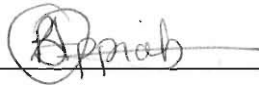Project Number: PZW-1225 - 41

The Effects of Education on
Public Perception and Acceptance of Genetically Modified Foods
in Developed and Developing Countries

An Interactive Qualifying Project Repost

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

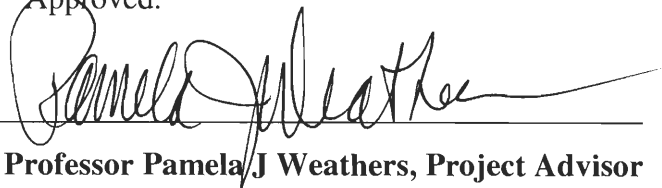Degree of Bachelor of Science

by

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Date: October 30, 2003

Approved:

Professor Pamela J Weathers, Project Advisor

ABSTRACT

The purpose of this project was to evaluate the effects of education on consumers' perception and acceptance of genetically modified foods in developed and developing countries. The two countries involved in this project are Ghana, and the United States. This project is comprised of two main sections: a short educational program on biotechnology, and a two-part evaluation survey to be completed before and after the presentation.

An analysis of the results showed that our educational program effectively changed the public's perception and acceptance of GM foods in Ghana. However, it was less effective in creating a significant impact on the opinions of Americans.

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1.0   INTRODUCTION

1.1 BACKGROUND

Biotechnology by definition is the "use of living organisms or their products to modify human health and the human environment". Karl Ereky a Hungarian engineer first brought the name to attention in 1919[1]. The idea of biotechnology is not new. It has been in existence for about 10,000 years when humans first "realized that they could breed their own animals and plant food to eat". In addition, biotechnology was put to use when "fruit juices were fermented to produce wine, when milk was converted to cheese", as well as when humans realized that flat bread could be turned into a "soft, spongy bread" with the addition of yeast[1].

Furthermore, "these primitive farmers, although ignorant of the natural principles at work, found that they could increase the yield, and improve the taste of crops by selecting seeds from desirable plants and they could improve each succeeding year's harvest by using seeds from only the best plants of the current crop"[2].

Some of the first pioneers of biotechnology are Louis Pasteur for his work on pasteurization, Robert Koch with his work on microbiology, and Gregor Mendel, whose experiments on the inheritance of genes from one generation to the next helped plant biotechnology evolve to what it is today.

Plant biotechnology describes a process in which scientific techniques are used to develop beneficial plants. Two of the main objectives of biotechnology involve production of transgenic plants and animals to improve the quality of life. Unlike traditional breeding, a transgenic plant or animal contains genes that have been "artificially inserted" instead of being acquired naturally[3]. This transgenic technology improves agriculture by increasing plant resistance to pests, diseases, drought, and salt conditions. It is also useful for mass propagation of plant clones, bioinsecticide development, and modification of plants to improve nutritional and processing characteristics[4]. However, the genes that are being transferred do not have to come from the same species. An example is the Golden Rice, which involves an insertion of beta-carotene, a precursor for vitamin A, into rice. This genetically modified crop is presently helping to alleviate the health crisis brought on by a deficiency of vitamin A in many developing countries[5]. Biotechnology has therefore opened new avenues for exploration and understanding how plants function and how they can be improved[6].

1.2 CONCERNS

The introduction of biotechnology has inevitably led to many debates over its possible negative impacts. The problems raised have remained controversial even 30 years after biotechnology was first introduced. There are two main areas of concern regarding the impacts of genetically modified (GM) crops: (1) Environmental (2) Socio-Economic.

Environmental:

- Gene flow:

  There are many concerns about the genes that are inserted into crops. For example, insect resistance or herbicide tolerance genes might spread to wild or weedy relatives, creating "super weeds" that are either difficult to control or detrimental to the environment[7].

Socio-Economic:

- Impacts on farmers:

  Farmers in developing countries may not be able to afford the seeds of the GM crops that are predicted to be more expensive. These countries may, therefore, be exploited and controlled by the powerful biotechnology companies that are mainly located in developed countries. Also, profit gained from growing GM crops may be less than non-GM crops unless there is some added value, since market prices in developing countries are comparatively lower than conventional crops[8].

- Health:

  Consumers are worried about the safety of GM crops since they are not usually aware of the components. Concerns such as allergies are brought up, with an example of the insertion of a transgene from an allergenic source, for example, inserting a gene from the Brazil nut in soybeans. This transgenic plant was determined to pose a danger to consumers who are allergic to Brazil nuts[9]. Another concern is the possibility of antibiotic resistance marker-genes being transferred from a GM crop into microorganisms living in human or animal guts, thereby making those microbes antibiotic resistant[11].

- Food labeling:

  Many people insist that all GM food should be labeled, regardless of the amount of GM ingredients contained in the product. Presently, countries are facing problems in the regulation of food labeling with concerns over the level of strictness that should be employed. For example, should consumers be informed of any GM ingredients when they purchase food from restaurants? Another major issue concerns religious groups, individuals with diet restrictions, and strict vegetarians. For example, if a Muslim consumed a GM crop containing a porcine gene, would that be a violation of Islamic dietary rules[10]?

1.3 PREVIOUS STUDIES

As observed by Thomas J. Hoban, Professor of North Carolina State University, "research indicates that consumers from different parts of the world have very different perceptions and understanding of agricultural biotechnology"[11]. This statement is clearly illustrated by one of his numerous published papers, titled *"Consumer Acceptance of Biotechnology in the United States and Japan"[12]*. This study, done in 1998, consisted of 15-20 minute telephone interviews on three main topics: the consumers' perception of biotechnology, awareness of biotechnology, and their acceptance of biotechnology. The subjects included an equal number of men and women, representing a wide variety of demographic backgrounds in age, education, and employment status.

Under the topic of perception of biotechnology, the subjects were asked what they perceived as the greatest threat to the food they consume. To evaluate the awareness of biotechnology in consumers, one of the questions presented was, "As far as you know are there any foods produced through biotechnology in the grocery store now?" In addition, Hoban also collected data on how often the respondents had talked about biotechnology. The acceptance of biotechnology in consumers was also evaluated. Hoban queried the respondents about their support for the use of biotechnology in agriculture and medicine.

According to Hoban's studies, even though the level of awareness of biotechnology is somewhat higher among the American consumers than the Japanese consumers, the overall awareness and understanding of biotechnology is still low in both countries. As suggested by

Hoban, most consumers would like to receive more information about the benefits and safety of biotechnology, thereby indicating a number of educational needs.

We, therefore, took this opportunity to investigate the effects of education on consumer perception and awareness of biotechnology in developed and developing countries. One of our group members carried out her interviews in her hometown of Accra, in Ghana, Africa, while the other two members individually interviewed people from the state of Massachusetts in the United States.

1.4 STATUS OF U.S. AND GHANA

Ghana is a developing country located in the west of Africa. Ghana is 230,940 sq km land with 8,520 sq km water, making it slightly smaller than the state of Oregon. Ghana is bounded in the north by the country of Burkina Faso, south by the Gulf of Guinea, and in the east and west by the countries Togo and Cote D'Ivoire, respectively. The population has a literacy age at 15yrs with 74% overall literacy. The literacy age means people over that particular age can read. The main labor force is divided into 60% agriculture and fishing, 15% industry, and 25% service. The main source of foreign exchange in Ghana comes from cash crops such as gold, timber, and cocoa. This is, however, not enough, so Ghana relies on financial assistance from outside. Despite these financial problems, Ghana has roughly twice the per capita output of the poorer countries in West Africa (CIA-The world Factbook)[13].

The United States, part of North America, is a highly developed nation with 50 states covering 9,629,091sq.km. It is bordered on the east and west by the North Atlantic Ocean and on the North by the Pacific Ocean, respectively. Canada is to its north with Mexico on its southern border. About 97% of the population is literate and on average children 15yrs and older can read. The labor force is divided into the following groups: managerial and professional 31%, technical, sales and administrative support 28.9%, services 13.6%, manufacturing, mining, transportation, and crafts 24.1%, farming, forestry, and fishing 2.4%. In the US, private business firms make most of the market-oriented decisions and drive its economy which is one the largest and most technologically advanced in the world. Different levels of governments buy needed goods and services mainly from privately owned producers. The Gross Domestic Product (GDP) of the US is divided into these main sectors: 2% agriculture, 18% industry and 80% services

(CIA-The world Factbook). Additional facts summarizing the differences between Ghana and the United States are shown in Table 1.

Table 1. Summary Status of U.S. and Ghana[13].

	US	**Ghana**	**Notes**
Population	290,342,554	20,467,747	2003 estimate
GDP per capita	$37,600	$2,100	2002 estimate
Exchange rate	$1	8,600 cedis	2003 estimate
Infant mortality rate	6.75 deaths per 1,000 live births	53.02 deaths per 1,000 live births	2003 estimate
Life expectancy	77.14yrs	53.02yrs	2003 estimate

One factor that will affect the response we get from the respondents in the US, most of whom are from Massachusetts, is the amount of knowledge the people in Massachusetts have of biotechnology. Massachusetts is considered one of the world's leading biotechnology centers with a high concentration of biotechnology companies and institutes of higher learning.[14] Hence we would expect people in Massachusetts to have a higher awareness in biotechnology when compared to Ghana.

2.0 OBJECTIVES

This project has several objectives:

1. To compare how two very different societies from developed and developing countries think about GM foods.
2. To determine if the respondents' opinions stem from the amount of prior knowledge they may or may not have in the area of GM foods, and to what extent opinions and knowledge vary between diverse demographic groups.
3. To determine whether the respondents' outlook could be altered if they are provided with a better understanding of the concepts behind GM crops.

3.0   METHODS

To help achieve our goals, we developed two tools – a perception evaluation tool and an education tool. The evaluational tool (Figure 1) was a survey aimed at examining the subjects' knowledge and attitude towards plant biotechnology and genetically modified crops before and after participating in our short educational program. The survey included a section for collecting demographic information section and required the subject to provide us with the following information:

1. gender
2. age
3. occupation
4. highest educational level obtained
5. country of citizenship
6. country of origin
7. diet restriction
8. type of diet restriction and reason
9. frequency of discussion

After obtaining demographic information, the following four types of queries were made as statements in various formats:

1. the individual's perception of food safety
2. awareness of biotechnology
3. awareness and acceptance of agricultural and medical biotechnology
4. awareness and acceptance of safety and regulation of biotechnology

Each individual could respond at one of five levels to each question: strongly agree, agree, don't know, disagree, and strongly disagree. At the end of the survey was a comments section which allowed the subject to provide written suggestions or concerns.

After respondents completed our pre-educational survey, we proceeded to present our educational tool (Appendix II). The educational tool was a factual presentation of plant biotechnology. It covered basic ideas in the following areas:

1. definition of plant biotechnology
2. benefits of genetically modified food for the society
3. potential impacts of genetically modified plants on the environment
4. methods for addressing safety concerns and possible remedies

This educational tool was made as straightforward as possible to ensure that the presented facts were clearly conveyed to the subjects. After the presentation, the subjects were asked to complete the same survey again. This allowed us to compare any changes in opinion in the same individual before and after our educational presentation.

1.	Gender :	□ male	□female			
2.	Age :	□10-20	□20-30	□30-40	□40-50	□>60

3.	Occupation: □Food or Agricultural Industry □Educational □Student □Health Industry □Other (please specify): _____

4.	Highest educational level: □Grades 1-6 □Grades 7-9 □Grade 10-12 □Bachelor □Master □PhD □Other: _____

5.	Country of citizenship: _____
6.	Country of Origin (if different from above): _____
7.	Does your diet have any restriction? □Yes □No

8.	If yes, why? □Health reason □Religion □Culture □Animal rights supporter □Environmentalist □Other (please specify): _____

9.	What is your restriction? □Strict vegetarian, no dairy products □Vegetarian, but will eat dairy □No beef □No pork □No mutton (lamb) □Other (please specify): _____

10.	Before today, have you ever talked about biotechnology with someone? □Frequently □Occasionally □Once or twice □Never

	Public Perception of food safety	Strongly Agree	Agree	Don't Know	Disagree	Strongly Disagree
1	Pesticide residue and additives (preservatives) is the greatest threat to the safety of the food I eat.	□	□	□	□	□
2	Genetic modification is the greatest threat to the safety of the food I eat.	□	□	□	□	□
3	My food supply is safe.	□	□	□	□	□
	Awareness of Biotechnology					
4	Traditional plant breeding involves the moving of genes between two plants.	□	□	□	□	□
5	Biotechnology is a process of adding or deleting genes from an organism.	□	□	□	□	□
6	Biotechnology can enhance the nutritional value of food.	□	□	□	□	□
7	Biotechnology can produce crops that are insect-resistant.	□	□	□	□	□
8	There is food produced through biotechnology sold in my grocery store.	□	□	□	□	□
9	I accept genetically modified (GM) food.	□	□	□	□	□

Figure 1. Evaluation Tool.

10	Organically produced food is better for human health than GM food.	☐	☐	☐	☐	☐
11	I am willing to purchase genetically modified food.	☐	☐	☐	☐	☐
12	Growing organic food is labor intensive.	☐	☐	☐	☐	☐
13	I will only purchase organically grown food.	☐	☐	☐	☐	☐
	Agricultural Biotechnology					
14	The use of pesticides poses environmental problems.	☐	☐	☐	☐	☐
15	I support use of crops that reduce the need for pesticides.	☐	☐	☐	☐	☐
16	Cultivating GM crops with reduced pesticide use will benefit the environment.	☐	☐	☐	☐	☐
17	I accept crops that are genetically modified to increase yield.	☐	☐	☐	☐	☐
	Medical Biotechnology					
18	I will consume food that is genetically modified to deliver vaccines or other beneficial drugs.	☐	☐	☐	☐	☐
19	I will consume food that has allergens removed through genetic modification.	☐	☐	☐	☐	☐
20	I will consume food enriched with vitamins through genetic modification.	☐	☐	☐	☐	☐
21	I will consume food enriched with lowered fat content through genetic modification.	☐	☐	☐	☐	☐
	Safety of biotechnology					
22	All genetically modified food is safe for human consumption.	☐	☐	☐	☐	☐
23	Genetically modified food poses great risks to humans.	☐	☐	☐	☐	☐
	Regulation of biotechnology					
24	Genetically modified foods are regulated by government agencies.	☐	☐	☐	☐	☐
25	All genetically modified foods should be labeled.	☐	☐	☐	☐	☐
26	I believe that regulation of GM food is adequate.	☐	☐	☐	☐	☐

Other comments you might have:

Figure 1. Evaluation Tool, cont.

In order to facilitate our data analysis, we pooled some categories together so that there will be fewer groups to compare, with each group having a larger population. For the five responses, we pooled "strongly agree" with "agree" and "strongly disagree" with "disagree". Similarly, we collapsed some of our other demographic data. Under "Education", the categories "Master" and "PhD" were pooled into "Graduate". Under "Frequency of Discussion on biotechnology", "Frequently" and "Occasionally" were pooled to become "Frequently/Occasionally".

Since there are so many possible ways to compare all the demographic fields, it required us to perform the same statistical test repeatedly. This was deemed not to be appropriate since it would have resulted in a very high overall error rate. As such the data were analyzed simply using graphical methods. For sections 4.2 to 4.5, results were compared between all demographic fields and only those with at least a 10% change in response have been displayed. In section 4.6.1, we were interested in seeing whether the awareness of regulation of GM food increases with one's educational level. In sections 4.6.2 and 4.6.3, only results with the most interesting changes were shown. For section 4.7, results were only compared between the occupations as we wished to know if the respondents working in the health industry, closely related to medical biotechnology, would have higher acceptance of the use of biotechnology in the medical field as compared to the other industries. Because Section 4.8 (Perception of Agricultural Biotechnology) mainly concerns those working in the food/agricultural industry, we compare only the responses from this demographic field.

4.0   RESULTS & ANALYSIS

In order to properly compare responses of people from these two diverse cultures and countries, a basic understanding of the individual respondent was needed. Thus, we gathered some demographic information. Subjects were then asked their opinion about a variety of biotechnology related topics. These responses are identified as pre-education responses. A subsequent short educational program (~15 min.) was given to them after which their opinions were again measured.

4.1 Overview of Surveyed Population

A total of 100 individuals were randomly chosen and interviewed in the US and Ghana; 50 are from Accra, Ghana, and the other 50 are from Massachusetts, US. The subjects were asked to provide the following demographic information in the survey: gender, age, occupation, highest education level and how often they discussed biotechnology.

As shown in Table 2, the gender distribution in Ghana was 50% males, 42% females, and 8% of the subjects decided not to respond. In the U.S., the male and female distribution was equal. In Ghana, the majority of the respondents were between 20-30 years old (52%). Of the remainder, 10% of the subjects were 10-20 years old, 18% were 30-40 years old, and 14% were 40-50 years old. None of the respondents were over 60 years of age. Again, 6% of the Ghanaian respondents did not provide their age. The subjects from Massachusetts had a similar age distribution, with half of the respondents between 20-30 years old. Of these, 10% were between 10-20 years old, 12% between 30-40 years old, 22% were 40-50 years old, and only 6% of the subjects were over 60 years of age.

The respondents were also asked to provide their occupation. As shown, the majority of respondents from both Ghana and the U.S. were students, both at 38%. In Ghana, the next highest percentage of occupation was the health industry (28%), followed by the food or agricultural sector at 14%, 12% chose "other", 4% worked in education, and 4% did not provide us with their occupation. In the U.S., following the large percentage of student respondents, was the food or agricultural sector, at 20%. Respondents from the educational sector and health industry both were at 10%. Of the U.S. subjects 20% indicated "other" as their occupation, while 2% chose not to respond.

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In both Massachusetts and Accra, the educational levels were relatively high. Only a total of 4% of the Ghanaian respondents completed grade 9 or less, and 28% of both Ghanaian and American respondents finished high school, with 18% of the Ghanaian respondents and 48% of the American respondents having Bachelor's degrees. Of the Ghanaians, 12% had graduate school as their highest level of education, and 34% did not respond. Of the American subjects, 16% have their masters degrees, and 4% chose not to respond.

When asked how frequently the topic of biotechnology came up in conversation, 62% of the Ghanaians respondents indicated they had previously discussed biotechnology. Out of those respondents, 16% talked about biotechnology frequently, 26% never talked about biotechnology before, and 6% chose not to respond. In the U.S., 76% of the respondents talked about biotechnology. Out of those respondents, 48% talked about biotechnology frequently. A fifth of the respondents (20%) never talked about biotechnology before, and 4% did not respond.

Table 2: Distribution of Demographic Information

Gender:	Male	Female	No Response			
Ghana	50%	42%	8%			
US	50%	50%	0%			
Age:	10 to 20	20 to 30	30 to 40	40 to 50	>60	No Response
Ghana	10%	52%	18%	14%	0%	6%
US	10%	50%	12%	22%	6%	0%
Occupation:	Food or Agricultural	Educational	Student	Health Industry	Other	No Response
Ghana	14%	4%	38%	28%	12%	4%
US	20%	10%	38%	10%	20%	2%
Education:	Grades 1-6	Grades 7-9	Grades 10-12	Bachelor	Graduate	Other
Ghana	2%	2%	28%	18%	12%	34%
US	0%	0%	28%	48%	16%	4%
Frequency of Discussion of Biotechnology	Frequently/ Occasionally	Once or Twice	Never	No Response		
Ghana	52%	16%	26%	6%		
US	48%	28%	20%	4%		

4.2 Public Perception of Food Safety

GM food as a safe food source

One of the first concerns we had was about the general perception of the respondents to the safety of their food supply. We provided the following statement to assess that perception: *"Genetic modification is the greatest threat to the safety of the food I eat"*.

The responses were then compared using the variety of demographic variables collected. Major variations in responses were only observed for two variables: occupation, and educational level, and are shown in Figures 2 and 3.

4.2.1 Occupation

Initially, there was a significant population of Ghanaians who viewed GM food as unsafe to consume, whereas the majority of Americans interviewed believed that their food is safe (Figure 2). After our educational presentation, the percentage of people who viewed GM food as a safe food source increased by as much as 100% for both countries. Although, a small percentage still remained skeptical about GM food being a safe food source, most people in both countries showed reduced concerns about eating GM food after some education (Figure 2).

4.2.2 Education

Although Americans' opinions remained approximately the same for all educational levels before and after our educational presentation, that of the Ghanaians had changed dramatically. Initially, Ghanaians with the least education did not consider GM food as a safe food source. After viewing our education tool, however, they showed up to a 100% increase in agreement with the test statement. In contrast, well-educated Ghanaians did not change their views (Figure 3).
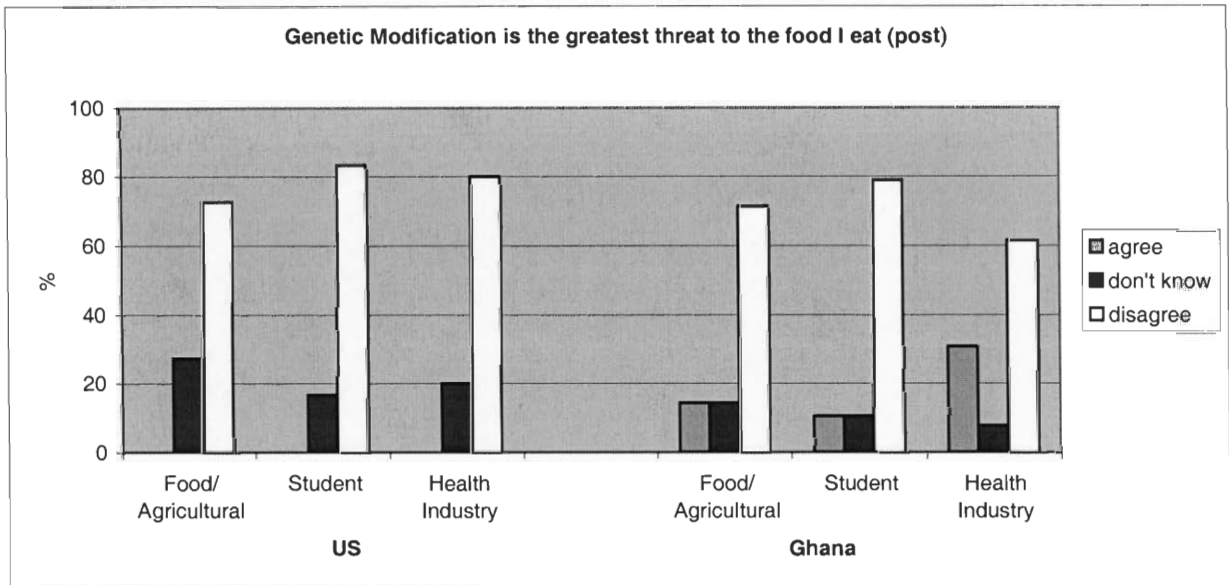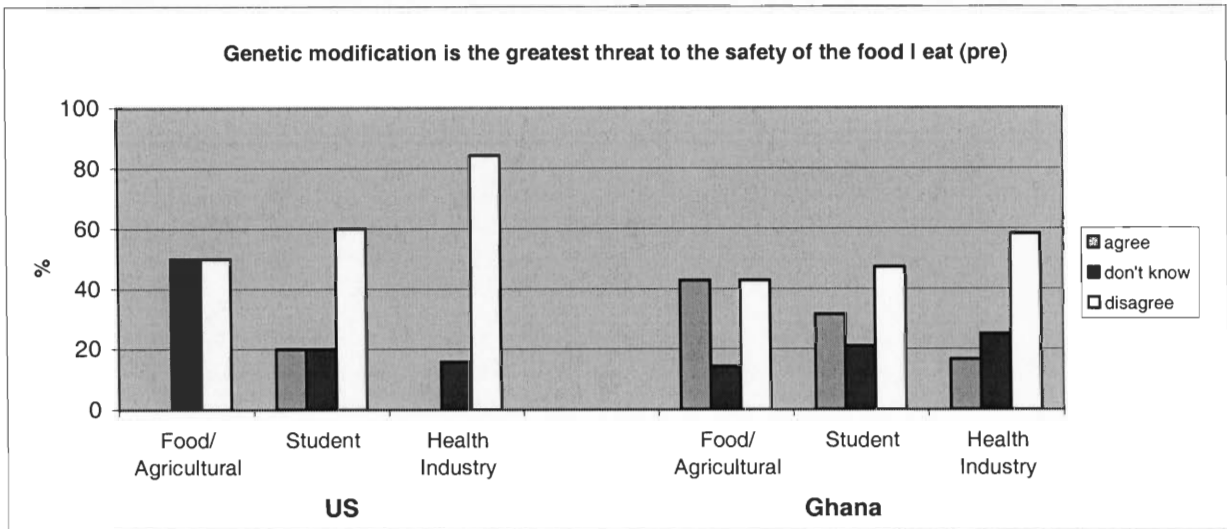
Figure 2. Correlation between occupation and public perception of food safety.
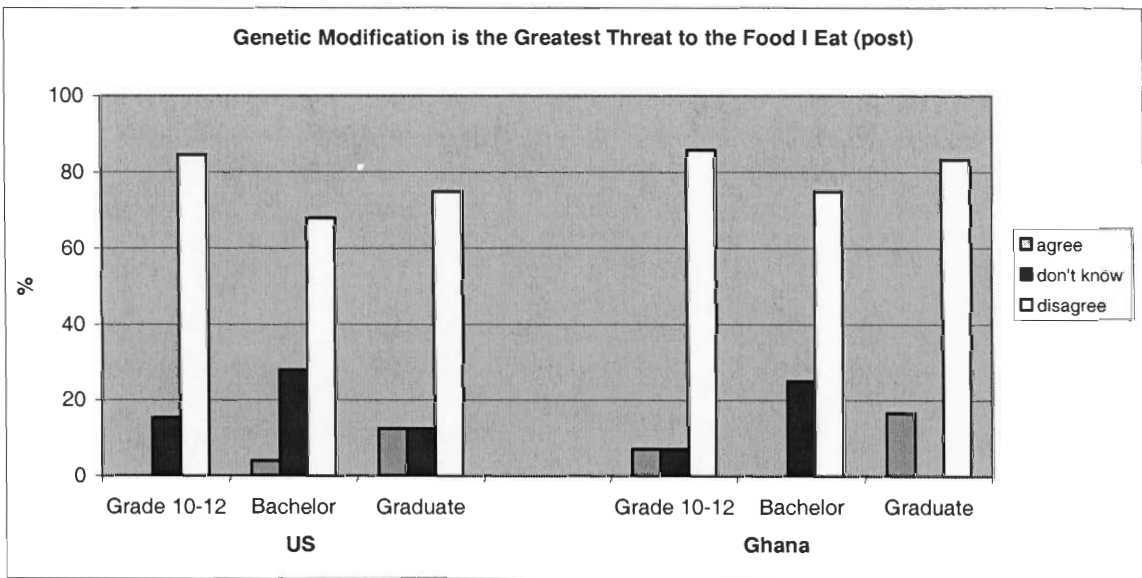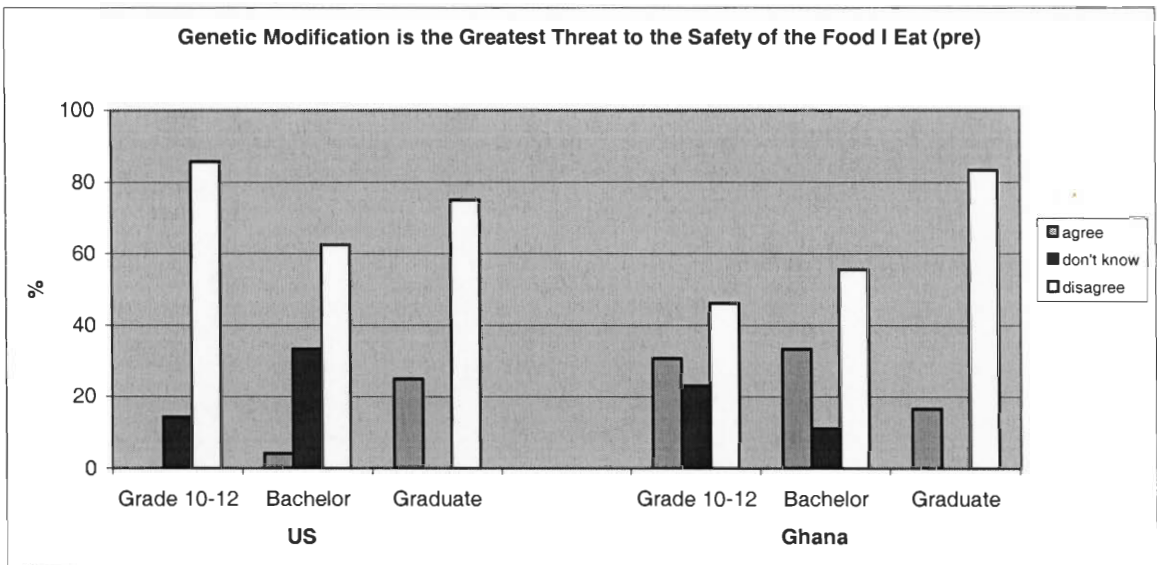
Figure 3. Correlation between educational level and public perception of food safety.

4.3 Awareness of Biotechnology

General knowledge of biotechnology

Another topic we wanted to examine was how much general knowledge people had about biotechnology. Four different statements were provided to assess how much they knew about biotechnology:

1) **Traditional plant breeding involves the moving of genes between two plants.**
2) **Biotechnology is a process of adding or deleting genes from an organism.**
3) **Biotechnology can enhance the nutritional value of food.**
4) **Biotechnology can produce crops that are insect-resistant.**

Answering "agree" means that they have a basic understanding of the fundamental capabilities of biotechnology. The responses were compared using the three demographic fields that showed major variations: educational level and gender.

4.3.1 Educational Level

Since biotechnology is a higher level science we anticipated that respondents with a greater level of education would be more aware of this technology. The responses should, thus, appear as an increasing level of awareness with an increasing level of education. Indeed, in our initial evaluation this was found to be true, but only for the Ghanaians (Figure 4).

The Ghanaians' awareness in biotechnology increased after viewing our presentation, whereas the Americans did not show significant changes in their responses. In general, Americans seem to be more aware of biotechnology as compared to the Ghanaians.

Since the level of the respondents' awareness of biotechnology did not really increase with one's education level, there appears to be no strong correlation between the two. The only exception is the responses from the Ghanaians before viewing our presentation (Figure 4).
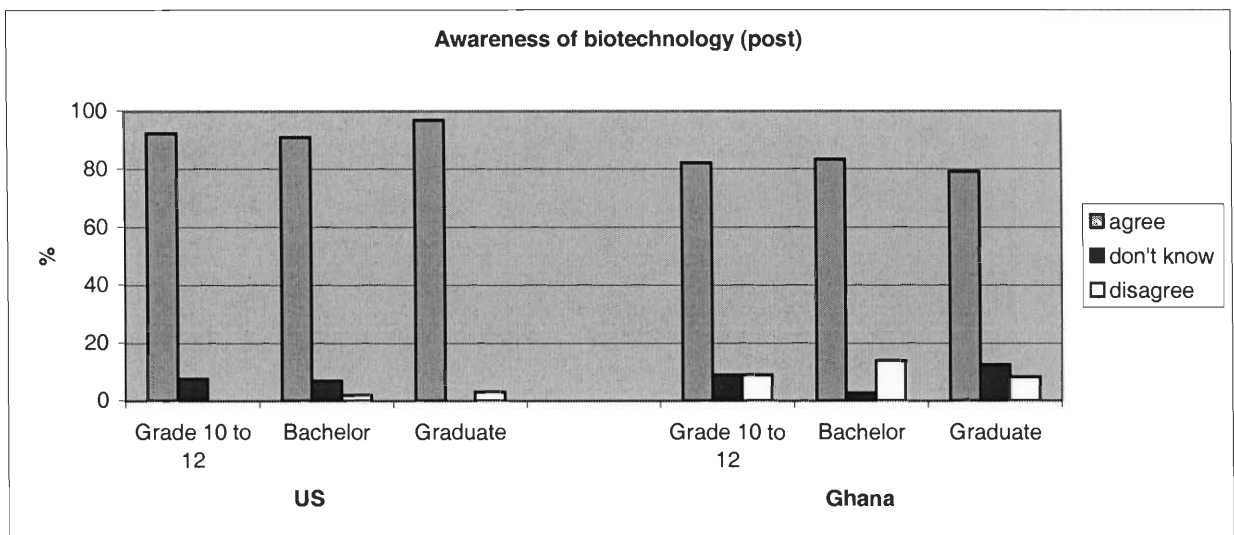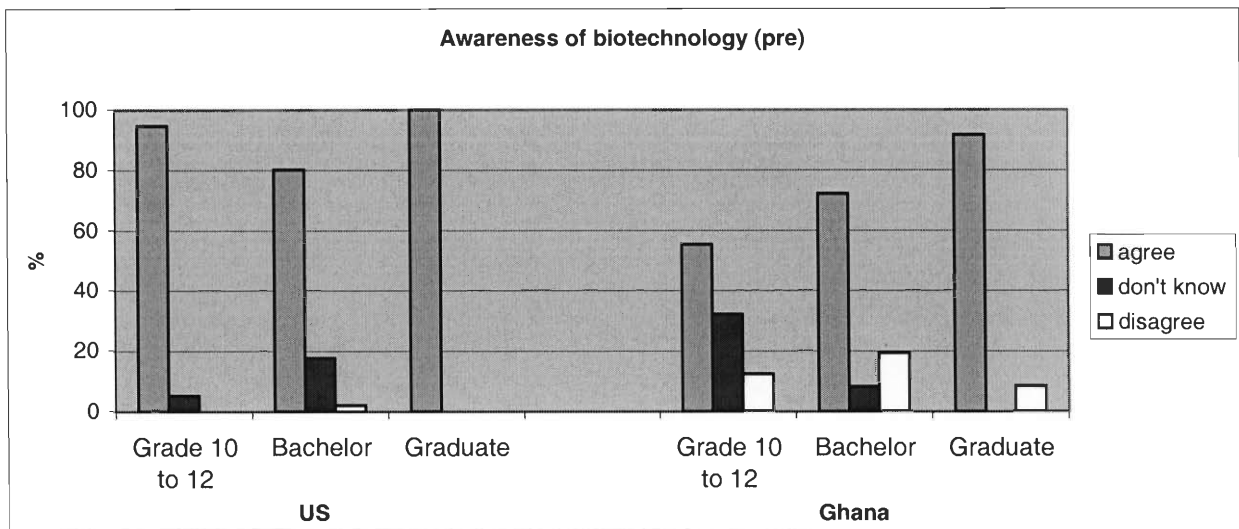
Figure 4. Correlation between educational level and awareness of biotechnology.

4.3.2 Gender

Due to cultural differences, women in Ghana are on average less educated than men. Thus we wanted to investigate the awareness of biotechnology between the genders in both Ghana and the US, and make comparisons between the two genders in between Ghana and the US (Figure 5).

US-males show a slightly better knowledge of biotechnology compared to US-females at first, whereas in Ghana gender did not seem to make any difference (Figure 5). While our

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educational tool did not manage to change the opinions of US-males, it did yield an increase in awareness for US-females. For Ghana, both genders increased their awareness to the same extent.
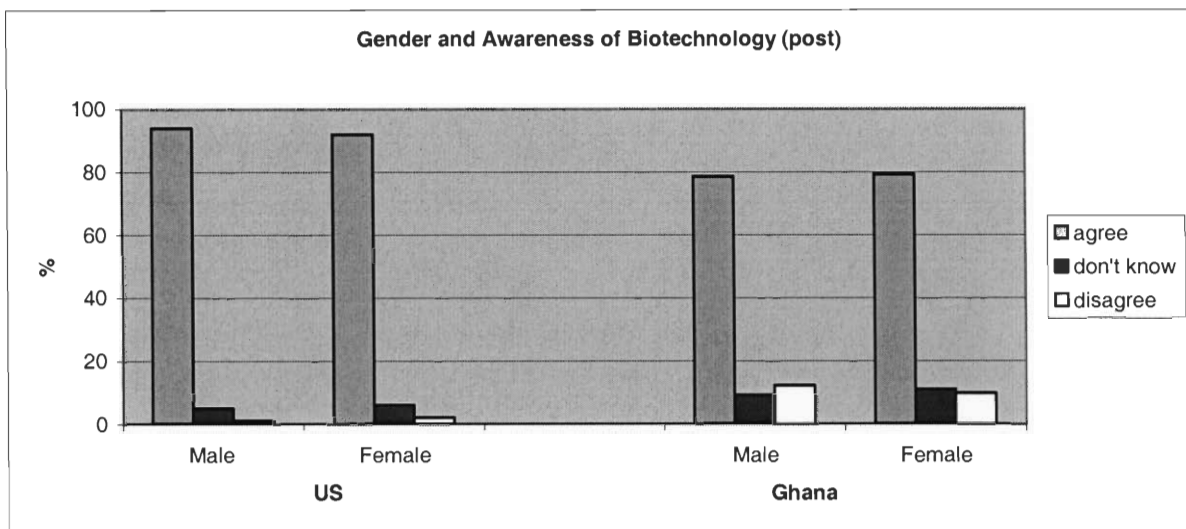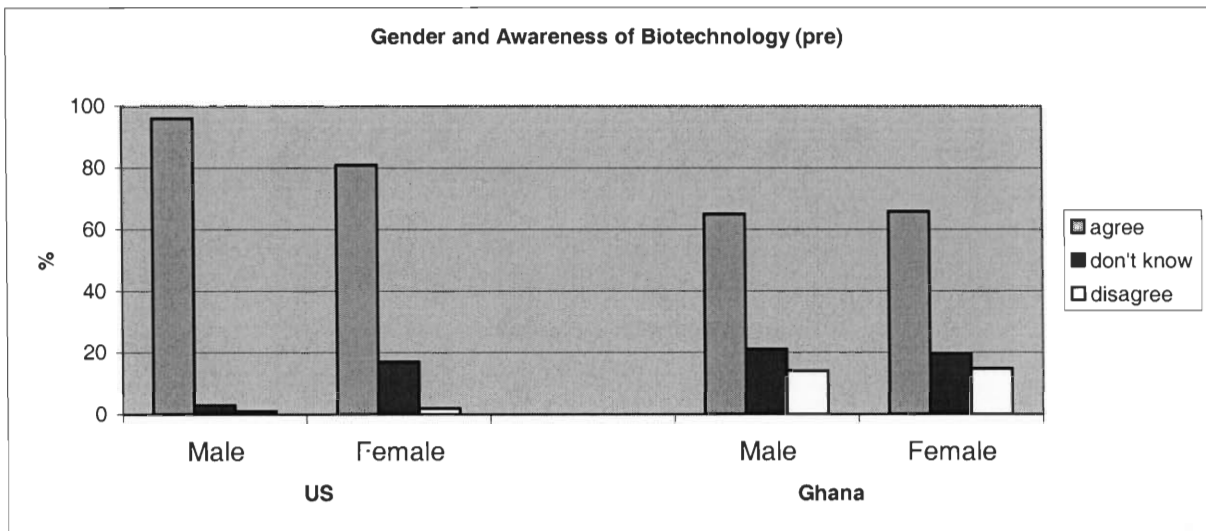

Figure 5. Correlation between gender and awareness of biotechnology.

4.4 Acceptance of GM Food

Similar to Hoban's study, one of our concerns was the consumers' acceptance of genetically modified foods. We presented the following statement to the respondent: "*I accept*

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genetically modified food". The demographic fields that presented the most interesting and relevant results were compared: Educational level, occupation, gender, and frequency of discussion of biotechnology (Figures 6-9).

4.4.1 Educational Level

As previously mentioned, we anticipated that the awareness of biotechnology would increase with increasing levels of education. The same hypothesis is tested once more with the acceptance of genetically modified foods.

After viewing our presentation, the overall acceptance of GM food for both U.S. and Ghana increased, for the most part, with increasing levels of education for both U.S. and Ghana (Figure 6). The only exception is the Americans in the Grade 10-12 category. They showed a decrease of acceptance of GM food post education compared to the in initial responses. Individuals with a bachelors degree in Ghana showed no change in acceptance after the presentation. Interestingly, some people who chose "disagree" at first selected "don't know" in the end. There is, thus, some evidence that people with higher education are more able to accept GM food, as demonstrated by the results in pre-Ghana and post-US (Figure 6).

4.4.2 Occupation

We considered that the respondents in the health industry and food/agricultural sectors would have an overall higher acceptance of genetically modified foods, because they would have a deeper understanding of the benefits of biotechnology.

The health industry in the U.S. initially showed full support in the acceptance of GM food (Figure 7). None of the Americans strongly objected to accepting GM food before or after our educational presentation. In contrast, the Ghanaians were generally willing to accept GM food, but were not as supportive as the Americans.

% who accept GM food (pre)

% who accept GM food (post)
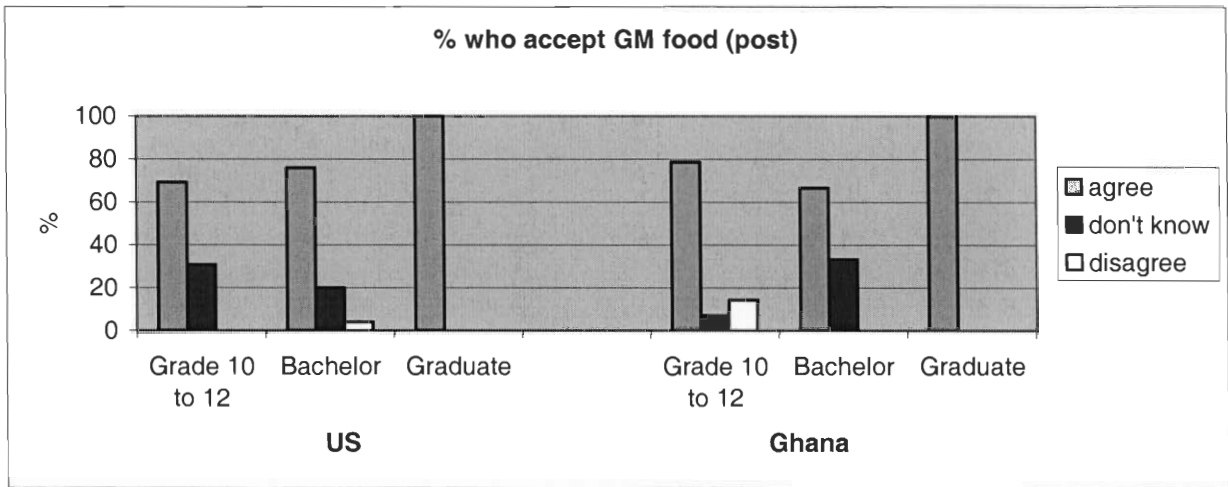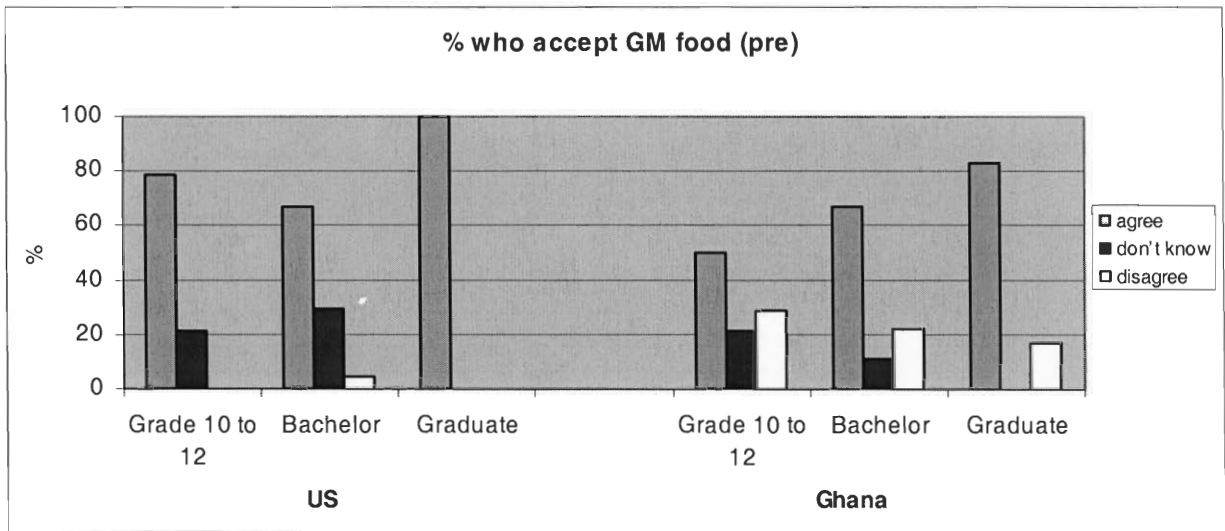
Figure 6. Correlation between educational level and acceptance of GM foods.
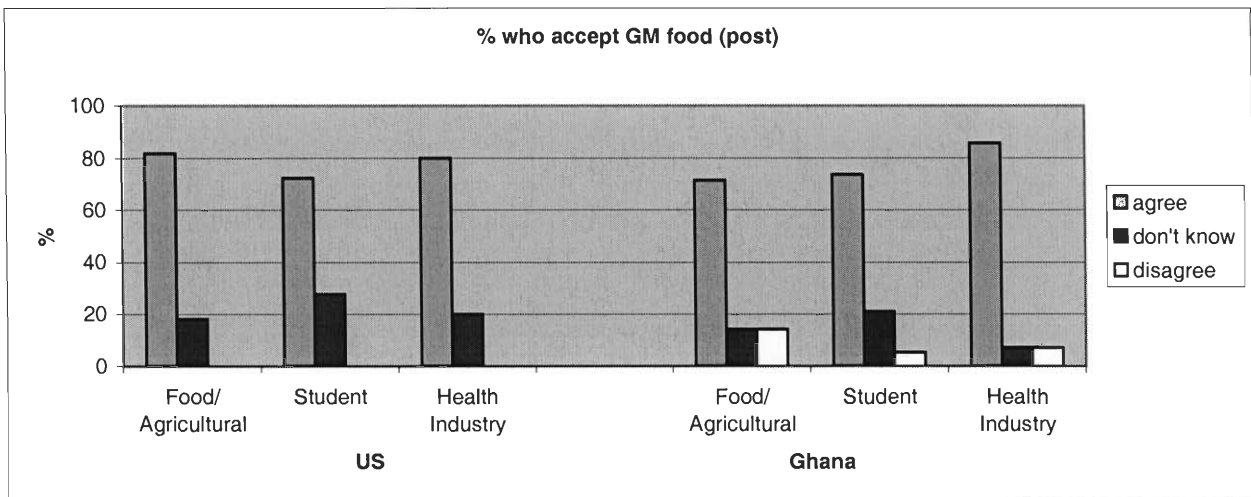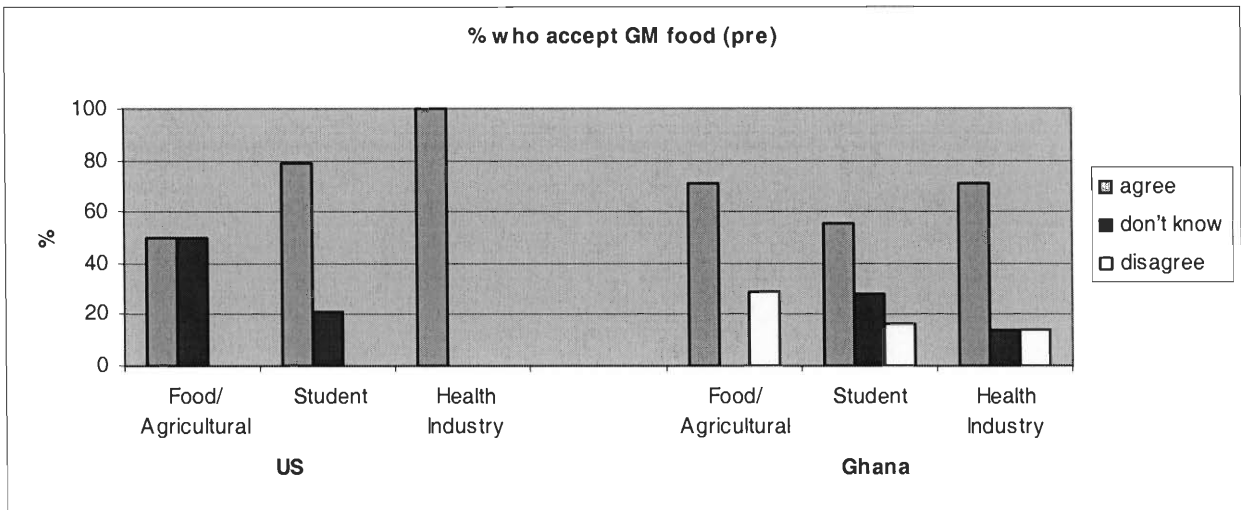
Figure 7. Correlation between occupation and acceptance of GM foods.

4.4.3 Gender

Because the men in Ghana are more educated than the women, we presumed that the men would be more willing to accept GM food, for they should be more informed about the benefits of biotechnology.

Initially, U.S. males were more willing to accept GM food than U.S. females, but this response reversed after they viewed our education tool (Figure 8). In Ghana, on the other hand, there was no major difference in responses between males and females until after viewing the

educational program. Then both genders showed greater acceptance of GM food with the females being more positive than the males, which was in contrast to what we had expected.
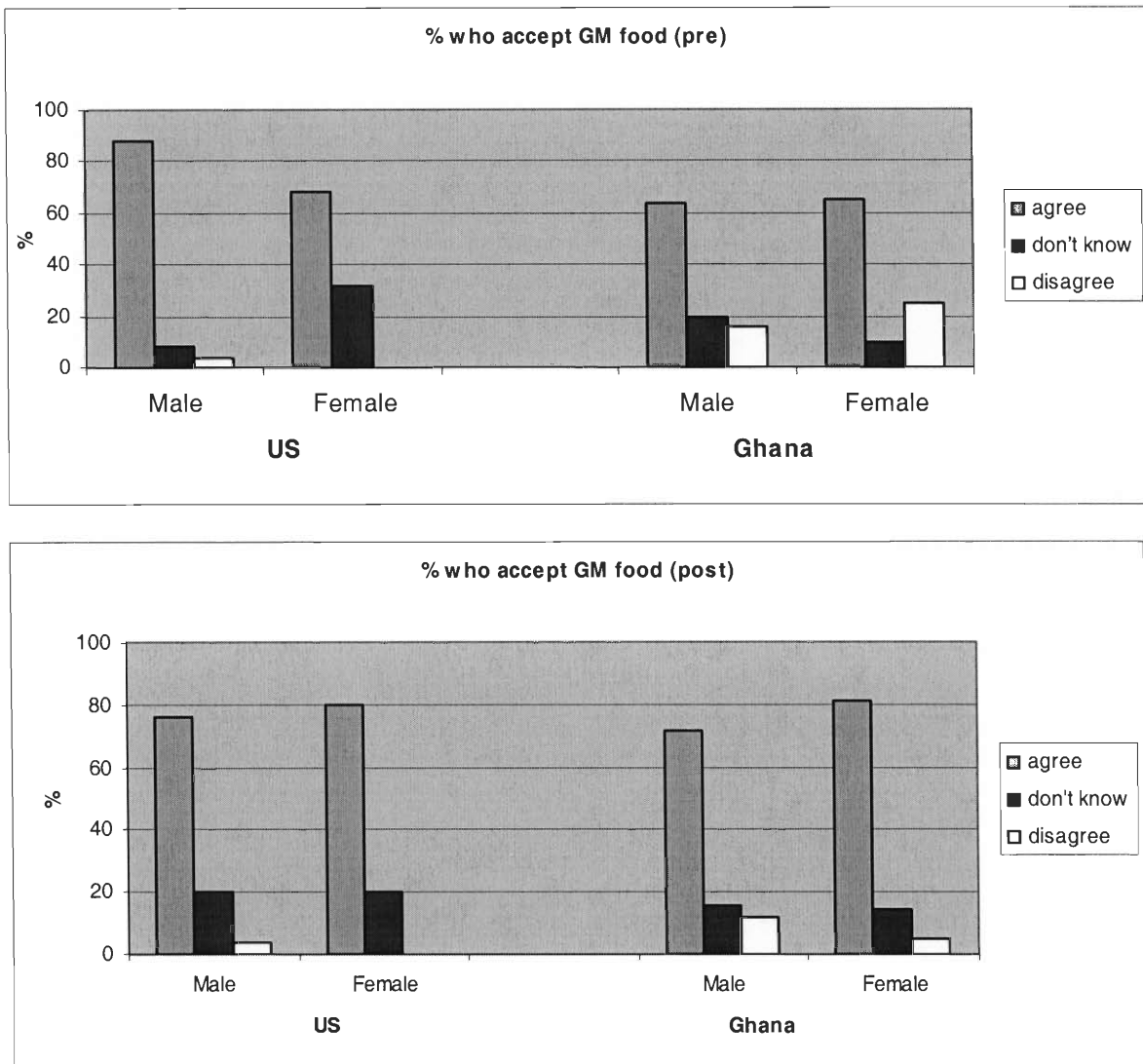
Figure 8. Correlation between gender and acceptance of GM foods.

4.4.4 Frequency of Discussion on Biotechnology

In his study, Hoban equates a person's awareness of a subject "with having heard something or a lot"[15] about it, in which case he evaluated a person's awareness of biotechnology with how much the individual has heard or read about biotechnology. Therefore, we wanted to find out if such a correlation existed in our results, i.e. whether respondents who discussed biotechnology more frequently was also more accepting of GM food.

In the pre-survey, people who discussed biotechnology frequently/occasionally showed greater acceptance of GM food in both U.S. and Ghana (Figure 9). Their responses did not change much after our presentation.

Our educational tool did not change the view of those who frequently/occasionally discuss biotechnology for both countries. In the U.S., people who had only discussed biotechnology once or twice became more willing to accept GM food, while those who had never discussed GM food became somewhat less supportive. In Ghana, those who had discussed biotechnology once or twice or never both showed an increase in acceptance of GM food and making them approximately on par with those who discuss biotechnology frequently.
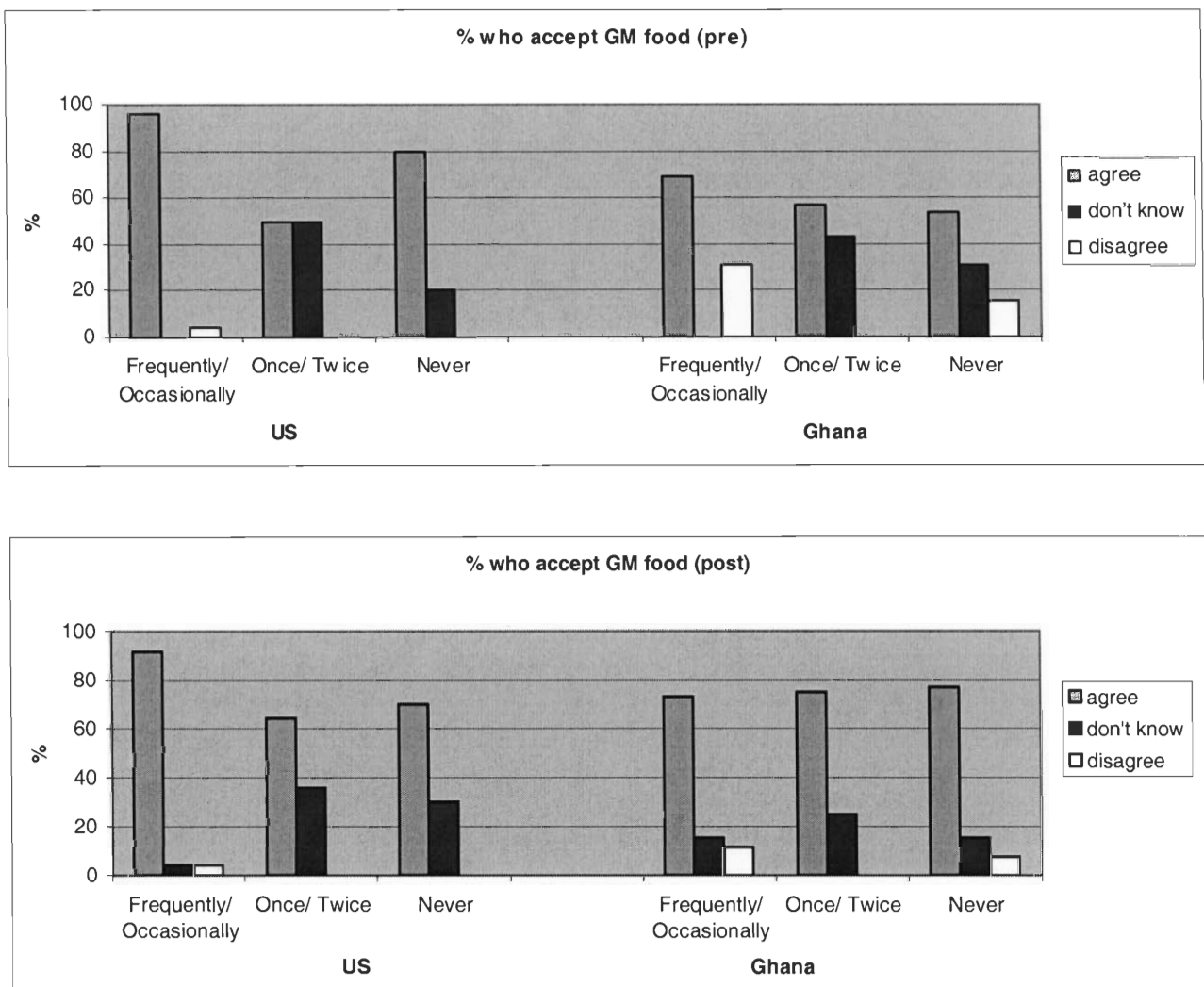
Figure 9. Correlation between frequency of discussion of biotechnology and acceptance of GM foods.

4.5 Willingness to Purchase GM Food

We were interested in finding out the relationship between a consumer's acceptance of GM foods and their willingness to purchase them. In addition, to determine whether our education tool would make a difference in the consumers' willingness to purchase, the respondents were presented with this statement: *"I am willing to purchase genetically modified food"*.

Similar to section 4.4, results were analyzed for the following demographic areas: 1) Education level, 2) Occupation, 3) Gender, and 4) Frequency of discussion on biotechnology.

4.5.1 Educational Level

In the beginning, Americans were more willing to purchase GM food than Ghanaians (Figure 10). We then presented our education tool, which resulted in a shift of the Ghanaians to a greater willingness to purchase GM food. The slight initial relationship between level of education and willingness to purchase GM food, in Ghana, continued and resulted in greater willingness at all levels of education to purchase GM food (Figure 10).

4.5.2 Occupation

Although there is not much difference in the responses before and after our presentation, Americans in the health industry were the most willing to purchase GM food (Figure 11). Surprisingly, those working in the food/agricultural sector were the least willing to purchase GM food in both countries. Again our education tool yielded an increase in the willingness to purchase GM food for most occupation sectors in both countries (Figure 11).

25
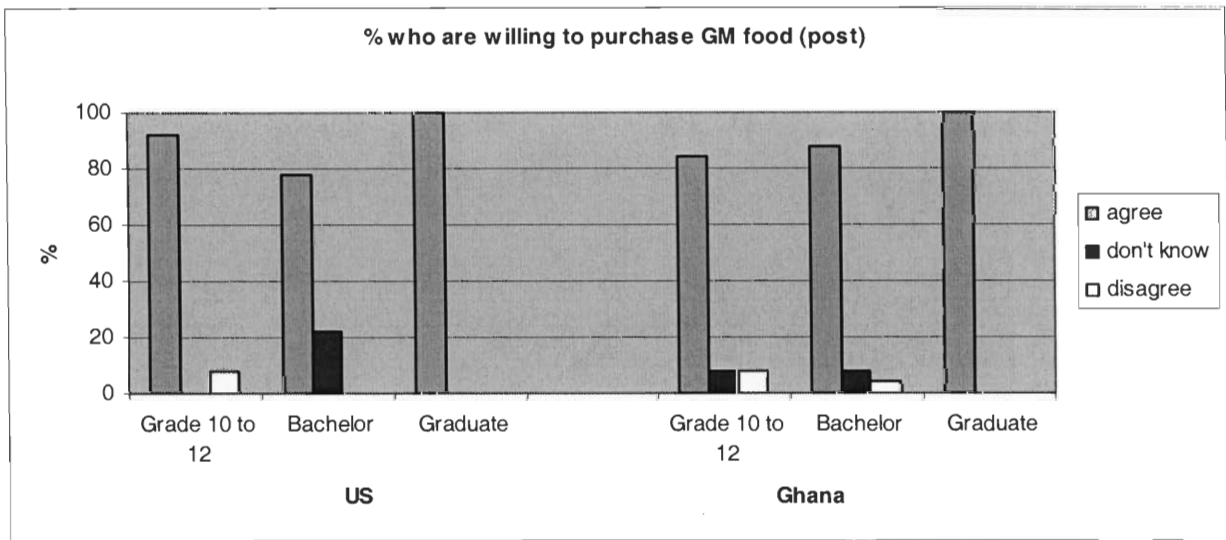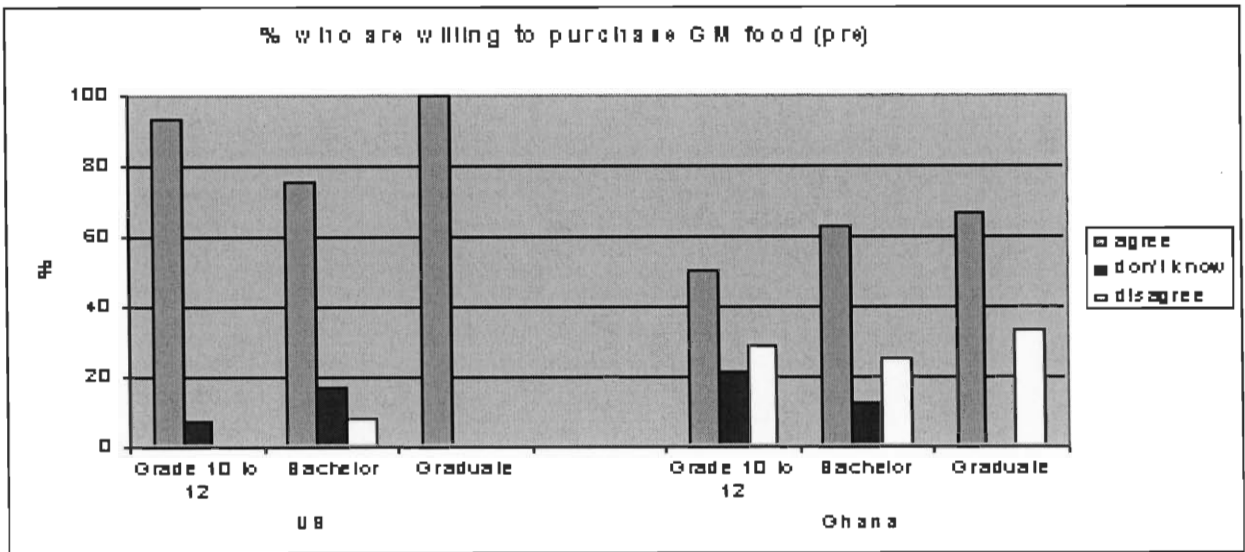
Figure 10. Correlation between educational level and willingness to purchase GM foods.

% who are willing to purchase GM food (pre)

% who are willing to purchase GM food (post)
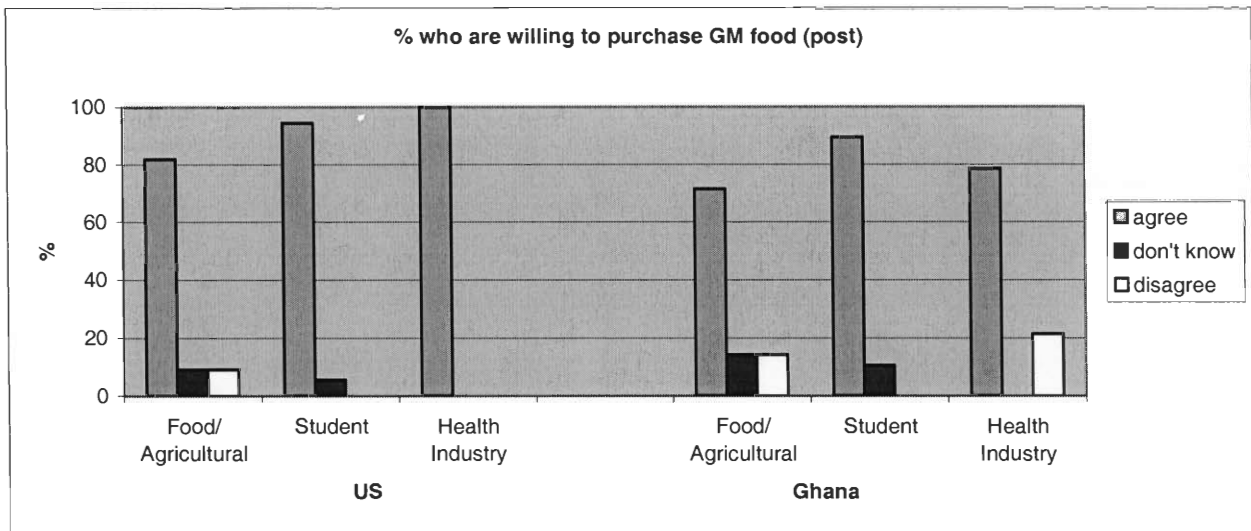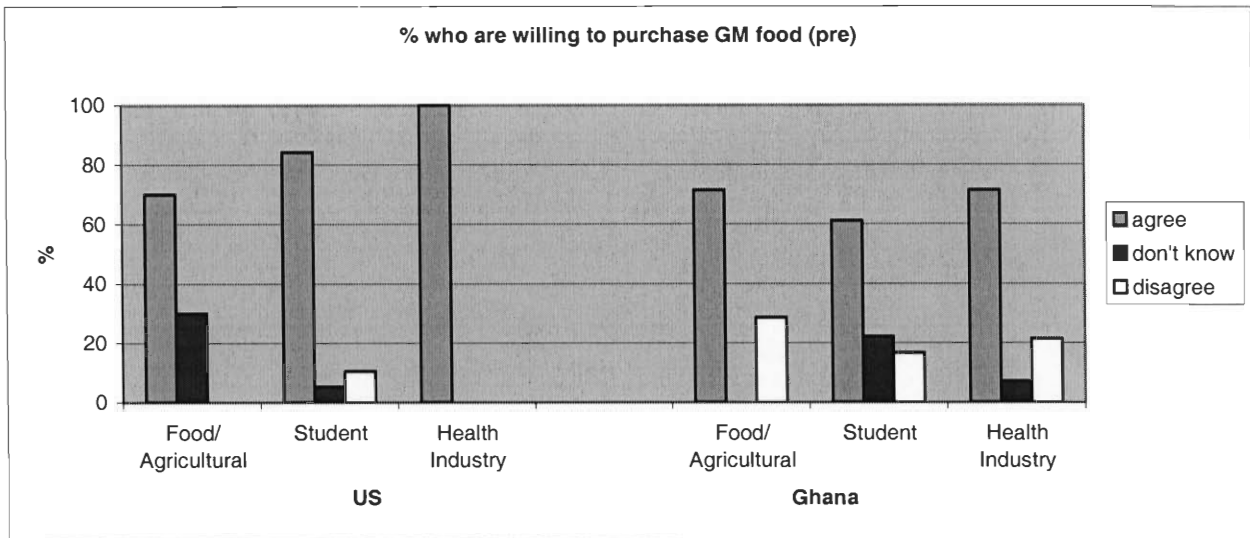
Figure 11. Correlation between occupation and willingness to purchase GM foods.

4.5.3 Gender

At first, people in the U.S. were more willing to purchase GM food than those in Ghana for both genders, though results from both countries illustrate that females were comparatively less willing than the males.

After viewing our education tool, U.S. females who agree exceeded that of U.S. males. In contrast, the Ghana females still remained less supportive than the males although both genders did increase in agreement overall (Figure 12).

% who are willing to purchase GM food (pre)

% who are willing to purchase GM food (post)
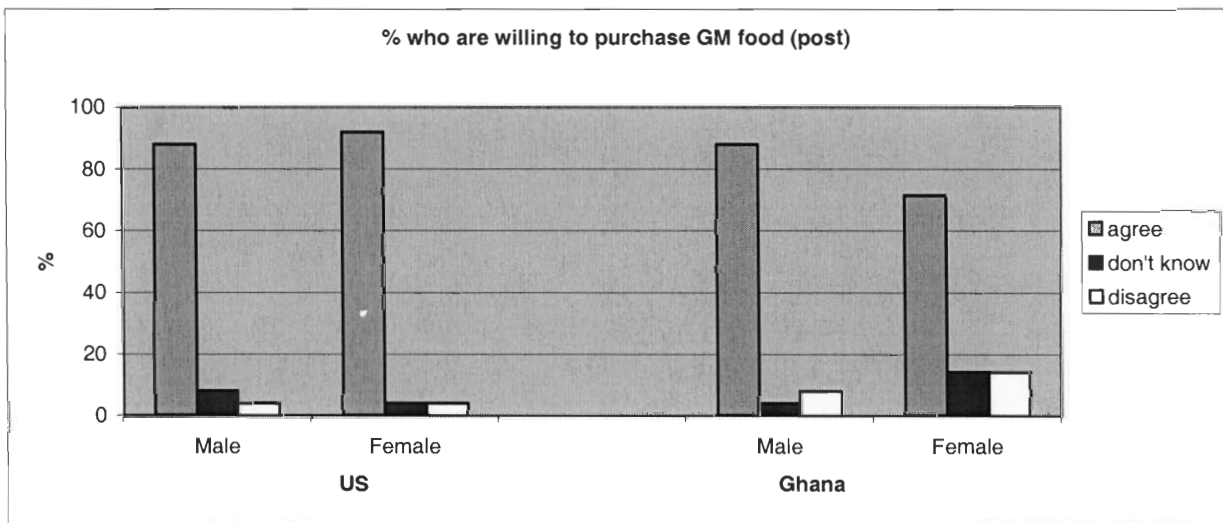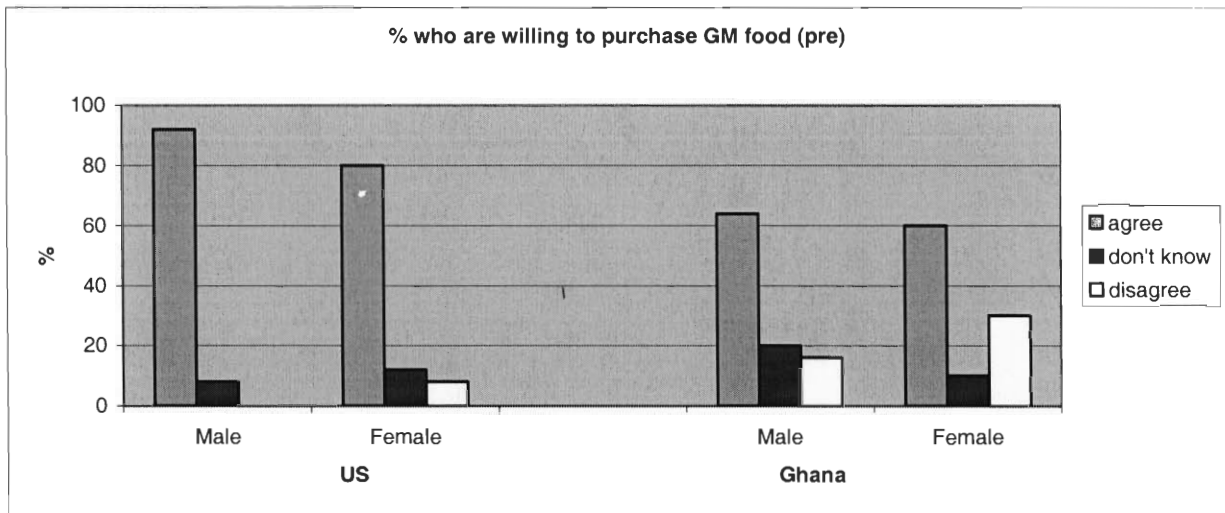
Figure 12. Correlation between gender and willingness to purchase GM foods.

4.5.4 Frequency of Discussions on Biotechnology

Those who seldom discussed GM food appeared to be more willing to purchase GM food in both the U.S. and Ghana (Figure 13). Although our education tool did boost the majorities' willingness to purchase GM food, those who most frequently discussed the topic were still resistant to changing their opinions.

% who are willing to purchase GM food (pre)

% who are willing to purchase GM food (post)
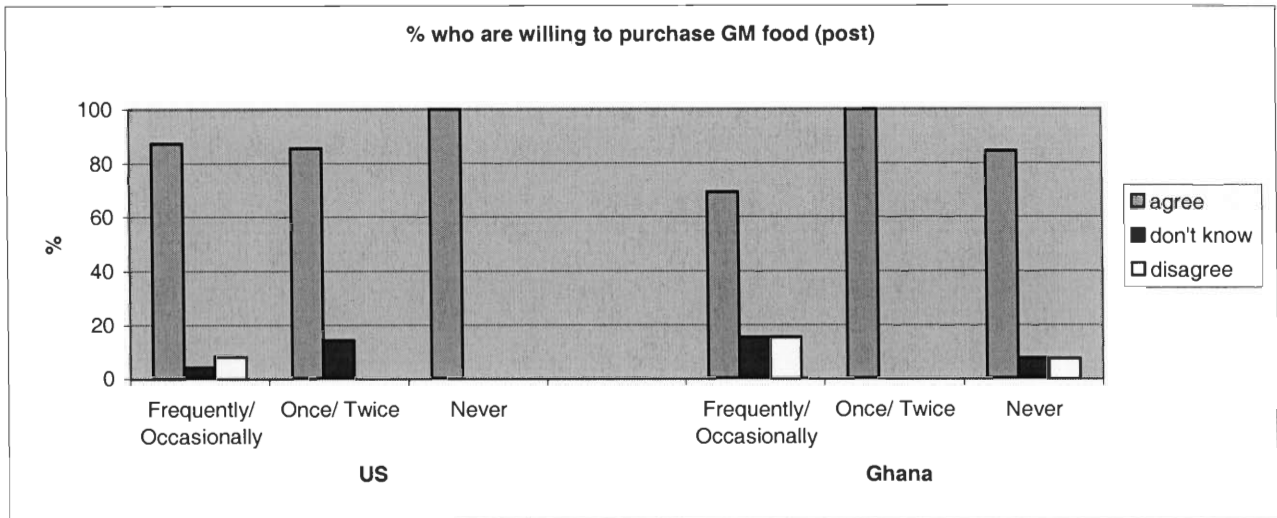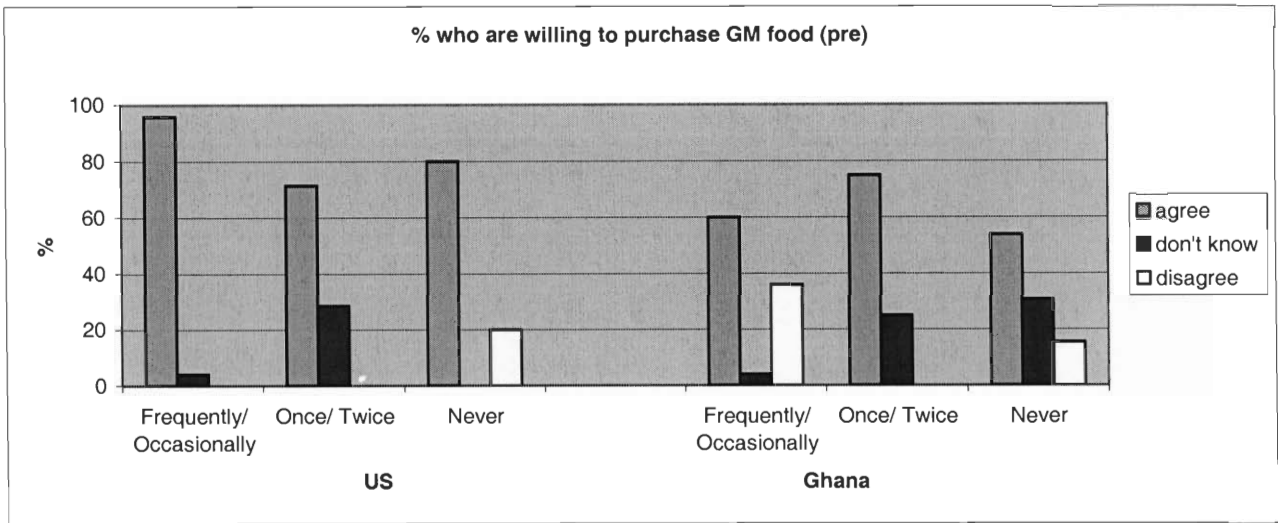
Figure 13. Correlation between frequency of discussion of biotechnology and willingness to purchase GM foods.

4.6   Regulation of Biotechnology

4.6.1 People's Awareness of the Regulation of GM Food

We wanted to know if our respondents were aware of the government agencies that regulated GM foods on the market. Knowing which agencies are in charge might instill in them confidence that GM food on the market is safe for human consumption. Hence if the respondents had awareness of and confidence in the regulatory efforts in place in each country,

they might agree to the statement: *Genetically modified foods are regulated by government agencies.* Results were analyzed at the three educational levels.

Initial responses showed that a large proportion of people were not aware that GM foods are being regulated (Figure 14). This may be a reason why they considered GM food as being unsafe to consume. However, awareness rose considerably after the respondents viewed our educational tool.
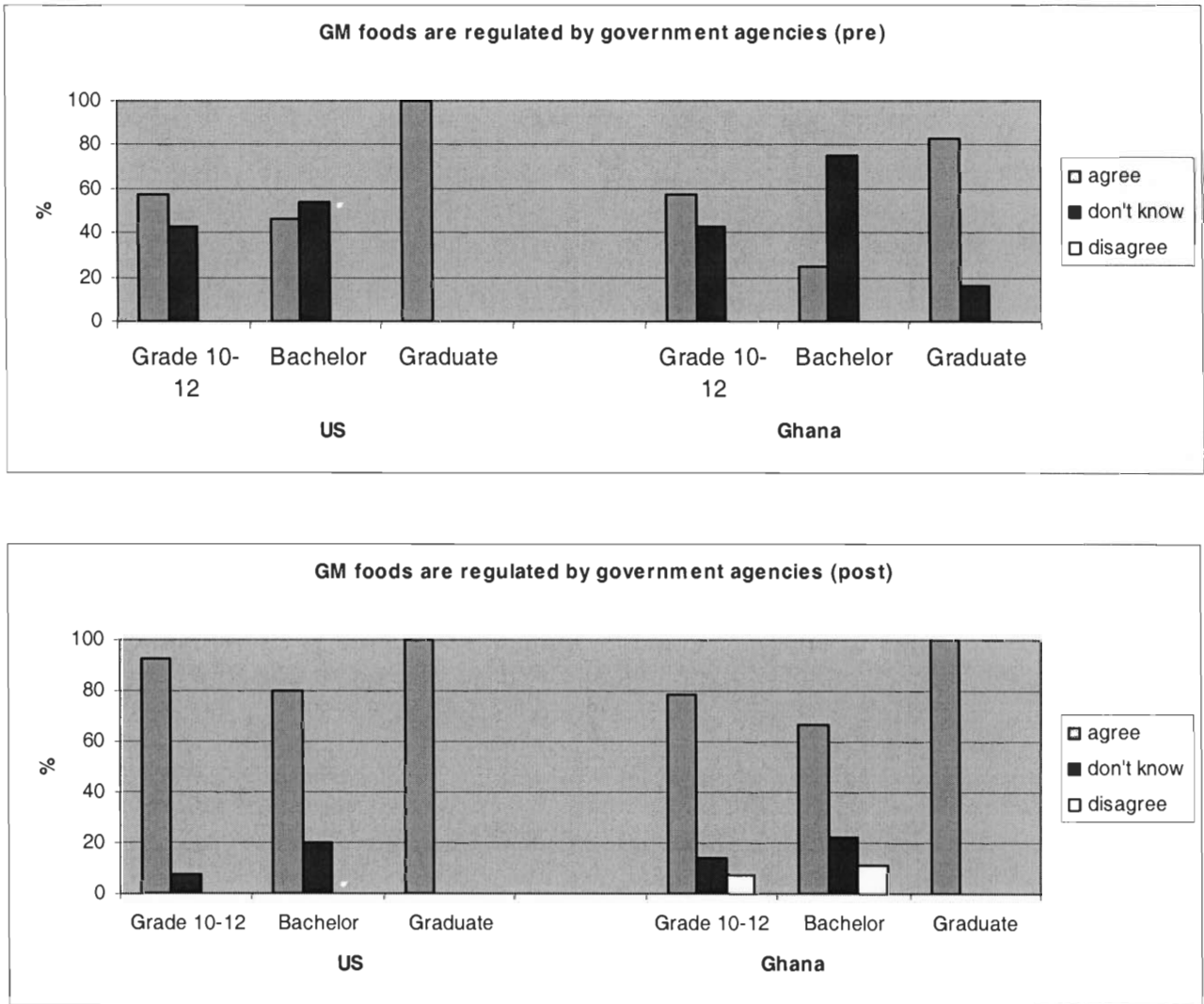
Figure 14. Correlation of Regulation of Biotechnology with Education.

4.6.2 Adequacy of Labeling of GM Food

Labeling of GM food has been a controversial issue as to when it should or should not be labeled[12]. We tried to educate respondents that not all GM foods need to be labeled but only ones which are significantly different from the natural kind. After the educational presentation, we expected a disagree response to the following statement: *All genetically modified food should be labeled.* Results were analyzed for occupations; that is where we saw the most interesting changes.

While the Ghanaians showed a clear response that all GM food should be labeled, the Americans seemed less concerned about labeling requirements (Figure 15). Interestingly, the Ghanaians decreased their concern about labeling after viewing our educational tool.

4.6.3 Adequacy of Regulation of GM Food

We thought showing our interviewees the government agencies that were in charge of supervising the release of GM food to the market as well as telling them that they can trust these people would increase their acceptance of GM food. The statement presented was: *I believe that regulation of genetically modified food is adequate.* After the educational presentation, we expected an agree response. Results were analyzed between post education, for the occupations where we saw major response changes.

Many people were not sure if regulation of GM food is adequate, even after viewing our educational tool, which presented facts about how GM food is being regulated by government agencies (Figure 16). This may imply that they were not confident of government regulation, that they didn't trust regulatory agencies, or that they expected to see even more stringent regulations.

All GM food should be labeled (pre)

All GM food should be labeled (post)
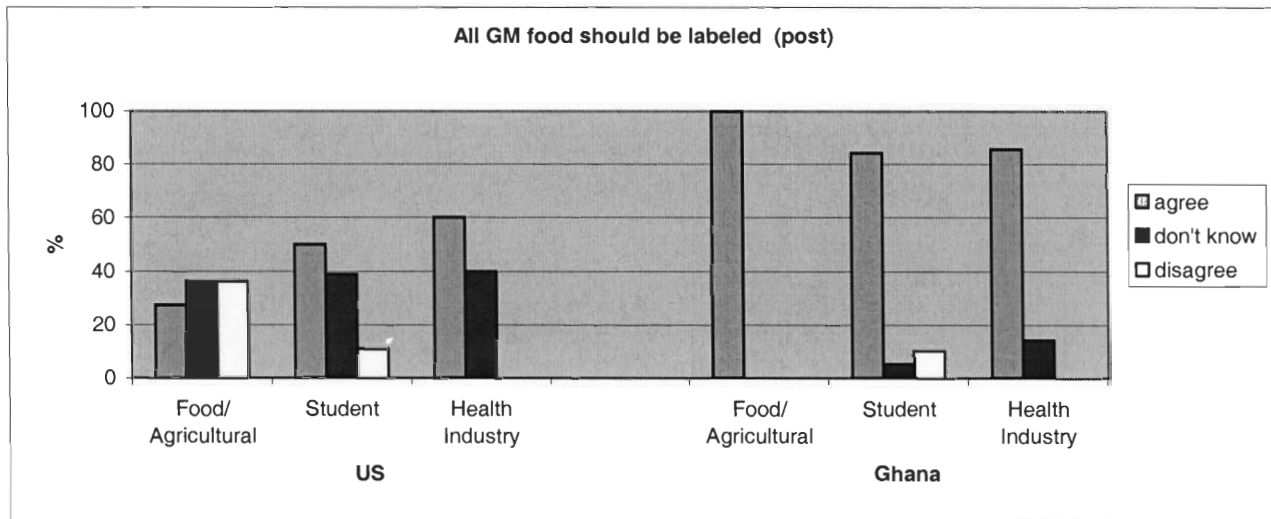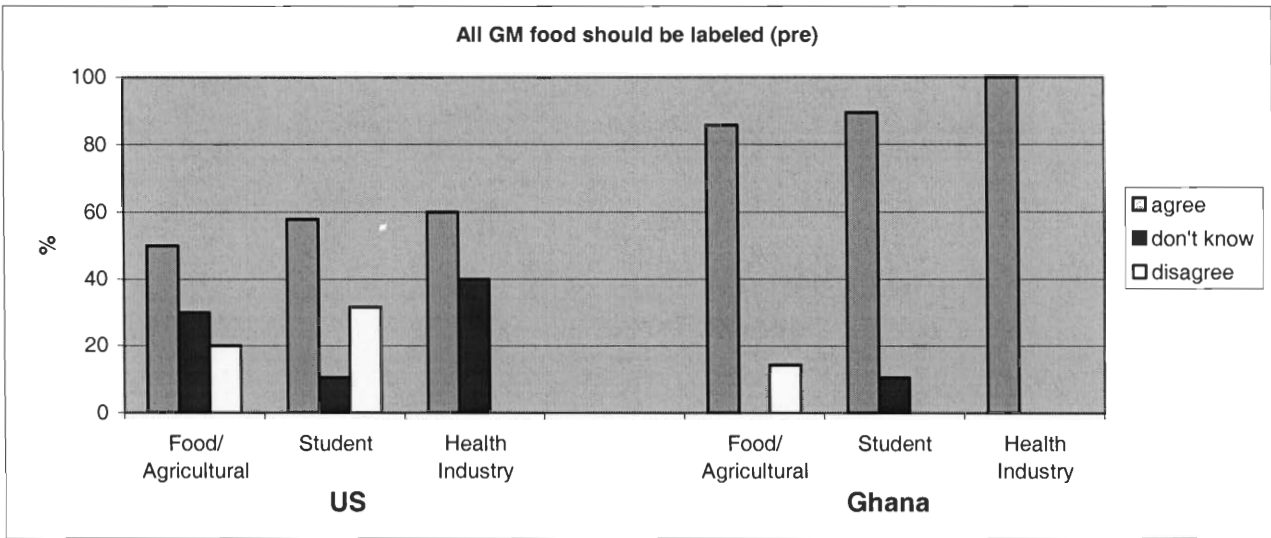
Figure 15. Correlation between food labeling and occupation.

I believe that regulation of GM is adequate (pre)

I believe that regulation of GM food is adequate (post)
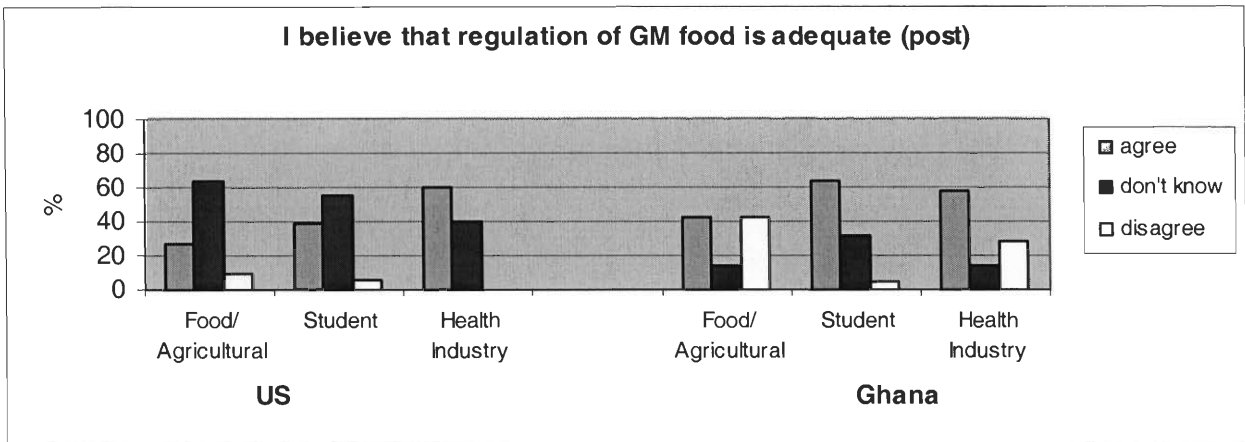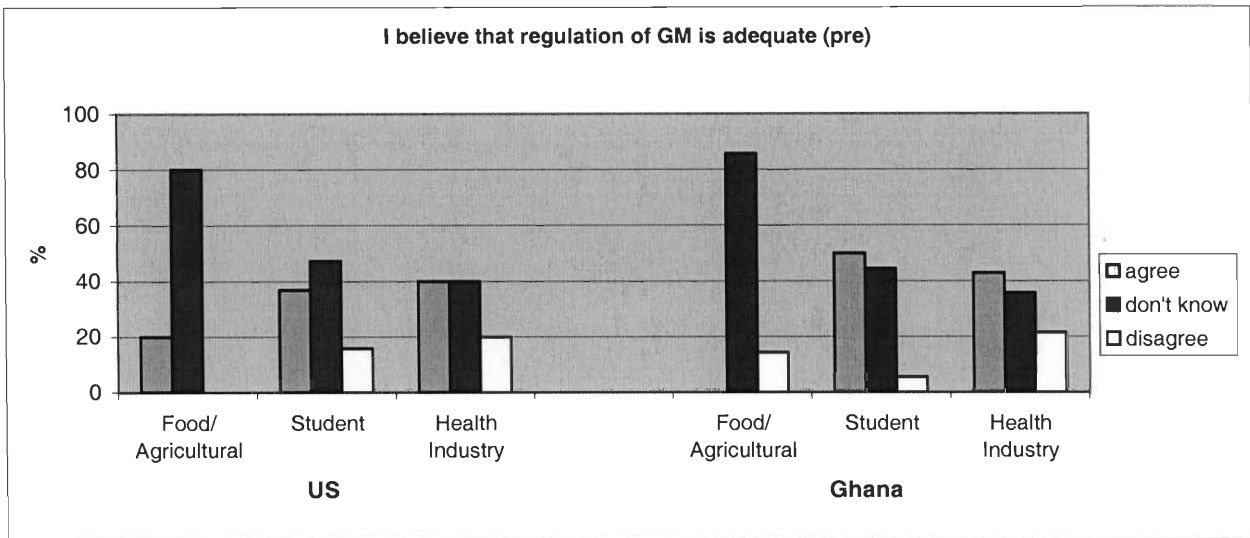
Figure 16. Connection between regulation of GM food and occupation.

4.7   People's perception on Medical Biotechnology

4.7.1 GM Food to Deliver Vaccines and Drugs

We thought that combining a drug into a labeled food product would be a good idea considering how expensive drugs are these days. Through our educational too, we showed our respondents that different drugs and vaccines could be inserted into food (e.g. edible vaccines) and still maintain the efficiency of the drugs. We thus, anticipated an agree response to this statement:

I will consume food that is genetically modified to deliver vaccines or other beneficial drugs.
We saw major response difference only for the occupational demographic group.

Before viewing our educational program, Ghanaians were more willing to consume GM foods containing vaccines than Americans were (Figure 17). This might be because Ghana is a developing country and so medical supplies tend to be expensive. Hence, if a drug is incorporated into a food, it would be cheaper to purchase.

After our educational program, American students and food and agricultural workers became supportive of the idea of using food to deliver drugs. Although American health workers were not as agreeable as the Ghanaians, those that previously disagreed were now uncertain about their response (Figure 17).
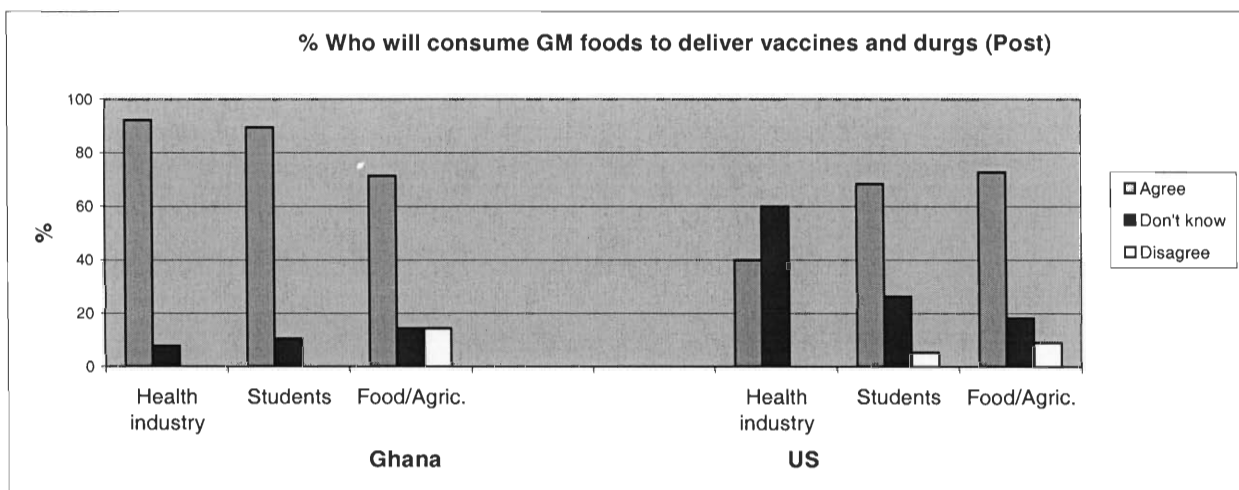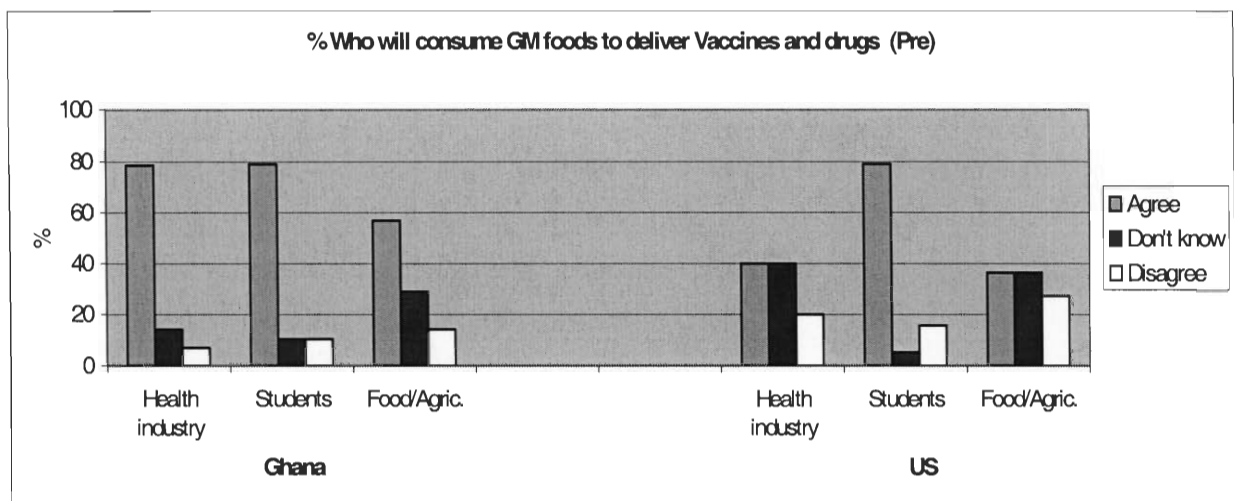
Figure 17. Relationship between GM foods to deliver drugs and occupation.

4.7.2 Allergen Removal

Allergic responses to certain foods restrict many people's diet. Hence, having a way to remove these allergens would be beneficial so that every one can enjoy all the different foods they want without any concern about an allergic response. We were expecting, therefore considerable agreement with the test statement especially after the educational program. The statement presented was: *I will consume food that has allergens removed through genetic modification.*
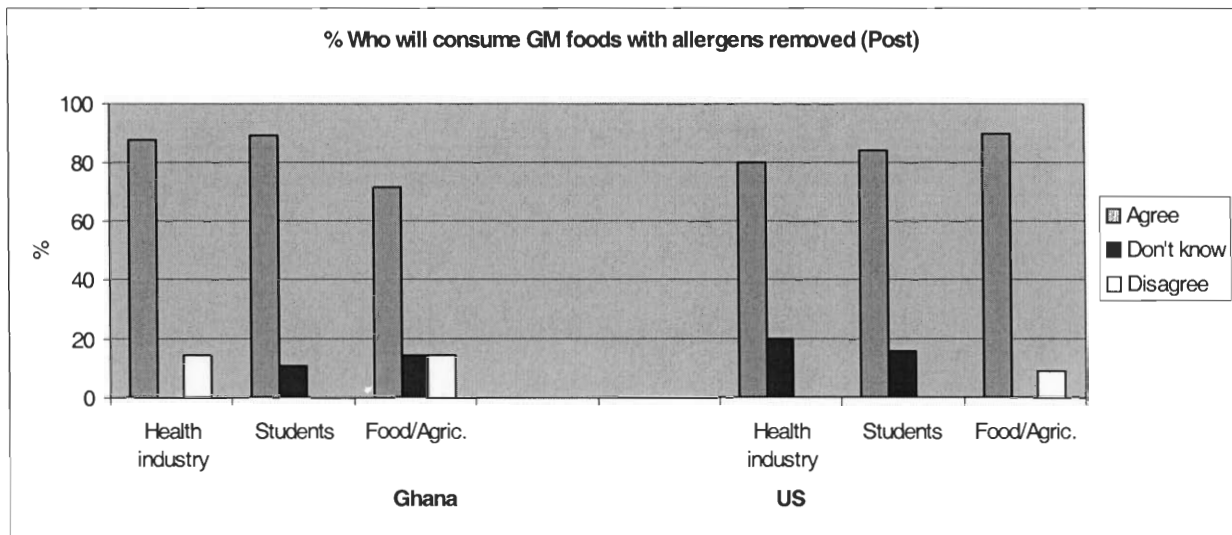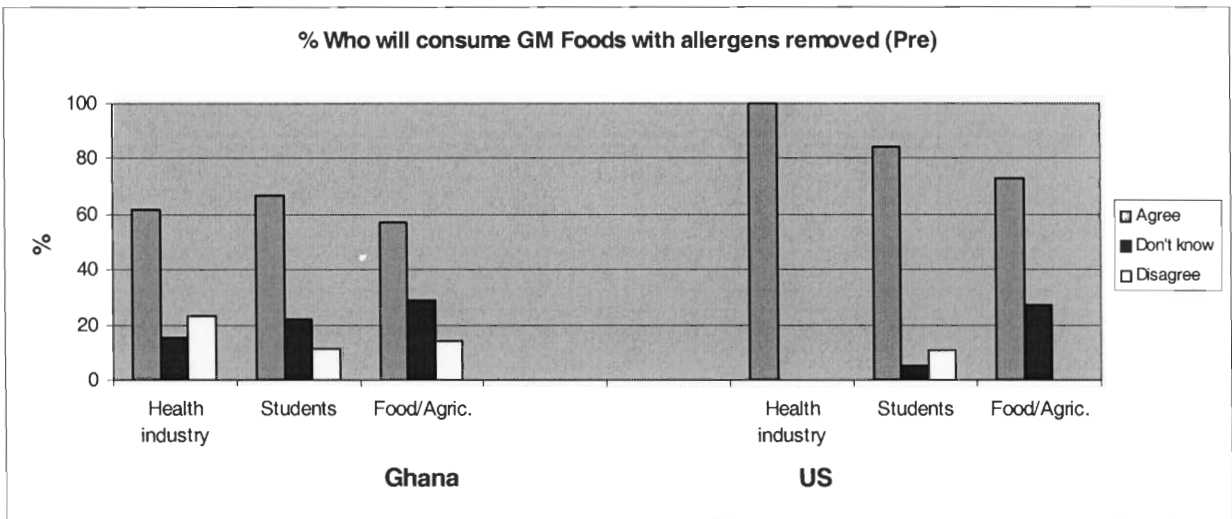
At first Ghanaians did not favor the idea of having allergens removed from food and this might be because they did not fully understand the importance of it (Figure 18). Therefore, after the presentation, when the advantages of the concept were stressed, their acceptance level increased. American health workers on the other hand responded oppositely; there was 100% approval in the pre survey but after the presentation, 20% changed their minds. The food and agricultural group on the other hand went up about 15% (Figure 18).

4.7.3 GM Foods Enriched With Vitamins

Since our body always needs vitamins to help it function properly, enriching food with vitamins would be a good idea. Eating certain kinds of food would give you your daily allotted dose of vitamins and in particular, provide minimum daily requirement of essential vitamins in staple foods for those in poorer countries as was done with the Golden Rice. The statement presented was: *I will consume food enriched with vitamins through genetic modification.* We were expecting an agree response to this statement because of its apparent benefit.

Most of the people seemed to maintain their perceptions about this concept. There was not much difference in response between the pre and post education surveys (Figure 19). This might be due to the fact they believe our food already contains all the vitamins and nutrients that we need and so there is no point in enriching it further.

% Who will consume GM Foods with allergens removed (Pre)

% Who will consume GM foods with allergens removed (Post)

Figure 18. Connection between occupation and GM foods with allergens removed.

% Who will consume GM foods enriched with Vitamins (Pre)

Ghana   US

% Who will consume GM foods enriched with vitamins (Post)

Ghana   US
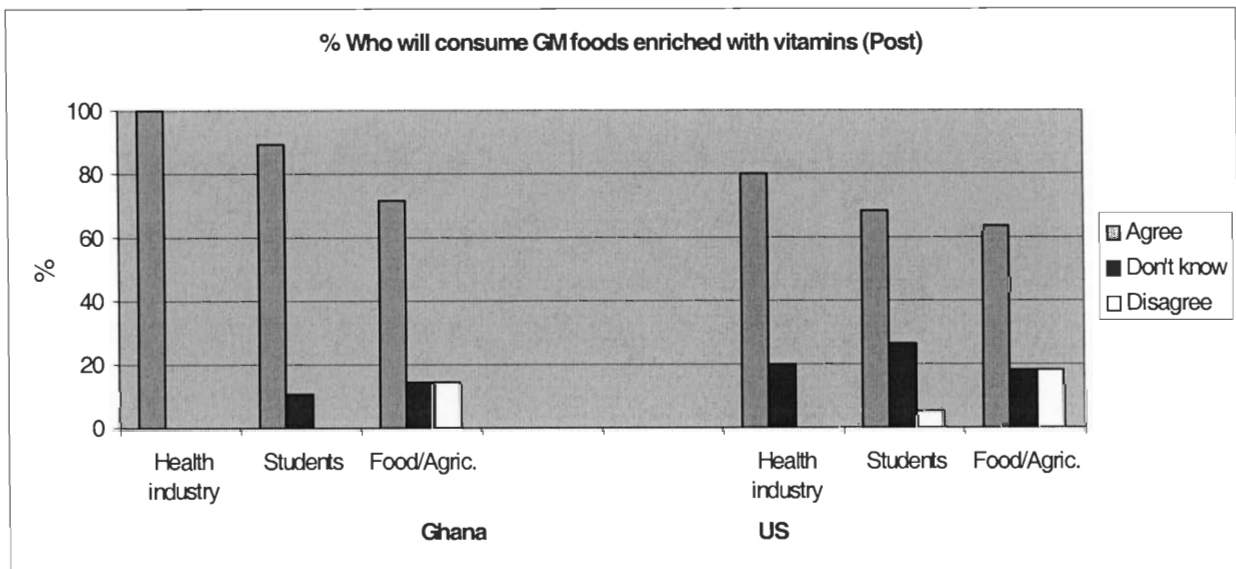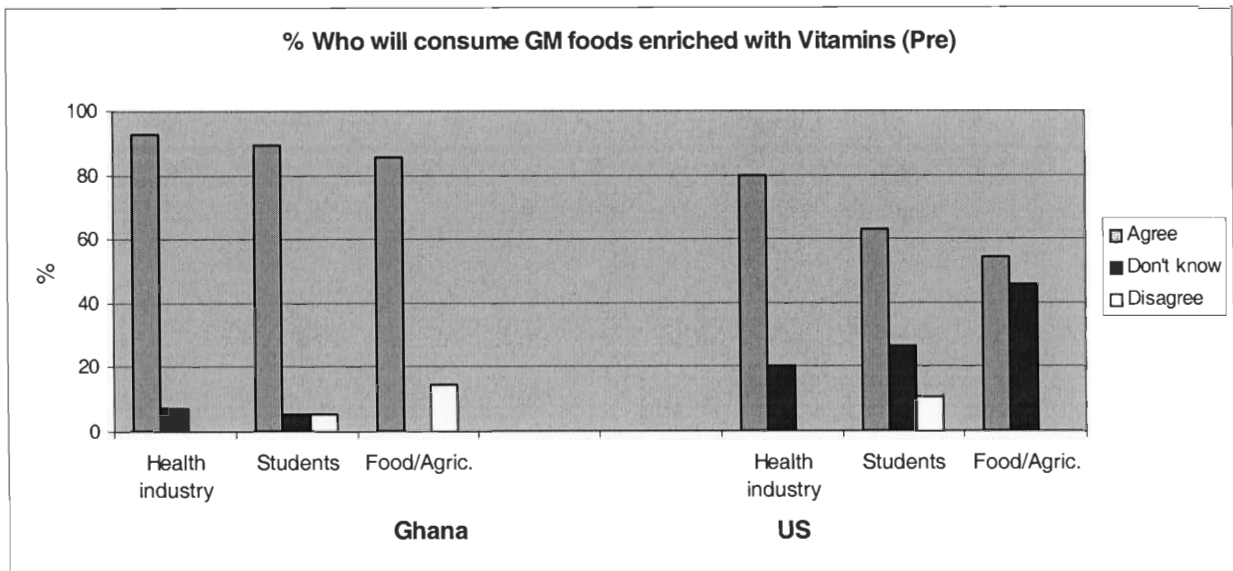
Figure 19. Correlation between occupation and GM food enriched with vitamins.

4.7.4 GM Food With Lowed Fat Content

Since weight gain has become a big problem especially in the United States[16] these days, we expected our respondents in America to embrace this idea favorably. Ghanaians on the other hand are not as concerned with weight gain.

The Statement presented was: *I will consume food enriched with lowered fat content through genetic modification.*

Surprisingly, Ghanaians favorably embraced this idea (Figure 20). Furthermore, our educational program appeared to have little impact on Ghanaians. Americans on the other hand were unsure of what they wanted as is shown in the more negative response post educational program. This might be due to the fact that many of them diet and exercise to lose weight.
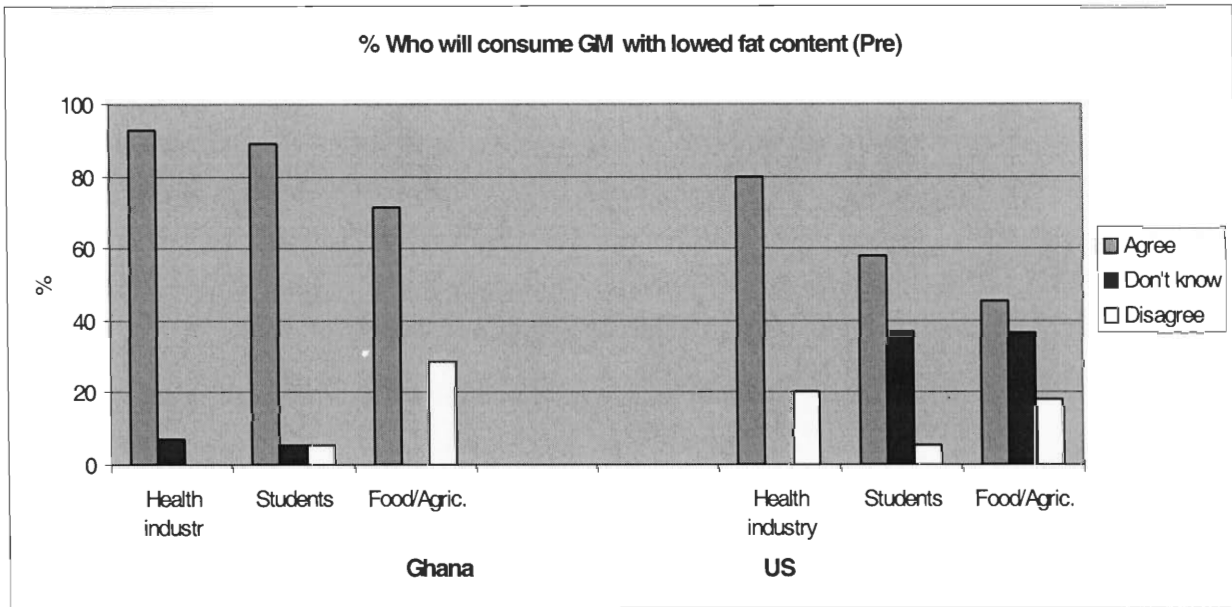
Fig 20. Correlation between occupation and GM food with lowered fat content.

4.8 Perception of Agricultural Biotechnology in the Food/Agricultural Sector

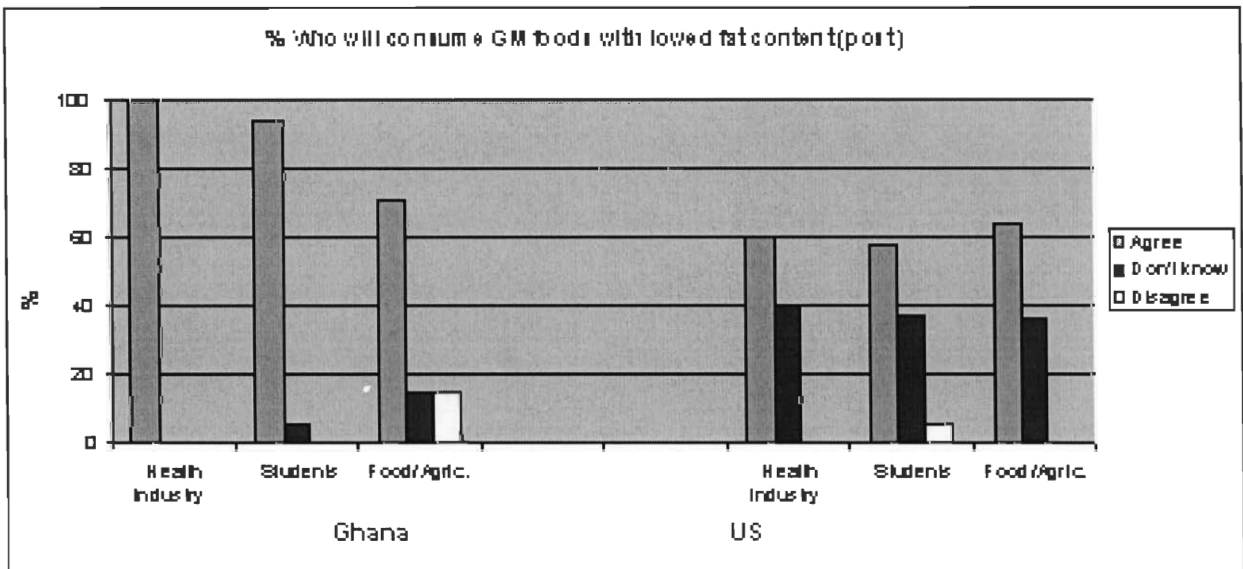We expected farmers in the population we interviewed to agree to the statements below. This is because the modification of plants through Biotechnology was done to make farming easier and also less expensive.

The Statements presented were:

1) **The use of pesticides poses environmental problems**
2) **I support use of crops that reduce the need for pesticides**
3) **Cultivating GM crops with reduced pesticide use will benefit the environment**
4) **I accept crops that are genetically modified to increase yield**

We analyzed the results for the people in the food/agricultural sector.

As a whole, farmers in both the US and in Ghana approved of the various forms of agricultural biotechnology even before our educational program (Figure 21). It is worth noting that the people who were unsure about whether or not they would accept GM crops with increased yield decreased from 45% to 10% after the presentation.
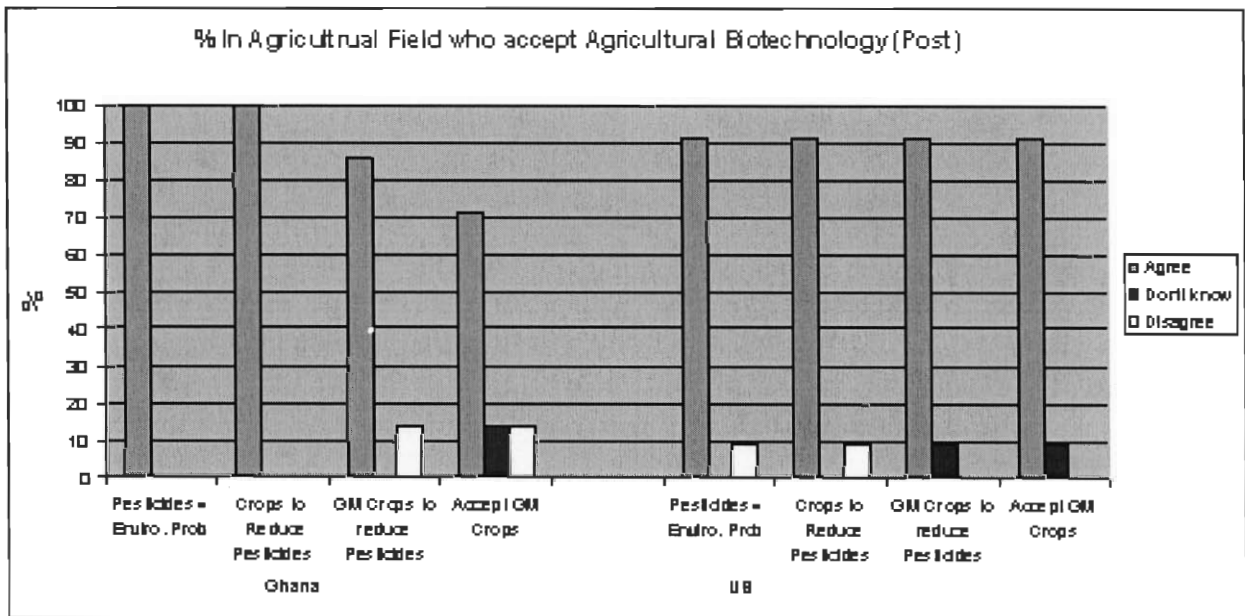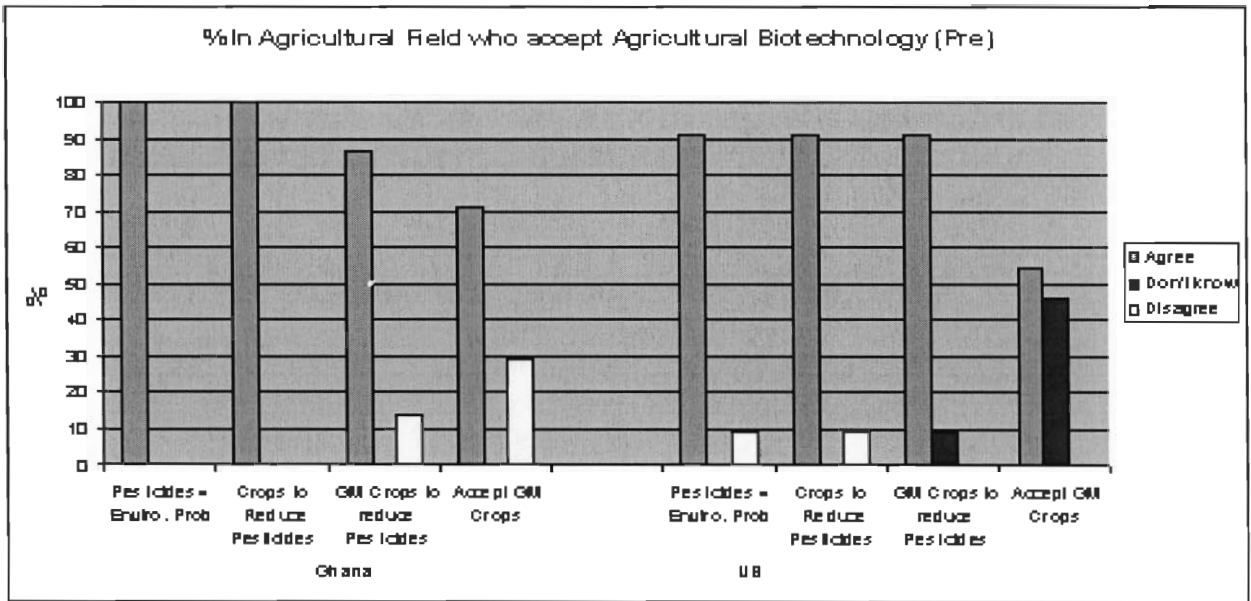
Figure 21. Connection between Farmers and Agricultural Biotechnology.

5.0   DISCUSSION

Our study has shown that people in Massachusetts are generally more aware of biotechnology as compared to the Ghanaians. Responses collected before the educational program reflected how the Americans performed better than the Ghanaians in answering factual questions on biotechnology (Figures 4 and 5). Since most Americans already have some understanding of biotechnology, the facts we presented in the educational tool may be too basic to dramatically alter their opinions, therefore we were unable to see any great changes in most of their responses in our survey. The same situation was observed for those who frequently/occasionally discussed biotechnology (Figure 9), where most of them still held onto their opinions even after the educational program. Conversely, our educational tool was proven resourceful for the less-informed Ghanaians, given that their awareness of biotechnology increased significantly after viewing the presentation (Figures 4 and 5).

In Hoban's study, awareness of biotechnology was also evaluated in Japanese and American consumers. One of the questions asked was whether they had talked about biotechnology with someone. Only one-third of the Japanese had talked about biotechnology, compared to over 50% of Americans who had talked about biotechnology. In our study, 68% of Ghanaians respondents previously discussed biotechnology, slightly less than the 76% in the U.S.

Interestingly, greater awareness of biotechnology does not necessarily lead to greater acceptance of GM food. Although our educational program often resulted in higher acceptance of GM foods, in several cases we observed an apparent negative effect (e.g. Figure 7). Hence, when it is presumed that greater knowledge will lead to higher acceptance, new information may in fact subject some people to more doubts, thereby making them less accepting of GM food. On the other hand, the assurance of food safety seemed to play a more influential factor in determining one's acceptance of GM food. There are more Ghanaians who view GM food as an unsafe food source (Figures 2 and 3), they are also comparatively less willing to accept GM food (Figures 6, 7, 8 and 9). This demonstrates that, while educating the public with scientific facts does promote acceptance of GM food to some extent, it is ultimately the safety of GM food that concerns the majority of the public.

On the other hand, our educational program positively affected people's willingness to purchase GM foods. This is particularly true for the Ghanaians which showed a large increase in

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their support after viewing our educational program (Figure 10), even though they were still slightly less willing to purchase GM foods as compared to the Americans. Hoban's study showed a similar result, where there were more Americans than Japanese who believed that the use of biotechnology will have a "positive effect" on their decision to purchase.

In addition, from the responses collected after the educational program, we observed that the willingness of people to purchase GM food is generally higher than that those who accept GM food (e.g. Figures 9 and 13). In other words, people are willing to purchase GM foods even though they may not accept them. A possible explanation is that while these people may not accept all GM foods, they are willing to purchase certain GM foods that they find beneficial. For example, for the four different applications of biotechnology in the medical field (Figures 7, 8, 9 and 10), our post-education responses reflected that people who will consume GM food with allergens removed (Figure 18) may not consume foods with lowered fat content (Figure 20). In another example, we can see that the willingness to consume GM food to deliver vaccines and drugs, or with lower fat content, is particularly low in the U.S. as compared to Ghana. Therefore, a person's willingness to purchase GM food differs according to the benefit offered, and hence is not a good indicator of his/her acceptance of all GM foods.

Similarly, Hoban's study also found that in both U.S. and Japan, GM foods with lower fat content or more vitamins, as well as crop plants that reduce the need for pesticides, are the more acceptable GM products compared to the use of biotechnology to produce human insulin and other medicines.

Both countries presented similar views on the regulation of biotechnology, where a significant portion of both Americans and Ghanaians are not satisfied with the present state of regulation of GM food. Regarding food labeling, close to 100% of the Ghanaians believe that all GM food should be labeled, in contrast to less than 50% of the Americans who wanted labeling of GM food.

Awareness of biotechnology was higher among the Americans in both Hoban's study between the U.S. and Japan, and in our study between Massachusetts and Ghana. Nonetheless, their willingness to purchase GM food was not as positive. Thus, a greater emphasis on the safety and benefits of GM food may be necessary in future educational plans among the Americans.

6.0   CONCLUSION

With every new technology comes a multitude of concerns about its possible impacts. Before reaching a definite conclusion on these impacts, public influences such as media, government, and interest groups will continue to indoctrinate the consumers' minds with their own set of beliefs. Ultimately, it is education that will present them with the facts, thereby providing people the freedom to make their own judgment. As illustrated by our study, different countries may require different approach in education. Regardless, our results show that biotechnology education for the general public is important, especially in developing countries, for promoting public acceptance of GM food.

"Most will accept the products if they see a benefit to themselves or society" (Hoban, 1998). This concept will hold true regardless of time, place, and background of any individual, as long as they are reassured about the safety of the food by someone they trust.

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APPENDIX A

Plant Biotechnology and Genetically Modified Foods

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What is Plant Biotechnology?

- Plant biotechnology describes a precise process in which scientific techniques are used to develop useful and beneficial plants.
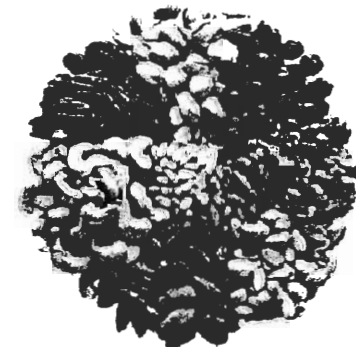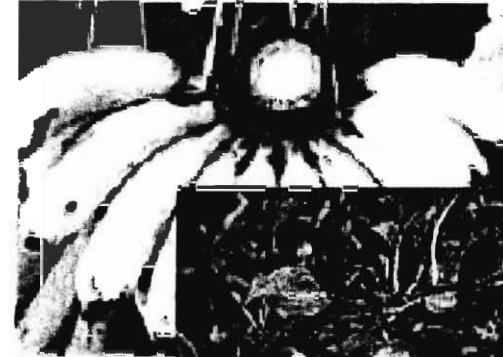
Examples

Bananas to deliver vaccine
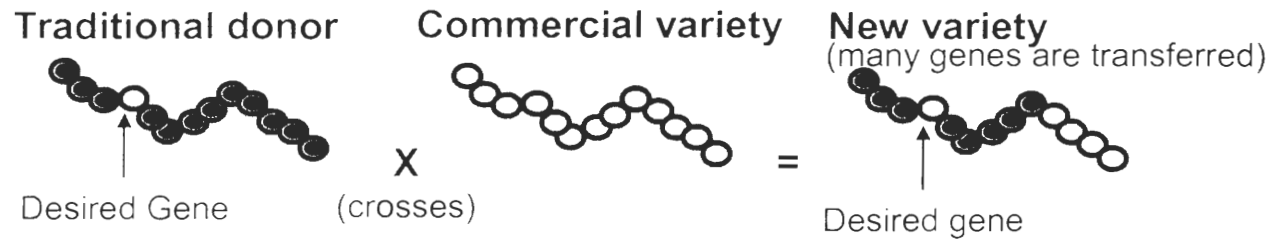
Apples to protect against
virus

Potatoes to protect
against cholera, E. coli and
Norwalk virus

Allergens removed from foods to
reduce allergic reactions

Traditional Plant Breeding

DNA is a strand of genes, much like a strand of pearls. Traditional plant breeding combines many genes at once.

Traditional donor

Desired Gene

X (crosses)

Commercial variety

= **New variety**
(many genes are transferred)

Desired gene

Plant Breeding Through Biotechnology

Using plant biotechnology, a single gene may be added to the strand.

Desired gene

O ➡ (transfers)

Commercial variety

= **New variety**
(only desired gene is transferred)

Desired gene
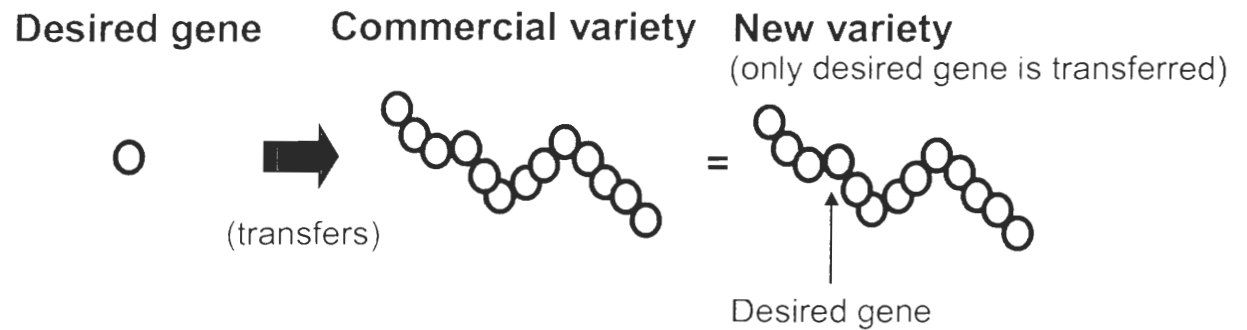
Foods on the Market

"More than 50 biotech food products have been approved for commercial use in the United States".
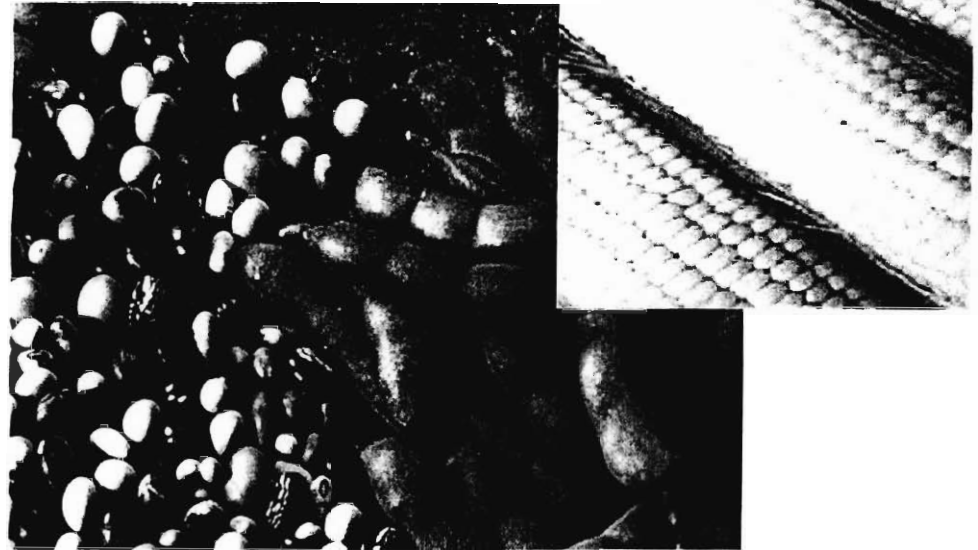
- Canola
- Corn
- Cotton
- Papaya
- Potato

- Soybeans
- Squash
- Sugarbeets
- Sweet corn
- Tomato

Most Widely Grown GM Crops

Soybeans 63%

Corn 19%

Cotton 13%

Canola 5%
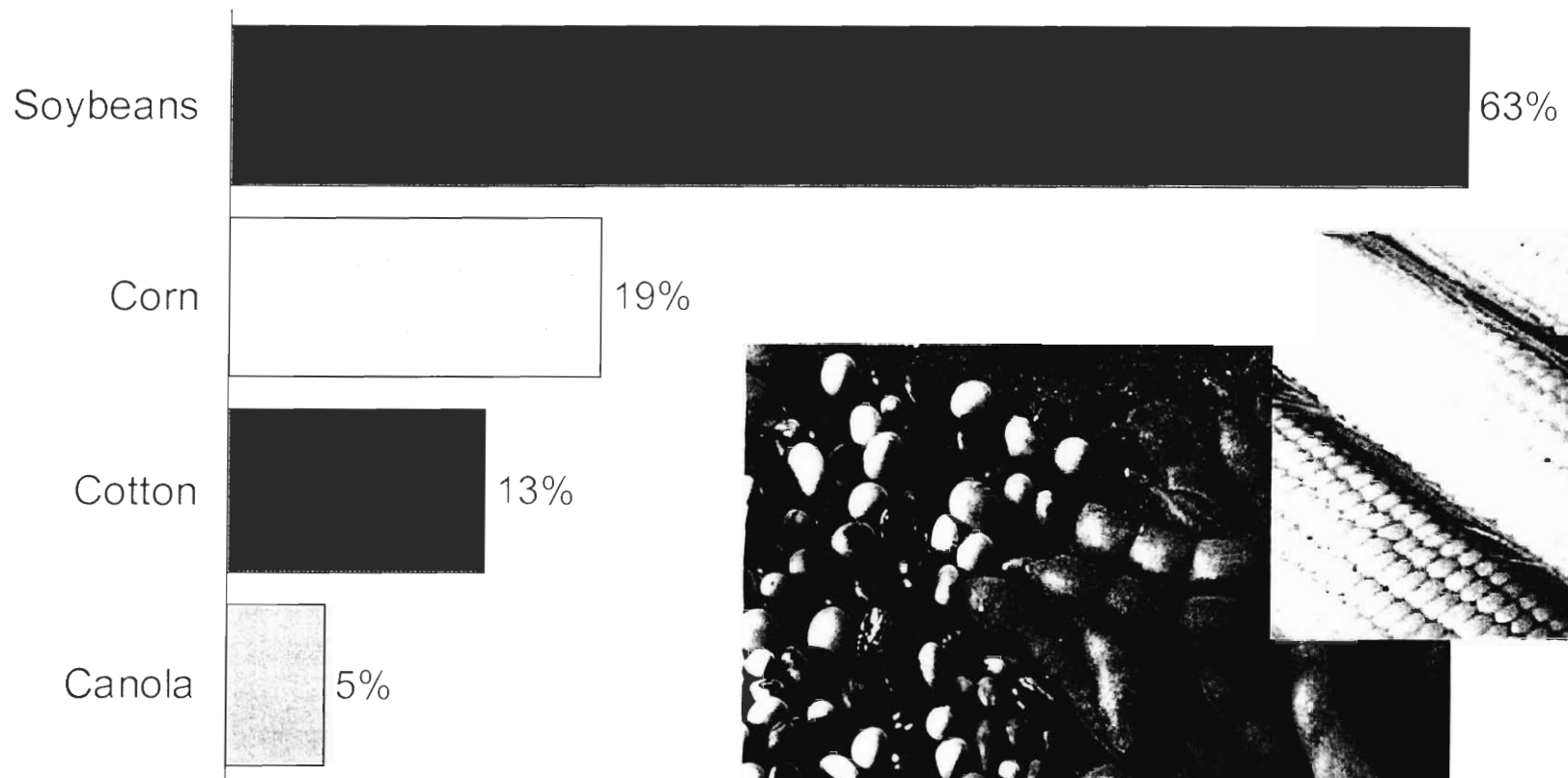
Benefits of Plant Biotechnology

- **Better for the Environment**
  - > Reduced Pesticide Use
- **Better Crops**
  - > Increased Yield
  - > Health Benefits
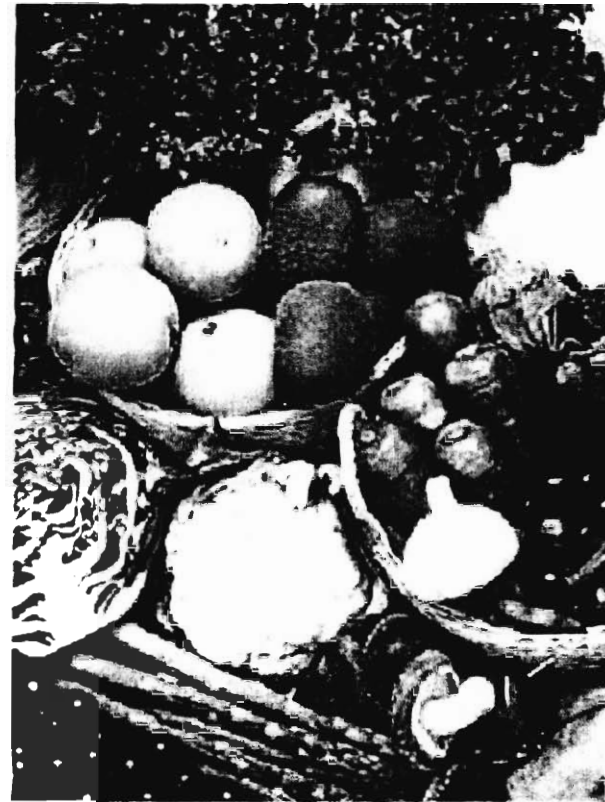
Concerns about the environment

Environmental Hazards from Pesticides

- Substantial health impacts on workers
- Pollution of natural ecosystems/waterways
- Loss of insect biodiversity in agroecosystems
- Creation of secondary pests
- Creation of insect races resistant to pesticides

Better I...

...de reduction

...on pounds

...ion ...5 million pounds

A new study released in October of 2002 ...the Conservation Technology Information Center found that the environmental benefits of plant biotechnology range from improved habitat for birds, such as pheasants and bobwhite quail, to cleaner drinking water and a reduction in harmful greenhouse gases and fuel use.

The study said that since biotech crops were first commercially grown in the United States in 1996, no-till conservation acreage has grown by 35 percent.

The study said "There is a clear association between sustainable tillage practices and biotech crops," noting that nearly three-fourths of no-till soybean acres – and 86 percent of no-till cotton acres – were planted with biotech varieties.

Better Crops
- increased yield

Bt corn – 3.5 billion pound yield increase

Bt cotton – 185 million pound yield
increase

Biotech soybeans – $1 billion
in additional income through production cost
savings

Better Crops - Health Benefits

Vitamin A Deficiency and "Golden Rice"

- Provides healthy eye sight
- Development of fetuses
- Differentiation of cells (prevents pre-cancerous cells)
- Vitamin A deficiency causes blindness in 250,000 children worldwide every year

Golden Rice ~ genetically modified rice containing beta-carotene, precursor for Vitamin A

http: www.sdcma.org gmfood.htm

Public Concerns

- Is this food safe?
- Should food be labeled?
- Are there adverse environmental effects?
- Is patenting of seeds fair?
- Are these foods too expensive for the poor?
- Who benefits from the profit?

Is it safe?

Safety Concerns

- Antibiotic resistant bacteria

  Transfer of antibiotic resistance from a transgenic plant to the human digestive system

  Explanation: In "artificial cow stomach" such transfer did not occur in 10 billion, billion generations → 10,000,000,000,000,000,000,000.

- Food Labeling

  How do we know what we are eating?

  Explanation: Biotech foods are labeled when they do not have the same characteristics as their conventional counterparts. Some of the characteristic are nutritional value, composition(example: ingredients from certain fats not present in their conventional counterparts) and intended use.

Government Regulation

USDA UNITED STATES DEPARTMENT OF
AGRICULTURE

U.S. Department of Health and Human Services
Food and Drug Administration

EPA United States
Environmental Protection Agency

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
National Institutes of Health

Ministry of Agriculture, Ghana

Environmental Concerns

- ## Gene Flow

    Gene flow occurs when crops cross with wild relatives growing in relative close proximity to the fields, thereby creating "superweeds".

    Explanation: Gene flow unlikely even in neighboring plants

    Likelihood and consequences of gene flow thoroughly examined.

- ## Reduced agricultural diversity

    Introduction of GM crops into the environment will affect and/or destroy biodiversity.

    Explanation: Companies need to take responsibility of maintaining gene pools. For example: people being paid to keep growing the original variety, or farmers "required" to grow a percentage of the original variety.

Socio-Economic Concerns

- Affordability of GM seeds

  Are GM seeds too expensive?

  Explanation: High yield exceed expenses (seeds, pesticides)

- Who benefits?

  The growers, sellers, and consumers. An example is a soy beam farmer in the southern United States who said engineered soy bean has help him lower pesticide use, farm land tilth, healthier bean as a result of reduced pesticide use, increase yield ECT.

After Thought

- The more people know, the more they support biotechnology.