AWARENESS OF UNIVERSITY UNDERGRADUATE STUDENTS ON GENETICALLY MODIFIED ORGANISMS IN GHANA

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Abstract

Consumers are generally subjected to Genetically Modified (GM) food items either directly or indirectly through the consumption of processed foods produced using GM ingredients. After the introduction of the first commercial GM foods in the early 1990s, contentions arose with regard to the potential benefits and risks to human and environmental health. This cross-sectional descriptive study focused on the awareness and perceptions of students from two Ghanaian public universities namely, the Kwame Nkrumah University of Science and Technology in the Ashanti Region and the University for Development Studies in the Northern Region. A total of 304 students participated in the study. The data were analyzed using the statistical software SPSS (Version 20). The results showed a high level of Genetically Modified Organisms (GMOs) awareness among students in the two universities. The fundamental theories underpinning GMOs, biotechnology, and genetic modification were understood by students. Most students had their information about GMOs from the media. Age played a major role in perceptions as students in the age range 21-23 were more receptive to innovations compared to students >23 years. Students with programmes related to biological sciences had fewer reservations towards GMOs unlike students pursuing non-biological science fields.

Keywords: Biotechnology, Genetically Modified Organism/Food, Students, Awareness, University

Introduction

Genetically Modified Organisms (GMOs) continue to receive public and policy debates across the globe (Vecchione & Verma, 2015). For Africa, the topic is occurring at a critical period when the occurrence of food insecurity, poverty, and malnutrition are alarming (Viljoen et al., 2006). Generally, GMOs headline the public debate because of safety concerns. In third-world countries, the GM topic continues to draw discussions around policy in the fields of food security and economic development. Proponents of GM technology are worried the benefits of GMOs may be significantly ignored because of the potential risks that the media sensationalizes (Blaine et al., 2002). As result,

public acceptance is with mixed feelings (Blaine et al., 2002).

In the African continent, Ghana since the passage of the Biosafety Act, 2011 to allow the testing, production, and commercialization of GM crops in the country has pushed the government to roll out comprehensive projects that will culminate in the introduction of Genetically Modified foods (GM foods) into the country's food chain, the most marketed products of modern biotechnology (Amofah, 2014). Modern biotechnology is touted as the science to essentially change society's food cultivation and distribution system (Hallman et al., 2003). Amidst many uncertainties, the world

cultivation of GM crops continues to rise in two decades of commercialization.

In democratic societies, public opinions can encourage or hinder the introduction of innovations or technology on a commercial scale (Owusu, 2015). In developed countries (Bonny, 2003; Moon, et al., 2005), over the years, GMOs have received extensive spotlight , however, in low income countries, the populace is left in a state of uncertainty because little or no research has been carried out , and the technology is not utilized commercially (Anderson et al., 2006). The paucity of GMO research on public concerns in Ghana has left the nation in a dawdle in its plan of adoption and commercial cultivation of GMOs and GM crops. It is therefore imperative that studies are carried out to evaluate the awareness and perception of the youth in higher learning institutions regarding their understanding of biotechnology and GMOs. This is very critical because these people are an important part of the developmental process of a country's human resources.

Materials and Methods
Study Design

The cross-sectional survey was carried out employing a structured questionnaire of open-ended and close-ended questions. Sections included demographic characteristics, biotechnology knowledge, GMO knowledge, GMOs and regulations in Ghana, and GMOs and health issues.

Study Site Population and Participants
The survey was carried out during the 2018/2019 academic session at the Kwame Nkrumah University of Science and Technology (KNUST), in the Ashanti Region and the University for Development Studies (UDS), in the Northern Region of Ghana. The KNUST has an undergraduate population estimated at 40,000. It operates on a collegiate bases and includes the following colleges: College of Agriculture and Natural Resources, College of Health Sciences, College of Humanities and Social sciences, College of Arts and Built Environment, College of

Engineering, and College of Science. The UDS, Nyankpala Campus had undergraduate population of 2,526 and operates a faculty/school system. The study made use of only undergraduate students. The study population was suitable because students in tertiary educational institutions often come from varied backgrounds. They were expected to be aware of the study topic as well.

Sample Selection
A total of 304 students with 108 and 196 from KNUST and UDS respectively participated in the study. A multi-stage simple random sampling approach was used to arrive at the participants interviewed. Foremost three colleges were selected using simple random selection (for each university) using the computer-based program MS Excel. Two programmes of study were randomly selected from each participating college or faculty. The registers of each of the participating programs were pooled to develop a sample frame out of which 304 students were randomly selected.

Data Collection
The study was quantitative utilizing a self-developed and self-administered questionnaire. Guidelines were provided when required by participants. To evaluate whether the questionnaire was standard, 20 students from the University for Development Studies, Nyankpala campus were used to pretest the questionnaire. This was done for purposes of refinement to assure the accuracy of measurement and to make administration and completion easy. Appropriate amendments were made to the questionnaire as required after the pretesting.

Data Analysis
Descriptive table on the socio-demographic data of respondents, awareness of Biotechnology and GMOs, sources of information on Biotechnology and GMOs, perceptions of GMOs was created using MS Excel 2016 and SPSS 20.0. Awareness levels of study respondents was measured based on a specific set of questions on GMOs and GMFs, the interest of the respondents on GMOs and GMO issues, the idea about GM Technology (GMT), and

what genetically modified foods are. Determination of association between the variables was done with Pearson's Chi-square (χ2) test with a 5% significance level was set for all statistics.

Consent and Ethical Considerations

Approval was obtained from the Dean of Students at the Kwame Nkrumah University of Science and Technology, Kumasi, and the Vice Dean of Students, University for Development Studies, Nyankpala campus for student participation. The purpose of the study was made known to respondents. Participation was voluntary and information was kept confidential. Alphanumeric codes were used to identify each questionnaire

Results

In the study, 196 participants took part in the survey from the University for Development Studies, Nyankpala. Data collected showed 68.9% (135 males) and 31.1% (61 females) with the majority being in the 21 to 23 age group. Furthermore, the majority (84.2%) were Christians. Agricultural Science students were the most dominant (40.8%). (Table 1).

On the other hand, 108 participants took part in the survey at the Kwame Nkrumah University of Science and Technology, Kumasi. They included 68 males (63%) and 40 females (37. 0%), and the majority fell within the 18 to 21 age group. The majority (97.2%) were Christians, and the most dominant programme of study among the respondents were Health Science (37%) (Table 1).

Table 1: Socio-Demographics of Study Participants

Attribute	K.N.U.S. T		U.D. S	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
Gender				
Male	68	62.96	135	68.87
Female	40	37.0	61	31.1
Age Group				
18-20	53	49.07	45	22.6
21-23	47	43.5	120	61.2
24-26	7	6.48	28	14.29
27-29	0	0	3	1.53
30-32	0	0		
33-35	1	0.9		
Marital status				
Single	107	99.07	196	100
Married	1	0.9		
Religion				
Christian	105	97.2	165	84.2
Muslim	3	2.77	31	15.8
Program				
Agricultural science			80	40.8
Applied science	12	11.1	16	8.16
Natural science			20	10.2
Food science			40	20.4

Social science	22	20.37	40	20.4
Health science	40	37.0		
Biological science	17	15.7		
Built environment	17	15.7		

Source (Field data, 2019)

Among the students surveyed, all (100%) responded affirmatively to awareness of the science of biotechnology. Except for one student, all (99.7%) students also responded affirmatively in respect to awareness of GMOs. Most of the respondents indicated that they got their information on biotechnology (44.7%) and GMOs (48.6%) from multiple sources (Table 2).

Table 2: Awareness of Biotechnology and GMOs

Biotechnology Awareness?	Frequency		Percentage (%)	
Yes	304		100	
No	0			
Do you have awareness of GMOs?	**Frequency**		**Percentage (%)**	
Yes	303		99.7	
No	1		0.3	
Information Source	**Biotechnology**		**GMOs**	
	Frequency	**Percentage (%)**	**Frequency**	**Percentage (%)**
Radio	6	1.9	4	1.3
Television	20	6.6	21	6.9
Newspaper	2	0.7	6	2.0
Books	18	5.9	44	14.5
Internet	27	8.9	17	5.6
Lecturer	57	18.9	33	10.9
Friends	38	12.5	31	10.2
Two or more of the above sources	136	44.7	148	48.6

Source (Field data, 2019)

Since the target population constituted respondents in tertiary institutions, the study additionally assessed their comprehension of biotechnology and GMOs. The rationale was to check respondents' distinction of biotechnology and GMOs. Amongst the respondents, 35.5% described biotechnology as biology plus technology, 3.3% understood biotechnology as biological resource exploitation and 61.2% viewed biotechnology as living organisms and products modification (Table 3). However, the description of GMOs as genetically modified organisms was 100%.

Table 3: Understanding of Biotechnology and GMOs

Understanding of Biotechnology as:	Frequency	Percentage (%)
Biological technology	108	35.5
The exploitation of biological resources	10	3.3
Modification of living organisms and their products	186	61.2
Understanding of GMOs as:		
Genetically modified organisms	304	100.0

Source (Field data, 2019)

The study also examined the perceived risk of GMOs among respondents. Here, 77.3% of the participants perceived that GMOs could cause allergies. Except for risks associated with a decrease in nutritional value, most of the respondents' perceived risks in respect of cancer development (75.7%), reproductive harm (68.8%), the release of genes to the environment (54.6%), and the incorporation of exogenous genes (69.7%) (Table 4).

Table 4: Perceived Risks of GMOs

Variable	Agree	Indifferent	Do not agree
	Frequency (%)	Frequency (%)	Frequency (%)
Cancer development	230 (75.7)	59 (19.4)	20 (6.5)
Reproductive harm	209 (68.8)	60 (19.7)	35 (11.5)
Allergy	235 (77.3)	64 (21.1)	5 (1.6)
Incorporation of exogenous genes	212 (69.7)	68 (22.3)	24 (7.9)
Decrease of nutritional value	109 (35.9)	86 (28.2)	109 (35.9)
Deterioration of taste and appearance	133 (43.8)	89 (29.3)	82 (26.9)
Release of genes into the environment	166 (54.6)	81 (26.6)	57 (18.8)
Threat to native biota	203 (66.8)	67 (22.0)	34 (11.2)

Source (Field data, 2019)

Additionally, the study examined the perceived benefits of GMOs among respondents. Most respondents perceived benefits of GMOs in respect of providing solutions to food insecurity (81.6%), vaccine and drug production (88.8%), environmental protection (62.4%), breeding of new species (83.9%), and medical procedures (85.2%) (Table 5).

Table 5: Perceived benefits of GMOs

Variable	Agree	Indifferent	Do not agree
	Frequency (%)	Frequency (%)	Frequency (%)
Food insecurity	248 (81.6)	50 (16.4)	6 (2.0)
Environmental protection	212 (69.7)	57 (18.8)	35 (11.5)
Medical procedures	259 (85.2)	32 (10.5)	13 (4.3)
Vaccine and Drug Production	270 (88.8)	29 (9.5)	5 (1.6)
The decrease in chemical use	211 (69.4)	51 (16.8)	42 (13.8)
Cosmetics production	183 (60.2)	102 (33.5)	19 (6.3)
Increase of nutritional value of foods	172 (56.6)	84 (27.6)	48 (15.8)
Cultivation/breeding of new species	255 (83.9)	35 (11.5)	14 (4.6)

Source (Field data, 2019)

The Pearson chi-square test performed determined the association between selected socio-demographic characteristics and perceived risks and benefits of GMOs. With the result a significant correlation exists between the programme of study, perceived risks, and benefits of GMOs. Age, gender, and religion, however, did not have a significant association with some perceived risks and benefits of GMOs. No significant association was recorded between the factor Gender (p=0.101) and the development of cancer (Table 6).

Table 6: Socio-demographics Associations with, Perceived Risks and Benefits of GMOs

Attribute	Gender P-value	Program P-value	Age P-value	Religion P-value
Cancer development	0.101	**0.000***	0.680	**0.006***
Reproductive Harm	0.075	**0.000***	**0.001***	**0.012***
Allergy	**0.022***	**0.000***	**0.000***	0.081
Incorporation of exogenous DNA	**0.000***	**0.000***	0.078	0.337
Decreased Nutritional value	0.231	**0.000***	**0.000***	0.275
Deterioration of taste and appearance	0.173	**0.000***	**0.000***	0.515

Increase in food prices	**0.000***	**0.000***	**0.000***	0.445
Release of genes to the environment	**0.024***	**0.000***	**0.000***	0.914
The threat to native biota	**0.161**	**0.000***	**0.000***	0.939
Food security	0.212	**0.000***	**0.000***	**0.003***
Environmental protection	**0.001***	**0.000***	**0.000***	**0.044***
Medical procedures	**0.036***	**0.000***	**0.013***	0.175
Drugs and vaccines production	0.074	**0.000***	**0.000***	0.129
Cosmetic production	0.259	**0.000***	**0.000***	**0.007***
Decreased chemical use	**0.002***	**0.000***	**0.000***	0.353
Increased nutritional value	**0.000***	**0.000***	**0.015***	0.204
Cultivation /breeding of new species	**0.007***	**0.000***	**0.000***	**0.009***

$* = p < 0.05$
Source (Field data, 2019)

Discussion

Awareness and understanding of GMOs

Discussions are important in today's world because of the media sensationalism of the GM technology. Introduction of GMOs over the years has got people from different parts of the world often showing marked interest (Buah, 2011). Our findings suggest that many undergraduate university students (99.67%) had awareness of GMOs and understood genetic modification as the improvement of living organisms and their products. Respondents also differentiated biotechnology from GMOs. Importantly, most students understood biotechnology to mean the modification of living organisms and their products. These findings corroborate the findings of previous studies carried out in Malaysia (Amin et al., 2011) and Ghana (Buah, 2011). Both studies ascertained a high level of awareness on GMOs amongst university students. Literature reveals a wide public perception and knowledge gap between developed countries and developing countries about GMOs. Hence,

students particularly in developing countries must be involved in the conversation. More so, in the not-too-distant future, creative solutions would be required of them (students who would have become leaders) in addressing ungrounded public aversions towards GMOs. The high level of awareness ascertained in this study was not surprising as many respondents indicated that they obtained information on both biotechnology and GMOs from multiple sources. Students indicated books and lecturers as prominent sources of information on GMOs. This finding perhaps could be attributed to the availability of a wide array of books at university libraries, and the frequent nature of contact between students and lecturers. Respondents also indicated the internet as a source of information, a finding that corresponds with findings of a related study (Folkerth, 2015) at Colorado Boulder University where many participating students named a valuable source of information as the internet.

Perceived Risks and Benefits of GMOs

Health concerns of GMOs have become the subject of ongoing debates, particularly in the electronic media. Our findings suggest that most university students perceive that the consumption of GMOs could pose multiple dangers to health. This finding was not surprising as a study (Finke & Kim, 2003) which sampled American and Korean university students found that most participants (84.4%) had some concern over risks from GMOs. Similarly, Rzymski & Królczyk (2016) also realized a high degree of skepticism towards GMOs (and GM foods in particular) among survey respondents. Perhaps the above finding could be attributed to a notion identified by earlier literature that though students may have unlimited access to substantive information and education on biotechnology, they often appear to be misinformed by contradictory views and sensationalism (Ransohoff & Ransohoff, 2001) from the media. In comparison, Finke & Kim (2003) realized that Koreans were more concerned about health risks from GMOs than Americans. Furthermore, it was ascertained those individuals who watched their diets and exercised regularly were more likely to be concerned about GMOs. According to Rzymski & Królczyk (2016), the will to gain and improve knowledge, expressed in the form of demand for reliable and accurate information on the risks and safety of GMOs is gradually being realized among populations in several parts of the world. Generally, issues concerning health, cost, environment, and religious beliefs were primarily identified as influencers of public aversion towards GMOs in the present study.

Perhaps the high level of skepticism ascertained (on the acceptance of GMOs) could be also attributed to poor public education on GM technology especially in developing countries (Anunda et al., 2010). In a related study carried out in Turkey, the results indicated that about 86.29% of the sampled students felt the public had not been properly informed about GMOs (Turker et al., 2013). Interestingly, even though many felt strongly about the possibility of GMOs undermining the health of populations, many participants suggested that they inadvertently also felt strongly that the use of GMOs could prove very beneficial to human populations particularly when it did not have to do with consumption. Notably, this was shown where findings revealed the most perceived benefits of GMOs in respect to vaccine and drug production, and improvements to medical procedures. The above finding agrees with the findings of a recent study (Rzymski & Królczyk, 2016), where the authors realized a high level of perceived support for GMO's adoption and beneficial use in drugs and vaccines production or lifesaving medical procedures. Importantly, the authors (Rzymski & Królczyk, 2016) noted that whereas controversies often arise with the consumption of GMO's, it is seldom the case when the conversation solely revolves around the use of GMOs for medical and pharmaceutical advancements. According to Demirci (2008), in health, industry, environment, and agriculture. modern biotechnology has contributed greatly.

The Relationship between Socio-demographics, and Perceived Risks and Benefits of GMOs

In its inception, classical biotechnology invariably emphasized plant protection against disease and harmful insects. However, over the last three decades, biotechnology has seen a shift in focus with much concern geared towards advancements in the areas of health, industry, environment, and agriculture (Demirci, 2008).

Our findings demonstrated the programme of study ($p=0.000$) significantly influenced respondents' beliefs of the benefits and risks of GMOs. It was particularly noted that participants studying programmes with some biotechnology component or biotechnology perceived more benefits with GMOs compared to those with programmes not related to biotechnology. This finding corroborates earlier findings (Finke & Kim, 2003) where it was revealed that increasing knowledge on biotechnological principles often translates into increased support for GMOs. In consonance with earlier findings (Finke & Kim,

2003) our results also revealed that gender significantly influenced risk perceptions involving allergies, increased food prices, incorporation of exogenous genes, and release of genes into the environment. In furtherance, the study ascertained that females perceived more risks with GMOs when compared to their male counterparts. This correlates with other studies which established that females are considerably more likely than men to believe that the risks of GMOs are non-negligible (Moerbeek & Casimir, 2005; Blaine et al., 2002). Burton et al., (2001) also concluded that female shoppers were willing to spend more money to get non-GMO alternatives compared to males. These results indicated that a significant variation exists between men and women regarding their opinions about GMOs. Since our respondents included individuals with similar education levels, the disparity between males and females on perceived risks of GMOs could not be attributed to an ignorance of biotechnology but perhaps due to the role of values and subjective norms. This implies that the gender variable with regards to GMOs and GMFs must be considered in making an informed decision for the public.

Findings also revealed that respondents' perception of risks to development of cancer (p=0.006) and reproductive harm (p=0.012) were significantly influenced by their religion of practice. Perhaps this finding could partly be attributed to the widespread nature of Abrahamic traditions especially in Africa, where popular convictions in Christian and Islamic societies may precipitate the view of GMOs being unnatural, and with the inherent potential of causing harm. Notably, religion also significantly influenced perceived benefits in respect to food security (p=0.003), environmental protection (p=0.044), cosmetic production (0.007), and the cultivation/breeding of new species (p=0.009). However, the rationale behind the influence of religion on these perceived benefits could not be explained. Additionally, age was shown to have a significant effect on participants' perception of the benefits of GMOs particularly to drugs, vaccine production and food security. Well over half (> 50 percent) of respondents aged 21-23 supported the use of GMOs which suggest that reception to innovations by young people is faster compared to the older people and this may explain why respondents in the particular age group supported the use of GMOs in contrast to their older counterparts.

Conclusion
In summary, undergraduate students studying at both the University for Development Studies and the Kwame Nkrumah University of Science and Technology have a high awareness of biotechnology and could be deemed to have basic knowledge of GMOs. Many participants perceived GMO consumption to pose health risks, but overwhelmingly supported the use of genetic modification in medicine and vaccine production. Programme of study, gender, and religion were found to determine participants' perception of GMOs.

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