participants and acceptability of GMFs. The result showed in table 10.0 indicates that there was no significant association between age, marital status, education level, religion and acceptability of GMFs. Meanwhile, gender ($p=0.006$) and program study ($p=0.034$) were found to be significantly associated with the acceptability of GMFs if they were cheaper (Table 10.0).

Table 9: Association between socio-demographics and acceptability of GMFs if they were cheaper

Characteristics	Will accept N (%)	Will not accept N (%)	Chi square	P value
Age Group	53(46.1)	62(53.9)		
>18	26(49.0)	27(50.9)		
28-37	13(50)	13(50)	0.2083	0.906
<47				
Sex				
Male	59(59.6)	40(40.4)		
Female	34.7(40.0)	65.3(60.0)	12.0156	*0.001
Education level				
Undergraduate				
Postgraduate	67(46.5)	77(53.5)		
	26(52.0)	24(48.0)	0.1795	0.672
Religion				
Christian	88(48.6)	93(51.4)		
Muslim	9(69.2)	4(30.8)		**0.150
Marital Status				
Single	82(49.1)	85(50.9)		
Married	10(37.0)	17(63.0)	1.3568	0.244

Data are presented in frequency (N) and proportions (%); *p-values< 0.05; **p-value of the Fisher exact test

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter discusses the findings of the study taking into account available literature. The purpose of the study was to examine the perception of GMOs and GMFs and its perceived risks and benefits on health among Students of University of Ghana. The objectives were to determine the level of awareness of GMOs/GMFs, to explore the sources of information of GMFs and to investigate the perceived health effects of GMFs.

The study found high awareness levels of GMOs/GMFs among university of Ghana students. The study found television and radio as the major sources from which the students access information on GMOs and GMFs. Out of the total participants, 73.2% of them believed that GMFs are in Ghana. Socio-demographic characteristics were found not to influence awareness level. Generally, the study respondents identified consumption of GMFs as harmful to health. These findings are discussed in detail in the following paragraphs.

5.2 Awareness level and Knowledge

Issue regarding GMFs and GMOs is very crucial one worldwide and since its inception, people from different part of the world have been concern and shown key interest (Buah, 2011). This may explain why, in this study all the participants showed interest in participating in the survey. The majority of the study participants (90.7%) had high awareness level on GMOs and GMFs. This findings corroborate with previous studies that showed high level of awareness of GMOs and GMFs among University Students in Malaysia (Amin, Azlan, Hamdan, Samian, & Haron, 2011) and Slovakia (Prokop, Lešková, Kubiátko, & Diran, 2007) and among geography teachers in Turkey (Demirci,

2008). Findings from this study was also in trend with awareness level of GMFs among academia, research institutes and governments ministries in Ghana (Buah, 2011). However, findings from this study compared by a study conducted at three different points of sale: supermarkets, kiosks (small roadside shops) and posho mills (mechanical mills for maize) in Nairobi Kenya where 62% of the study participants were totally unaware of biotechnology and GMFs (Kimenju, De Groote, Karugia, Mbogoh, & Poland, 2005). This disparity could be because 58.3% of the study respondents in the Kenyan study were below the university level of education as compared to the current study where all the study participants were university students; pursuing either first degree or postgraduate degree and for that matter they are academic imbibed and enlightened and can easily access information. High level of awareness of biotechnology and GMFs among University of Ghana students was reflected in their knowledge about GMFs. The study results showed that study participants (73.7%) had good knowledge about what GMFs mean and understand the application of GM technology. This is consistent with a similar study conducted in Indonesia (Februhartanty, Widyastuti, & Iswarawanti, 2007) which found that 70% of study participants had good knowledge about GMFs.

In this study, the respondents' awareness level was found not to be the influence of socio-demographic characteristics. This observed difference could be explained by the special knowledge of GMFs possessed by that age group. It could also be as a result of the skewness of the data (table 4).

5.3 Sources of information on biotechnology and GMFs

With regards to accessing information, this study identified the mass media (television and radio) as the main sources of information on biotechnology and GMFs. This is

consistent with findings from previous study that showed that the main sources information on biotechnology is the media (television, radio and newspaper (Kimenju et al., 2005). Again, in the work of Frewer et al., (2004), television and radio were identified as part of major sources of information on GMOs and GMFs. Also it was confirmed by studies of Curtis, McCluskey, & Wahl, (2004) and Tekedere, Taban & Çaliskan, (2011) that the mass media is very important sector on GMOs and GMFs issues. The public now spend much time watching television and listening to the radio because is the major source of entertainment and education, and it appears to have greatly impacted on the public awareness on GMFs. The media have been identified as an important tool to disseminate health information (Haque, Arafat, Roy, Khan, Majbah Uddin, 2014). Due to GMFs effect on public health (Maghari & Ardekani, 2011), it has become the subject of ongoing debate which usually takes place in the electronic media. This could be the underlying reasons why the electronic media is the major source of information.

The television and radio were found to be the most trusted sources of information on GMFs. This is contrasted by study which found that television, radio, newspapers and other media outlets were not well trusted by the international public(Blaine, Kamaldeen, 2002). Several studies had also found that people trusted accessing information from environment and consumer organizations as well as medical profession (Bonny, 2003; Gaskell, 2000)

5.4 Risk and benefits Perceptions about GMFs effects on health

In the past biotechnology was basically used for protecting plants from disease and harmful insects. However, from the last two decades it has spread its tentacles to different areas. Current research in biotechnology focuses on health, industry, environment, and agriculture (Demirci, 2008).

With regards to health, more than one-third of the study respondents expressed fears about the health effects of GM foods. About forty two percent of the study participants perceived that consumption of GMFs could be harmful to human health. They thought people could suffer from allergy, cancer, antibiotic resistant, infertility after consumption of GMFs. The findings of this study is consistent with an earlier study (Kimenju et al., 2005). This could be argued that it was “misinformation’ stirred up by activists circulated by the media, which led the study respondents to view GMFs as harmful to health. The implication of GMFs on health has become public health concern (Maghari & Ardekani, 2011). There seems to be no established empirical evidence about the risk of GMFs in relation to health. This has led to much speculation about GMFs effect on health. This could also account for the negative perception of the study participants concerning GMFs. However, a significant number of the respondents (32.0%) believed that consumption of GMFs has positive effect on health. Most of those who believe that GMFs has positive effect on health assigned their reasons to it improved nutritional value. This observation is similar to an earlier study conducted in Indonesia among agricultural scientist which found that 39% of the study participants which perceived GMFs consumption as positive to health associated their reason to the improved nutritional value (Februhartanty et al., 2007). Some study participants also believed that use of GMFs as vaccine to infer immunity in human is a very important benefit to human health. For example in the whole of South East Asia; GM potatoes are required to meet annual demand for hepatitis B vaccine (Key, Ma, & Drake, 2008).

Potential benefits are seen from GMFs (Kimenju et al., 2005). However, in general, participants did not see GMFs to be as healthy as its organic counterpart nor did they feel very strongly about the health attributes associated with GMFs. The study participants perceived organic food products to be more closely linked to positive health attributes

compared to GMFs. This observation is consistent to a study conducted among students at North Dakota State University in Fargo and the University of North Dakota in Grand Forks which found that people preferred organic foods because it's more safe and healthier (Anderson et al., 2005).

On the other hand, there is a lack of scientific data concerning environmental and health effects from both industrial and public research sources (Pryme & Lembcke, 2003; Pusztai, 2002; Zdziarski, Edwards, Carman, & Haynes, 2014). Furthermore, there is little empirical evidence that eating today's GMFs is unhealthy, except in rare cases of allergenicity (Pryme & Lembcke, 2003; Pusztai, 2002; Zdziarski, Edwards, Carman, & Haynes, 2014). GMFs have been consumed by hundreds of millions of people across the world for more than 15 years, with no reported ill effects (Key et al., 2008). Therefore, conclusion drawn by scientific panels sponsored by the National Academy of Sciences, the British Royal Society, and the World health Organization, and other reputable institutions stated that Genetically Modified Crops (GMCs) are both safe to human and the environment, however, they accentuated the need for careful research and oversight (Chen & Li, 2007; Appell, 2014).

Generally, the use of GMT to produce foods with enhanced nutrient was perceived by study participants to have both potential benefits and risk; 51% of the study respondents' perceived the use of GM technology to produce food as risky while 49% believed it's useful. However, with regards to the use of GMT to make crops more resistant to pest and diseases; majority of the respondents (63.9%) believes that is very useful. Similarly, previous studies have shown more positive views towards GM when used as crop disease resistant as compared to food enhancement generally (McComas, Besley, & Steinhardt, 2014; Anunda, Njoka, & Shauri, 2010).

5.5 Other perceptions about GMOs and GMFs

On the issue on the environment, the findings of this study corroborate with Sloan (2000) study. The previous study reported that consumers perceived organic food production as environmentally friendly, however using GMT in food production is perceived as less environmentally friendly and that consumers are unaware of the benefits that GM has to the environment (Siró, Kápolna, Kápolna, & Lugasi, 2008). It was revealed in this study that participants who believe GMOs has negative impact on the environment are much more concern about the unknown effect on the environment. However, a significant number of the study participants held positive perception of GMOs impact on the environment with believe that GM crops uses less chemicals. .

5.6 The Relationship between Gender and Perception

Generally, the findings from this present study showed that female had more unfavorable perceptions of GMO and GMFs. There were significant relationships between perception of GMFs effect on health, GMOs Impact on the environment, the acceptability of GMFs and gender. Furthermore, it was revealed that females perceived more risks in relation to GMFs effect on health and also to the application of GMT as compared to their male counterpart. This observation is in trend with National Science report which found that there is significant gender gap in attitude towards genetic modification, with female considerably more likely than men to believe that the risk outweighed the benefits (Blaine & Kamaldeen, 2002). Similarly, the findings of this study also showed that males were more likely to accept GMFs if they were cheaper as compared to females. However the findings is consistent with the hypothesis (Moerbeek & Casimir, 2005). Again the current findings of this study is also supported by other studies (Buah, 2011; Moerbeek & Casimir, 2005; James & Burton, 2003; Anunda, Njoka, & Shauri, 2010) which detected

difference in perception according to gender, mainly, females, had more negative attitude towards GMFs. In a related study, (Burton, Rigby, Young & James, 2001) concluded that females shoppers were willing to pay more premiums to avoid GMFs than males, suggesting less acceptability of GMFs among females. Moreover, studies have revealed that women perceive lower benefits and are less likely to accept GMT than men (Siegrist, Cvetkovich, & Roth, 2000; Costa-Font, Gil, & Traill, 2008). These results indicate a significant divergence exists between men and women regarding their opinions about genetic modification of crops and foods. Since the study was made up highly educated participants, therefore, the disparity between male and female attitude towards biotechnology and GMFs could not be explained by lack of knowledge of biotechnology. However, they may be explained by variation in trust, values and subjective norms. This implies that views and perception of gender with regards to GMOs and GMFs is very important to be considered in making informed decision for the public.

5.7 Application of the Conceptual Framework to Perception about GMFs

From the conceptual framework the content of information and its source influence consumer or individual attitudes, beliefs and perceptions regarding GMFs. Also it shows that attitude has greatest influence on perception. Favorable attitudes/unfavorable attitudes depends on the subjective thinking of individuals about GMFs. The conceptual framework was supported by Fishbein Multi-attribute Model (Fishbein, 1963) states that an attitude towards a product is based on knowledge about the product itself as well as its attributes, which is referred to as the so-called 'bottom-up' formation of attitude. The results from this study revealed that respondents widely accessed information on GMFs from mainly the mass media (television and radio) and other sources which reflected in the high awareness on GMFs recorded among the respondents. This simply means that

perception form by the respondents about GMFs was largely influence by the kind of information received from the mass media, as an individual's perception (risks/benefits) is influence by the content of the message received (Frewer et al., 1996). Also the conceptual framework shows that process or techniques used in production of the products influence attitude about GMFs. The result revealed that majority (73.7%) of the study respondents preferred organic fertilizer source of food production followed

In conclusion, the results of the study revealed that providing information on GMFs will help improve people's knowledge about GMFs, perceptions about the potential health outcomes of GMFs and in turn develop positive attitude towards GMFS. The results of this study supported the constructs of the conceptual framework.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This study sought to investigate the perception of GMOs and GMFs and its perceived risks and benefits on health among students of the University of Ghana.

This study revealed a high awareness of GMOs and GMFs among student of the University of Ghana with majority of them indicating the availability of GMFs in Ghana. The majority of the study respondents does understand what GMOs and GMFs mean and comprehend the basic concept underpinning GMT.

University of Ghana Students accessed their information on GMOs and GMFs mainly from the television and radio. Additionally the study revealed television and radio were the most trusted sources of information on GMOs and GMFs for the study participants.

Generally, the study participants moderately held risk perception about GMOs and GMFs. Averagely, the study participants believed that consumption of GMFs could pose health risk to individuals. However, it was revealed that the majority of the study participants supported the use of GMT to produce crops that resist disease caused by insects and pests. Furthermore, it was also found that more females perceived GM products to have health risk compared to their male counterpart.

6.2 Recommendations

6.2.1 Education

The study revealed a high awareness about GMOs and GMFs. However, emphasis must also be given to educating people about the technology by providing them factual information.

The mass media (television and radio) can serve as a starting point for effective targeted communication on GMFs in the future. Television and radio should be used as effective media to disseminate and educate students on GMOs and GMFs issues. This same media strategy could also be extended to the general public in terms of awareness creation and educational campaigns to help the general public make well informed decisions and become actively involved in the decision making process.

6.2.2 Policy

Based on the findings of the study, it seems to be a common knowledge to the majority of the study participants that GMFs are present in Ghana. The implication therefore is that, policy-makers must consider the issue of GMFs and bring all appropriate stakeholders on board so as to discuss the way forward to make the right and appropriate GM policies.

6.2.3 Research

Finally, studies tracking public opinion should be conducted regularly, in order to determine awareness levels, capture the impact of awareness activities, the perceptions and reveal trends. Studies should be extended to other tertiary institutions, smaller towns, rural areas, and urban areas in Ghana in order to include these segments of the population in the national discourse.

Gender has been identified to predict attitudes towards GMOs and GMFs. It is therefore recommended that more studies should be carried out to unearth the underpinning causes behind the disparities. This will inform appropriate measures to address the issues on what is lacking and needed for further improvement.

REFERENCES

- Albert, D., Aschenbrenner, K. M., & Schmalhofer, F. (1989). Cognitive Choice Processes and the Attitude-behavior Relation BT - Attitudes and behavioral. In *Attitudes and behavioral*. http://doi.org/10.1007/978-1-4612-3504-0_3
- Amin, L., Azlan, N. a a, Hamdan, M. F., Samian, a L., & Haron, M. S. (2011). Awareness and knowledge on modern biotechnology. *African Journal of Biotechnology*, *10*(58), 12448–12456. <http://doi.org/10.5897/AJB11.1055>
- Anderson, J. C., Wachenheim, C. J., & Lesch, W. C. (2005). Perceptions of genetically modified and organic foods and processes : north dakota college students, (571).
- Anne Ingeborg Myhr, T. T. (1999). The Precautionary Principle Applied to Deliberate Release of Genetically Modified Organisms (GMOs). *Microbial Ecology in Health and Disease*, *11*(8), 65–74. <http://doi.org/10.1080/089106099435790>
- Anunda, H. N., Njoka, F. M., & Shauri, S. H. (2010). Assessment of Kenyan public perception on genetic engineering of food crops and their products. *Journal of Applied Biosciences*, *33*, 2027–2036.
- Appell, D. (2014). *The Wilson Quarterly*, *18*(3), 82–85.
- Bonny, S. (2003). Why are most Europeans opposed to GMOs? Factors explaining rejection in France and Europe. *Electronic Journal of Biotechnology*, *6*(1), 47–68. <http://doi.org/10.2225/vol6-issue1-fulltext-4>
- Brookes, G., & Barfoot, P. (2014). The global income and production effects 1996 – 2012 Economic impact of GM crops. *GM Crops*, (March), <http://dx.doi.org/10.4161/gmcr.28098>. <http://doi.org/10.4161/gmcr.28098>
- BUAH, J. . (2011). Public Perceptions of genetically modified foods in Ghana. *American Journal of Food Technology*, *6*(7), 542–554.
- Burton, M., Rigby, D., Young, T., & James, S. (2001). Consumer attitudes to genetically modified organisms in food in the UK. *European Review of Agricultural Economics*, *28*(4), 479–498. <http://doi.org/10.1093/erae/28.4.479>
- Chen, M.-F., & Li, H.-L. (2007). The consumer's attitude toward genetically modified foods in Taiwan. *Food Quality and Preference*, *18*(4), 662–674. <http://doi.org/10.1016/j.foodqual.2006.10.002>
- Cormick, C. (2005). Lies, Deep Fries, and Statistics!! The search for the truth between public attitudes and public behaviour towards genetically modified foods. *Choices*, *20*(4), 227–231.

- Costa-Font, M., Gil, J. M., & Trill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy*, *33*(2), 99–111. <http://doi.org/10.1016/j.foodpol.2007.07.002>
- Curtis, K. R., McCluskey, J. J., & Wahl, T. I. (2004). Consumer acceptance of genetically modified food products in the developing world. *AgBioForum*, *7*(1-2), 70–75.
- Dean, M., & Shepherd, R. (2007a). Effects of information from sources in conflict and in consensus on perceptions of genetically modified food. *Food Quality and Preference*, *18*(2), 460–469. <http://doi.org/10.1016/j.foodqual.2006.05.004>
- Dean, M., & Shepherd, R. (2007b). Effects of information from sources in conflict and in consensus on perceptions of genetically modified food. *Food Quality and Preference*, *18*(2), 460–469. <http://doi.org/10.1016/j.foodqual.2006.05.004>
- Demirci, A. (2008). Perceptions and attitudes of geography teachers to biotechnology : A study focusing on genetically modified (GM) foods, *7*(23), 4321–4327. <http://doi.org/10.5897/AJB08.817>
- Dwane Hal Dean. (2004). Consumer Reaction to Negative Publicity: Effects of Corporate Reputation, Response, and Responsibility for a Crisis Event. *Journal of Business Communication*, *41*(2), 192–211. <http://doi.org/10.1177/0021943603261748>
- Ekici, K., & Sancak, Y. C. (2011). A perspective on genetically modified food crops. *African Journal of Agricultural Research*, *6*(7), 1639–1642. <http://doi.org/10.5897/AJAR10.284>
- Februhartanty, J., Widyastuti, T. N., & Iswarawanti, D. N. (2007). Attitudes of agricultural scientists in Indonesia towards genetically modified foods. *Asia Pacific Journal of Clinical Nutrition*, *16*(2), 375–380.
- Finucane, M. L., & Holup, J. L. (2005). Psychosocial and cultural factors affecting the perceived risk of genetically modified food: An overview of the literature. *Social Science and Medicine*, *60*(7), 1603–1612. <http://doi.org/10.1016/j.socscimed.2004.08.007>
- Frewer, L. J., Frewer, L. J., Miles, S., Miles, S., Marsh, R., & Marsh, R. (2002). The Media and Genetically Modified Foods: Evidence in Support of Social Amplification of Risk. *Risk Analysis*, *22*(4).
- Frewer, L. J., Howard, C., Hedderley, D., & Shepherd, R. (1996). What determines trust in information about food-related risks? Underlying psychological constructs. *Risk Analysis : An Official Publication of the Society for Risk Analysis*, *16*(4), 473–486. <http://doi.org/10.1111/j.1539-6924.1996.tb01094.x>
- Frewer, L. J., Shepherd, R., & Sparks, P. (1994). Biotechnology and Food Production: Knowledge and Perceived Risk. *British Food Journal*, *96*(9), 26–32. <http://doi.org/10.1108/00070709410072562>

- Frewer, L., Lassen, J., Kettlitz, B., Scholderer, J., Beekman, V., & Berdal, K. G. (2004). Societal aspects of genetically modified foods. *Food and Chemical Toxicology*, 42(7), 1181–1193. <http://doi.org/10.1016/j.fct.2004.02.002>
- Fukuda-Parr, S., & Birdsall, N. (2001). *Human development report 2001: Making new technologies work for human development. ... Development ...* Retrieved from <http://dspace.cigilibrary.org/jspui/handle/123456789/20137>
- Gaps, K., Genetically, C., Crops, M., Inventory, A., Nijhuis, E. H., Elsas, J. D. Van, & Dueck, T. a. (2000). Crops of Uncertain Nature ?, (August).
- Gaskell, G. (2000). Agricultural biotechnology and public attitudes in the European Union. *AgBioForum*, 3(2-3), 87–96.
- Gruissem, W. (2015). Genetically modified crops : the truth unveiled. *Agriculture and Food Security*, 3–4. <http://doi.org/10.2527/jas>.
- Hakan tekedere, Birce TABAN, Mustafa çalışkan, H. D. (2011). Analysis Of Training Needs Of Health Services School Of Higher Vocational Education Students On Genetically Modified Organisms. *Journal of Turkish science education*, 8(3), 157–160.
- Hallman, W. K., & Aquino, H. L. (2005). Consumers ' Desire for GM Labels : Is the Devil in the Details ? Articles in this Theme : *Agricultural Economics*, 20(4), 217–262.
- Hallman, W. K., Hebden, W. C., Aquino, H. L., & Cuite, C. L. (2003). Public perceptions of g enetically m odified f oods : A National Study of American Knowledge and Opinion.
- Han, J. H., & Harrison, W. R. (2007). Factors influencing urban consumers' acceptance of genetically modified foods. *Review of Agricultural Economics*, 29(4), 700–719. <http://doi.org/10.1111/j.1467-9353.2007.00382.x>
- Henseleit, M., Kubitzki, S., & Herrmann, R. (2009). “GMO-free” labels – Enhancing transparency or deceiving consumers? 49. *Jahrestagung Der gewisola “Agrar- Und Ernährungsmärkte Nach Dem Boom,”* pp. 15. Retrieved from http://ageconsearch.umn.edu/bitstream/53263/2/v26_53263.pdf
- Hoban, T. J. (2001). American Consumers' Awareness and Acceptance of Biotechnology* Thomas J. Hoban. *Most*.
- Hollingworth, R. M., & Meade, B. J. (2003). The Safety of Genetically Modified Foods Produced through Biotechnology The Safety of Genetically Modified Foods Produced through Biotechnology, 8, 2–8. <http://doi.org/10.1093/toxsci/71.1.2>
- Hosking, S. G., Liu, C. C., & Bayly, M. (2010). The visual search patterns and hazard responses of experienced and inexperienced motorcycle riders. *Accident Analysis and Prevention*, 42(1), 196–202. <http://doi.org/10.1016/j.aap.2009.07.023>

- Hossain, F., Onyango, B., Adelaja, A., Schilling, B., & Hallman, W. (2002). Uncovering factors influencing public perceptions of food biotechnology. *Food Policy*, (June), 1–31.
- Huang, J., Qiu, H., Bai, J., & Pray, C. (2006). Awareness, acceptance of and willingness to buy genetically modified foods in Urban China. *Appetite*, 46(2), 144–151. <http://doi.org/10.1016/j.appet.2005.11.005>
- Isserman, A. M. (2001). from the SAGE Social Science Collections . All Rights Reserved . *SAGE Journals*, 33(10), 928–940. <http://doi.org/0803973233>
- Jae-Hwan, H. (1995). The Effects of Perceptions of Consumer Acceptance of Genetically Modified Foods. *Sunchon National University*, (May).
- James, C. (2010). brief 42 Global status of Commercialized biotech / GM Crops : 2010. *Crops*, 42(44), 2009–2009. <http://doi.org/10.1017/S0014479706343797>
- James, C., & Isa. (2009). Global Status of Commercialized Biotech / GM Crops : 2009 executive summarY, (41).
- James, S., & Burton, M. (2003). Consumer preferences for GM food and other attributes of the food system. *The Australian Journal of Agricultural and Resource Economics*, 47(4), 501–518. <http://doi.org/10.1111/j.1467-8489.2003.t01-1-00225.x>
- Joffe, H. (2003). Risk: from perception to social representation. *The British Journal of Social Psychology / the British Psychological Society*, 42(Pt 1), 55–73. <http://doi.org/10.1348/014466603763276126>
- K. Blaine, S. Kamaldeen, and D. P. (2002). Public Perceptions of Biotechnology: Another Look. *Journal of foods scienceournal of foods SCIENCE*, 67(9), 3200–3206. <http://doi.org/10.1038/nbt0196-35>
- Kaya, I. H., Poyrazoglu, E. S., Artik, N., & Konar, N. (2013). Academicans ' Perceptions and Attitudes toward GM-Organisms and – Foods. *International Journal of Biological, Ecological and Environmental Sciences*, 2(2), 2–6.
- Key, S., Ma, J. K.-C., & Drake, P. M. (2008). Genetically modified plants and human health. *Journal of the Royal Society of Medicine*, 101(6), 290–298. <http://doi.org/10.1258/jrsm.2008.070372>
- Kimenju, S. C., De Groote, H., Karugia, J., Mbogoh, S., & Poland, D. (2005). Consumer awareness and attitudes toward GM foods in Kenya. *African Journal of Biotechnology*, 4(10), 1066–1075.
- Linacre, N. a, Gaskell, J., Rosegrant, M. W., Falck-zepeda, J., Quemada, H., Halsey, M., & Birner, R. (2005). Analysis for Biotechnology Innovations Using Strategic Environmental Assessment (SEA). *Food Policy*, (August). <http://doi.org/10.1.1.81.3865>

- M. Haque, Y. Arafat, S.K. Roy, Z.H. Khan, A.K.M. Majbah Uddin, S. P. (2014). Nutritional Status and Hygiene Practices of Primary School Children. *Journal of Nutritional Health & Food Engineering*, 1(2), 1–5.
<http://doi.org/10.15406/jnhfe.2014.01.00007>
- Maghari, B. M., & Ardekani, A. M. (2011). Genetically modified foods and social concerns. *Avicenna Journal of Medical Biotechnology*, 3(3), 109–117.
- Malcolm, B., Sinnett, A., Malcolm, B., & Sinnett, A. (2015). Are We Risking too much? Are we @ Risking too much? By. In *Are w at risk too much?*
- Markon, M.-P. L., & Lemyre, L. (2013). Public Reactions to Risk Messages Communicating Different Sources of Uncertainty: An Experimental Test. *Human and Ecological Risk Assessment: An International Journal*, 19(4), 1102–1126.
<http://doi.org/10.1080/10807039.2012.702015>
- Marris, C., & Marris, C. (2001). Public views on GMOs: deconstructing the myths. *Molecular Biology*, 2(7), 545–548. <http://doi.org/10.1093/embo-reports/kve142>
- Matthen, M., & Stephens, C. (2007). *Philosophy of Biology*. Retrieved from <http://www.amazon.com/Philosophy-Biology-Handbook-Science/dp/0444515437/>
- McComas, K. a., Besley, J. C., & Steinhardt, J. (2014). Factors influencing U.S. consumer support for genetic modification to prevent crop disease. *Appetite*, 78, 8–14. <http://doi.org/10.1016/j.appet.2014.02.006>
- Mizerski, R. W. (1982). An Attribution Explanation of the Disproportionate Influence of Unfavorable Information. *Journal of Consumer Research*, 9(3), 301.
<http://doi.org/10.1086/208925>
- Moerbeek, H., & Casimir, G. (2005). Gender differences in consumers' acceptance of genetically modified foods. *International Journal of Consumer Studies*, 29(July), 308–318.
- Moon, W., & Balasubramanian, S. K. (2003). Is there a market for genetically modified foods in Europe? Contingent valuation of GM and non-GM breakfast cereals in the United Kingdom. *AgBioForum*, 6(3), 128–133.
- Morris, S. H., & Adley, C. C. (2000). Genetically modified food issues: Attitudes of Irish university scientists. *British Food Journal*, 102(9), 669–691.
<http://doi.org/10.1108/00070700010362040>
- Oladele, I., & Akinsorotan, A. (2007). The attitude towards genetically modified organisms (gmo's) and their effect on health and environment in southwestern. *Journal of Central European Agriculture*, 8(1), 91–98.
- Onyango, B., Jr, R. N., & Schilling, B. (2005). Role of product benefits and potential risks in consumer acceptance of genetically modified foods. *AgBioForum*, 7(4), 202–211.

- Paper, W., Hallman, W. K., Ph, D., Cuite, C. L., & Morin, X. K. (2013). Public Perceptions of Labeling Genetically Modified Foods, (848), 1–42.
- Peterson, M. J. (2010). Asilomar Conference on Laboratory Precautions When Conducting Recombinant DNA Research – Case Summary. *International Dimensions of Ethics Education in Science and Engineering*, (0734887).
- Pierrier Ganiere, Wen S. Chern, D. H. (2004). *Who are Proponents and Opponents of Genetically Modified Foods in the United*.
- Ploeg, J. D. Van Der. (2000). Revitalizing Agriculture: Farming Economically as Starting Ground for Rural Development. *Sociologia Ruralis*, 40(4), 497–511. <http://doi.org/10.1111/1467-9523.00163>
- Poortinga, W., & Pidgeon, N. (2004). *Public Perceptions of Genetically Modified Food and Crops, and the GM Nation? Public Debate on the Commercialisation of Agricultural Biotechnology in Th*. Retrieved from http://psych.cf.ac.uk/understandingrisk/docs/survey_2003.pdf
- Prokop, P., Lešková, A., Kubiátko, M., & Diran, C. (2007). Slovakian Students' Knowledge of and Attitudes toward Biotechnology. *International Journal of Science Education*, 29(7), 895–907. <http://doi.org/10.1080/09500690600969830>
- Pruitt, M. J. (2014). *Consumer Perceptions and Knowledge of Genetically Modified Organisms in Belgium: A Case Study of the Potato Event*.
- Pryme, I. F., & Lembcke, R. (2003). In vivo studies on possible health consequences of genetically modified food and feed--with particular regard to ingredients consisting of genetically modified plant materials. *Nutrition and Health (Berkhamsted, Hertfordshire)*, 17(1), 1–8. <http://doi.org/10.1177/026010600301700101>
- Pusztai, A. (2002). Can science give us the tools for recognizing possible health risks of GM food? *Nutrition and Health (Berkhamsted, Hertfordshire)*, 16(2), 73–84. <http://doi.org/10.1177/026010600201600202>
- Quaye, W., Yawson, I., Yawson, R. M., & Williams, I. E. (2009). Acceptance of biotechnology and social-cultural implications in Ghana, 8(9), 1997–2003.
- Rimal, A., Moon, W., & Balasubramanian, S. K. (2005). Labeling Genetically Modified Food Products : Attitudes among the consumers in the United States and United Kingdom. *AAEA Annual Meeting in Providence, RI*, (417), 1–22.
- Ruttan, V. W. (1999). Biotechnology and agriculture: A skeptical perspective. *AgBioForum*, 2(1), 54–60.
- Sajeev, M. V, Gangadharappa, N. R., Directorate, Z. P., Sustainable, K., Management, F., Project, B. C., & Bhavan, A. (2011). Genetically Modified Crops : A Pre-Introductory Assessment of Farmer Readiness , Its Determinants and Extent of Support in India. *Journal of Agricultural Science*, 2(1), 29–37.

- Scholderer, J. (2004). *Consumer Attitudes towards Genetically Modified Foods in Europe: Structure and Changeability*. Retrieved from <http://opus.kobv.de/ubp/volltexte/2006/624/pdf/scholderer.pdf> accessed June 16, 2010
- Sheeran, J. (2008). The challenge of hunger. *The Lancet*, 371(9608), 180–181. [http://doi.org/10.1016/S0140-6736\(07\)61870-4](http://doi.org/10.1016/S0140-6736(07)61870-4)
- Siegrist, M., Cvetkovich, G., & Roth, C. (2000). Salient value similarity, social trust, and risk/benefit perception. *Risk Analysis*, 20(3), 353–362. <http://doi.org/10.1111/0272-4332.203034>
- Siró, I., Kápolna, E., Kápolna, B., & Lugasi, A. (2008). Functional food. Product development, marketing and consumer acceptance—A review. *Appetite*, 51(3), 456–467. <http://doi.org/10.1016/j.appet.2008.05.060>
- Sj, L., Moen, E., & Rundmo, T. (2004). *of the psychometric Explaining risk. An evaluation of the psychometric paradigm in risk perception research* (Vol. 2). <http://doi.org/10.1080/135753097348447>
- Sjöberg, L. (2008). Genetically Modified Food in The Eyes of the Public and Experts. *Risk Management*, 10(3), 168–193. <http://doi.org/10.1057/rm.2008.2>
- Smithson, M. (1999). Conflict Aversion: Preference for Ambiguity vs Conflict in Sources and Evidence. *Organizational Behavior and Human Decision Processes*, 79(3), 179–198. <http://doi.org/10.1006/obhd.1999.2844>
- Sophia, K., & A.Powell, D. (2000). Public perceptions of biotechnology Sophia Kamaldeen and Douglas A. Powel. *Foodsatey Network Technical Report*, (17), 1–14.
- Souza, D. K. De, Brown, C. A., Ahorlu, C. K., & Suzuki, T. (2013). Understanding the requirements and factors necessary for the acceptance of genetically modified mosquitoes as a potential malaria control tool in Ghana : a questionnaire survey. *AsPac J. Mol. Biol. Biotechnol*, 21(3).
- Suleyman, & Tuna, N. and Fi. (2011). An Overview of Biotechnology in Turkish Secondary Schools : a Student ' S Perspective on Health and Environmental Issues. *European Journal of Educational Studies*, 3(1), 123–133.
- Swiatkiewicz, S., Swiatkiewicz, M., Arczewska-Wlosek, A., & Jozefiak, D. (2014). Genetically modified feeds and their effect on the metabolic parameters of food-producing animals: A review of recent studies. *Animal Feed Science and Technology*. <http://doi.org/10.1016/j.anifeedsci.2014.09.009>
- Tenbült, P., De Vries, N. K., van Breukelen, G., Dreezens, E., & Martijn, C. (2008). Acceptance of genetically modified foods: The relation between technology and evaluation. *Appetite*, 51(1), 129–136. <http://doi.org/10.1016/j.appet.2008.01.004>

- Tuffour, M., Sedegah, D. D., Nana, O., & Akyiaa, A. (2013). Is it Appreciation with Caution ? Attitude towards Genetically Modified Foods, *01(04)*, 190–198.
- UNDP. (2001). *Development Report 2001. Human Development*.
- Upsaliensis, A. U. (2004). Consumer Perception of Organic and Genetically Modified Foods.
- Viljoen, C. D., Dajee, B. K., & Botha, G. M. (2006). Detection of GMO in food products in South Africa : Implications of GMO labelling. *African Journal of Biotechnology*, *5*(January), 73–82. Retrieved from <http://www.aseanfood.info/Articles/11018178.pdf>
- Wieczorek, A. (2003). Use of Biotechnology in Agriculture — Benefits and Risks. *Biotechnology*, *3*(May), 1–6.
- Zdziarski, I. M., Edwards, J. W., Carman, J. a., & Haynes, J. I. (2014). GM crops and the rat digestive tract: A critical review. *Environment International*, *73*, 423–433. <http://doi.org/10.1016/j.envint.2014.08.018>

APPENDICES

Appendix 1: Consent Form

Title of Research: Perceptions of Genetically Modified Goods (GMFs) and Its Perceived Risks and Benefits on Health among University Of Ghana (Ug) Students

Principal Investigator: Johnny Owusu

Address: P. O. Box LG 13, School of Public Health, College of Health Sciences, University of Ghana, Legon

Email: jondell100@yahoo.com

Mobile: 0243088882

Introduction:

This study aims at examining the perception of GMFs and its perceived risks and benefits on health which is undertaken by Johnny Owusu, a Master of Science student at the School of Public Health, University of Ghana. The study seeks to examine the awareness level of GMOs/GMFs and perception regarding it. The study aims at providing the basis for public health interventions, and in designing awareness and educational campaigns about GMFs. This consent form contains all the information you will need to know about the study to be undertaken before you decide to consent to take part in the above mentioned study.

Confidentiality and Anonymity

You are been invited to participate in this study and your participation is voluntary. You will be given the opportunity to ask questions before you decide to take part in the study. If you agree to take part in the study, you will be asked to provide personal information and other related information about GMFs. All the information you provide will be kept confidential and the data will be locked in a cabinet. The information will be accessible only to the researcher and the research team. Your name and identity will not be needed for the study. The information you provide will only be identified by a code number and will be treated strictly confidential. Your name shall not appear or be mentioned in any part of the report that will come out of this study.

Benefits and harm

Your involvement in this study will only be through an interview and you will not be exposed to any form risks if you consent to take part. Your participation in the study or your decision to withdraw from the study, will not affect you in any way whatsoever. You will not be given any monetary or any kind of reward. All the information you will give to the researcher will be used for this study.

For further questions and clarification about the study, you contact the principal investigator on jondell100@yahoo.com or 0243088882 or the administrator of the Ghana Health Service Ethical Review Committee, Mrs. Hannah Frimpong on 0243235225 or 0507041223.

Appendix 2: Questionnaire

**Study on Perceptions of Genetically Modified Foods and its Effect on Health
among University of Ghana Students (Ghana)**

We are carrying out this survey to explore the perceptions people have about genetically modified organisms/genetically modified foods. We would ask for your views on number of different subjects relating to the genetically modified foods. Your input will be treated strictly confidential but it will contribute to the Knowledge in understanding people's perceptions of genetically modified foods.

Demographics

1. What is your age (as of your last birthday)

__DD/mm/yyyy

--	--	--

2. What is your gender?

1. Male

2. Female

3. What is your marital status?

1. Single	2. Married	3. Divorced	5. Other, Specify

4. What is your level?

1. Undergraduate (Specify the level)

2. Master's degree

3. PhD

5. What programme are you studying?

--

6. What is your religion?

1. Christian	
2. Muslim	
3. Traditional	

**Other,
Specify** _____

—

7. Have you heard of GMOs/Genetically Modified Foods (GMFs)? Yes No

8. What is your level of interest in GM foods issues?

1. Very interested
2. Not interested
3. Somehow interested

9. What does a genetically modified food mean? (Please chose your best answer

1. Genetically modified foods are foods derived from organism whose genetic material (DNA) has been modified by the introduction of a gene sequence from different organism
2. Genetically modified foods are foods derived from organism with modified genetic material
3. Genetically modified foods are foods derived from other organisms

10. Do you think GM foods are available in Ghana? (Please if yes answer the next question)

1. Yes _____
2. No _____

11. Where can we found these GM foods? (Please list them)

-

12. What is your source of information on GM foods? (You may choose more than one option)

1	Radio	
2	Television	
3	Newspapers	
4	Books	
5	Internet	
6	Lecturer/Teacher	
7	Workshop	

8	Friend	
---	--------	--

Other, Specify _____

13. To what extent are these sources trustworthy?

1. Highly trusted
2. Lowly trusted
3. Not sure

14. What is your view on GM foods in terms of consumption? (Please select your best answer only)

1. Harmful to health
2. Not harmful to health
3. Not sure

15. Which of these food production sources would you prefer? (Please select your best answer)

1. The use of genetic modification technology
2. The use of organic fertilizer
3. The use of inorganic fertilizer

16. What is your reason for your chosen source of food production in question 15?

17. What do you think about the impact GMOs on the environment?

1. Positive
2. Negative
3. Not sure

18. Please give reason(s) to your answer (Q17).

19. Name any known potential health risk associated with genetically modified foods.

20. Name any known health benefit(s) associated with GM foods? (Please list them).

21. Do you know any known economic benefits associated with genetically modified foods? (Please list them)

Please rate the following questions (Question 22 to 25) as useful or risky and whether it should be encourage or not.

22. The use of modern biotechnology in production of GM food. For example to make them higher in protein, keep longer or change the taste.

1. Useful 2. Risky

23. Will you encourage it?

1. Yes 2. No 3. Not sure

24. Taking genes from plant species and transferring them into crop plants to make them more resistant to insect pest in order to avoid insect related disease which usually culminate in low yield

1. Useful 2. Risky

25. Will you encourage it?

1. Yes 2. No 3. Not sure

26. Will you accept GM Foods if they were cheaper?

1. Will accept
2. Will not accept
3. Not sure