

Awareness, Knowledge, and Perception of Genetically Modified Foods Among Maize Farmers in Uasin Gishu and Trans-Nzoia Counties, Kenya

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Abstract

Several awareness studies have generally reported that the public is aware of genetically modified foods (GMFs). However, when their knowledge is probed, most studies have indicated that the public tends to fail to demonstrate an understanding of GMFs equivalent to the awareness levels reported. Nevertheless, there is scarce knowledge on the role of information on public knowledge of GMFs. In this study, we administered a semi-structured questionnaire to 298 farmers from Uasin Gishu and Trans-Nzoia counties in Kenya to assess their awareness, test their knowledge, and examine their perception toward GMFs. We then interrogated the farmers' reported sources of GMFs information to determine the nature and quality of information accessible to them and its role in their knowledge and perceptions toward GMFs. Findings indicate that despite 99.3% of the farmers reporting being aware of GMFs, most had inadequate knowledge. Farmers receive unreliable information from sources that warrant misinformation, confusing them about GMFs. This confusion leads to farmers' concerns primarily about the perceived risks of GMFs on human health and the environment. Scientific information about GMF is scarce, giving room for misinformation and increasing farmers' anxiety and scepticism about GMFs. Still, farmers were found to be more optimistic than negative toward GMFs. The study concludes that inadequacy of knowledge is associated with the nature and quality of information farmers receive. We recommend that scientists and other parties involved with GMF rethink their communication strategies to engage the public with reliable and understandable facts about GM technology and foods to allow farmers and the general public to make informed decisions.

Keywords: awareness, GMFs, farmers, genetic modification, perception

DOI: 10.7176/JEP/14-20-02

Publication date: July 31st 2023

1. Introduction

Genetic Modification (GM) technology and the resulting products, such as Genetically Modified Foods (GMFs), have continued to spark much mixed opinions among the public, policymakers, and politicians worldwide. The potential benefits and the perceived adverse effects of GM technology and foods on human health and the environment have been the main areas of contention in these debates. Despite literature indicating that research has not found GMFs to cause any new risks to human health or the environment (cf., Nicolai et al., 2013; Wong and Chan, 2016), GMO opponents continue to loud their campaign against the adoption of the technology insisting that there are serious safety concerns associated with genetic modification of food crops. Nevertheless, there seems to be a lack of scientific facts about GM technology and foods informing public debates. Some blame for this, especially in developing countries, has been apportioned to the scientists involved for not engaging in public scientific discussion about GMFs, warranting public misconception about GM technology and food (cf., Kosgey and Cyrus, 2019). The situation could also pave the way for misinformation and miscommunication by anti-GMO groups. Such groups "lure the public to the most controversial and sometimes immeasurable issues, which appeal to feelings and emotions rather than facts" (Oloo et al., 2020a, p. 698). They are also good at exploring the communication gaps left by scientists to push their agenda to the public (Oloo et al., 2020b).

The mixed opinions about GM technology and foods have rendered the status of GMFs in most parts of the world, Kenya included, unknown. For example, although there has been continued research in Kenya on GM food crops, the government's ban of November 2012, which was introduced following a publication by Seraline et al. (2012) (later retracted) that associated GMOs with cancer, persisted until this study was carried out. Oloo et al. (2020a) partly blame the scientists for not doing a good job convincing the decision-makers at the political level about the safety and attending benefits of GM crops for the people and the economy of developing countries. On the other hand, opinion leaders may also be blamed for misleading the public by talking to them about GMF without having the facts about it. These opinion leaders (who are not scientists), such as religious

leaders, NGOs, and politicians, are said to be successful in formulating their messages about science in a manner that connects with key stakeholders and the public but, at times, contradict scientific consensus (Nisbet and Mooney, 2007). Similarly, Kosgey and Cyrus (2019) observed that leaders and policymakers, without clear information about GM crops, pass on the wrong perception to the public about GM (p. 13951). The impact of this miscommunication may be said to slow the adoption of GM technology while at the same time fueling the mixed public perception/attitude towards GMF.

Knowledge about GM technology positively influences GM adoption (De Steur et al., 2019). However, a situation like the above leaves one wondering about the public awareness and knowledge of GMFs and the kind of information that informs this awareness and knowledge.

Most awareness studies have demonstrated that the public tends to report being aware of GMF but falls short when required to demonstrate this awareness. For example, Karau et al. (2020) reported that although most of the respondents in their study (89.3%) said they were aware of GMOs, they failed to demonstrate this awareness because a significant number of them provided misleading information that they were aware of farmers who grew GM crops such as maize, tomatoes, and bananas in Kenya. A related case was reported by Changwena et al. (2019), who assessed public knowledge and perception of GMFs. They reported that only 38% of their respondents could provide simple, meaningful definitions of GMOs when required despite most of them reporting to be aware. The study concluded that consumers had poor knowledge associated with their level of education and that a lack of understanding of the genetic engineering process was common among them. They recommended improving consumer awareness of GE to empower them to make informed decisions about GMFs. Generally, the public seems to have wrong perceptions about GM crops because of a lack of scientific knowledge about them (Ezezika et al., 2012) and the confusion caused by the negative communication from the anti-GMO campaign.

2. The present study

The only way to make informed decisions about GMOs is by adequately understanding GMOs' potential risks and benefits (Oloo et al., 2020a). It means the scientific facts must be communicated to the public understandably and proactively. However, the literature generally shows that the public has a poor-to-medium level of knowledge of GMF. Most studies have associated awareness and knowledge levels with socioeconomic factors. They also report that this awareness comes from farmers'/consumers' self-reported sources of GMF information. Still, how the nature and quality of information the public receives inform their awareness, knowledge, and perception of GMF remains unknown.

Given the mixed opinions about GM technology and food, the public will likely receive incomplete or rather competing sets of information about GMF, rendering them at a crossroads, not knowing what to believe. It is also important to note that most studies in Kenya have studied consumers primarily in urban areas (very few studies have featured farmers, e.g., Kagai 2011). Thus, in the present study, we conducted a survey with maize farmers (who are both producers and consumers) from Kenya's food basket in terms of maize production to (i) assess their awareness, knowledge, and perception of GMFs, and (ii) determine the role of accessible information on farmers' knowledge and perception of GMF. We did this by first examining their awareness and the sources of this awareness before testing their knowledge of GMF and examining their perception of GMFs. We also interrogated their sources of GMF information to determine the nature and quality of information available to them and its role in their awareness, knowledge, and perception of GMFs.

2.1 Materials and methods

In this study, we report findings from a survey among maize farmers from Kenya's Uasin Gishu and Trans-Nzoia counties regarding their awareness, knowledge, and perception of GMFs. The respondents were drawn from a total of six sub-counties: Moiben, Ziwa, and Soy in Uasin Gishu County and Cherangany, Saboti, and Kwanza in Tans-Nzoia County (Table 1 below). The study involved a total of 298 farmers from these counties.

Table 1. Distribution of sampled maize farmers according to county and sub-counties

County	Sampling unit	Sample size	Percent
Uasin Gishu (141)	Moiben	48	16.1
	Soy	48	16.1
	Ziwa	45	15.1
Trans-Nzoia (157)	Cherangany	61	20.5
	Kwanza	46	15.4
	Saboti	50	16.8
Total		298	100.0

We designed a semi-structured questionnaire to allow the generation of both quantitative and qualitative data from the farmers. First, the questionnaire sought to obtain information about farmers' awareness of GMF

and the sources of this awareness. We specifically asked farmers to indicate whether they were aware of GMF or GMOs and, as a source of their awareness, to state whether they had read or heard about the same. We also included an item allowing farmers to indicate the sources from which they heard or read about GMFs. We also used the questionnaire to probe the farmers' knowledge of GMF by asking the respondents to state what GMF meant to them. The last part of the questionnaire had items that allowed farmers to explain their concerns (if any) about GMF and to comment on their perceptions about GM technology and food on aspects like ethical/moral concerns, benefits, equity issues, and risks.

We recruited and trained four research assistants who helped administer the questionnaire to the farmers. Their roles included explaining the items of the questionnaire in the farmers' local language where required. Before administering the whole questionnaire, we instructed the research assistants to begin by asking whether the respondent was aware of GMF/GMO and if they had heard or read about GMFs. The whole questionnaire was administered only if the respondent reported being aware or having heard or read about GMFs. The respondents were encouraged to be as relaxed and free to provide their opinion because there were no right or wrong answers. The research assistants were given the farmers' list and instructed to approach every Nth farmer depending on the respondents needed from every sub-count. If the farmer in question was unavailable, did not want to volunteer participation in the study, or reported being unaware of GMFs, they were to go for the next farmer on the list.

3. Results

3.1 Farmers' awareness of genetically modified foods

This study assessed maize farmers' awareness of GMFs by asking them to indicate whether they were aware of GM technology/GMOs and if they had read or heard about GMFs. Overall, almost all the farmers (99.3%) reported being aware of GM technology and GMOs. Regarding the source of this awareness, all the 298 farmers involved in the study said they had read or heard information about GMFs. Table 2 below summarises the results of farmers' reports on the awareness of GMFs.

Table 2. Percentage of farmers' awareness of GM technology or GMFs

	N	Percent
Aware of GM technology/GMOs	296	99.3
Not aware of GM technology/GMO	2	7
Read or heard about GM food	298	100

Previous studies have reported on the public's self-reports of awareness and knowledge about GM food/crops (cf., Kimenju et al., 2005; Chengwena et al., 2019; Karau et al., 2020). However, contrary to the results of this study, Kimenju et al. (2005) reported that only 38% of the 604 respondents had heard or read something about GM crops. Similarly, only three respondents out of 19 reported having heard the term "genetic modification" in a study by Lewis et al. (2010). Generally, the public, and the farmers in this study, seem to be aware of GMF through reading or hearing about them.

3.2 Sources of awareness of genetically modified foods

We designed the questionnaire to determine where farmers got information about GMFs (i.e., where they read or heard something about GMFs). The study's results revealed that, overall, media dominated the farmers' sources of information, with 78.2% of the farmers indicating receiving GMF information from the radio, 46% from television, and 40.6% from newspapers (figure 1 below). 33.2% of the farmers said they received GMF information from the internet.

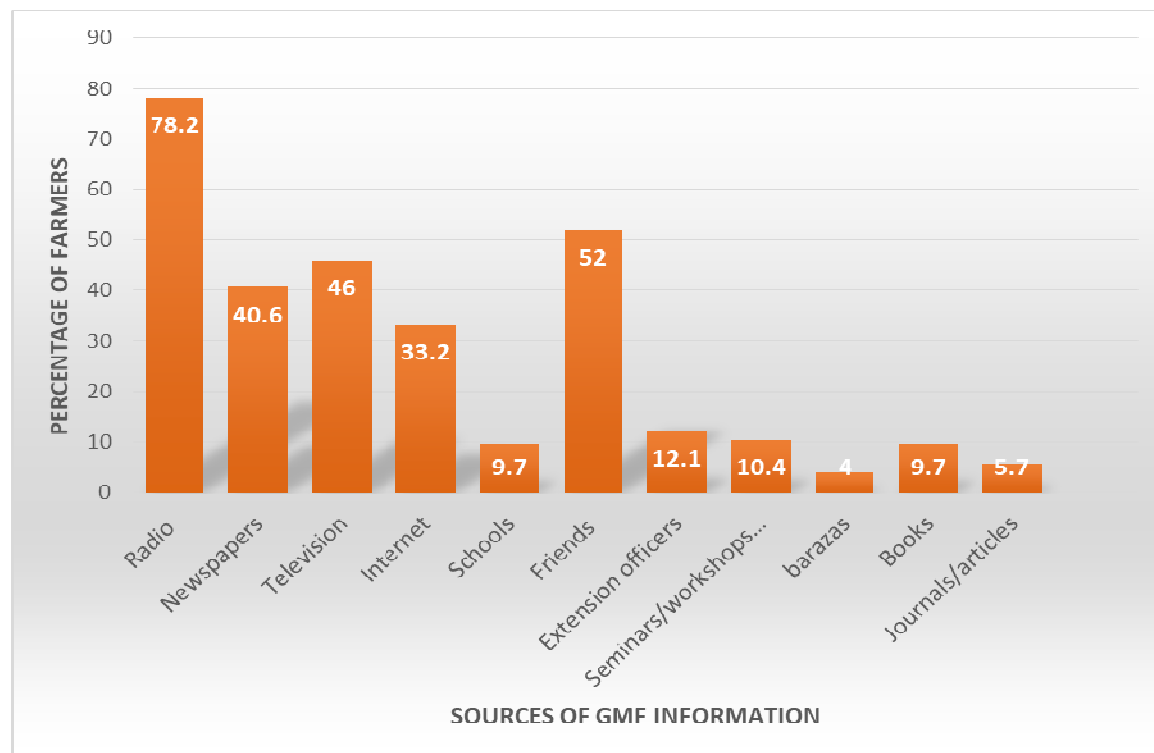


Figure 1. Farmers' sources awareness of genetically modified foods

Generally, the media has been reported to dominate the public's sources of information about GMFs (e.g., Kimenju et al., 2005; Kagai, 2011; Lewis et al., 2010; Karau et al., 2020; Oluwakemi et al., 2020). It is important to note that although media may dominate the farmers' sources of awareness, the reliability of the information in these sources may be questionable because anyone can use media to communicate their opinions about GMFs, including negative and non-scientific information. An excellent example of the unreliability of information from the media is an announcement through a local radio in Uganda by ActionAid-Uganda (a UK-based organisation) that GMOs can cause cancer and infertility (cf. Karembu, 2017). Although the organisation later apologized, stating that their announcement was misleading, the public had already consumed and perhaps acted on the information. Changing the public perceptions that may result from communication like this may sometimes be next to impossible. The same media is known to be used by other anti-GMO campaign groups and opinion leaders such as religious leaders, politicians, and government leaders (who may not necessarily have the facts about GMFs) to reach the public with information about GMFs.

Interestingly, 52% of the farmers indicated that they received GMF information from friends, which casts more doubt on the unreliability of the information they received. We also designed the question to allow the farmers to indicate whether they shared the information they received. The results revealed that 80.2% of the farmers shared the information with others, as summarised in Table 3 below.

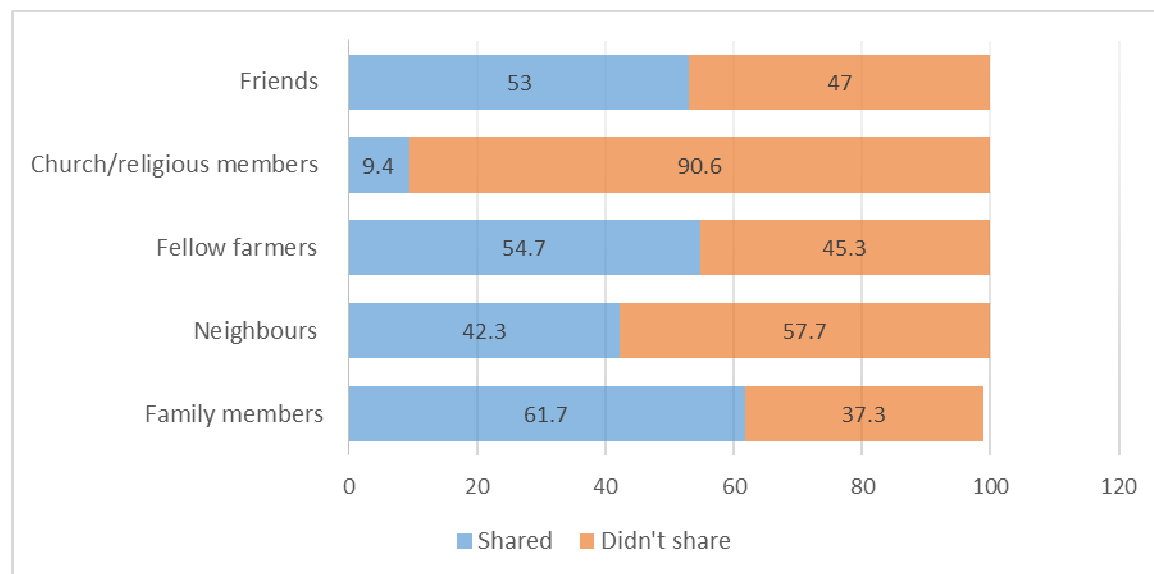


Figure 2. Percentages on the farmers' sharing of GM food information

These results imply that farmers were themselves the sources of GMFs information to other farmers, first by reporting receiving information from friends and sharing the information they received with others, including friends, neighbours, and fellow farmers. It seems evident that using friends as a source of information and farmers' reports of sharing information about GMFs may warrant misinformation/miscommunication about GMFs.

Notably, farmers seemed to receive very little information about GMFs from sources like barazas (4%), extension officers (12.1%), and seminars/workshops/conferences/training (10.4%). These are the sources where the farmers could get reliable (first-hand) information from experts such as scientists, especially in barazas and seminars/workshops/conferences/training. Therefore, farmers received information about GMF more from indirect sources such as the media and friends than direct sources. This situation means interaction between the farmers and the parties involved in GMFs, such as the scientists, may likely be minimum, thus denying farmers an opportunity to clear doubt (if any) over information received.

3.3 Farmers' knowledge of genetically modified foods

After farmers reported being aware of GMF through reading or hearing information from various sources, we probed on their knowledge of GMFs by asking them to explain what GMF meant to them. We realized that farmers gave different definitions focusing on numerous aspects of GM food or GM process. The findings revealed that farmers' definitions were a mixture of correct and incorrect descriptions of GM process and GMFs. These results demonstrate, similar to various previous studies, that there was a mismatch between the farmers' self-reports of awareness of GMFs and their ability to demonstrate an understanding of GMFs.

The study revealed that some definitions from farmers focused on the potential benefits of GMFs, such as increased or improved yields and resistance to pests and diseases. Farmers said that GMFs are crops genetically engineered for better yields by increasing their resistance to diseases and pests. On the other hand, others said GMF requires fewer farm inputs and has increased production (yields). Other farmers focused on the growth of GMFs and stated that GMFs are foods that grow faster than conventional ones, which could also make them dangerous to human health. Farmers seem to believe GMFs are beneficial, but ultimately, they may adversely affect human health.

The study's results further revealed that the perceived risks of GMFs on human health dominated farmers' definitions. Regarding this, some examples of farmers' descriptions of GM food are:

- *GM foods are foods that make people grow abnormally after consuming them.*
- *These are foods that cause cancer and ulcers.*
- *It has some side effects when used on human beings and animals.*
- *Crops that increase production up to double, but they can also affect the human body; they could cause mutations, reduce lifespan, and productivity.*
- *GM food is food that is tasteless and not fit for human consumption.*

The farmers' focus on these perceived adverse effects of GM food on human health could be said to echo misinformation and miscommunication surrounding GMFs. Indeed, studies have reported misinformation about GMF primarily by anti-GMO groups, which could be said to be very strategic in getting their message across to the public. As Oloo et al. (2020a) observed, instead of communicating facts about GMOs, these groups focus on

matters that appeal to the audience's feelings and emotions rather than facts about GMOs. Indeed, the public is drawn to new sources that confirm and reinforce their pre-existing beliefs (Bubela et al., 2019); therefore, if scientific information is insufficient, such groups can easily win the public or intensify their fears through consistent communication.

Some other farmers' definitions were centred on the GM process. Farmers defined GMF based on their perception of the process involved or the composition of the resulting food. Most farmers' perceptions of the GM process seemed negative and could also be deemed incorrect. For example, farmers said:

- *GM foods are Seeds injected with chemicals for the purpose of increasing productivity.*
- *I think it is food that is prepared from the lab by the use of chemicals.*
- *These are food Crops artificially manipulated in the laboratory and which tempers with the ecosystem.*
- *GM foods are foods whose genes are artificial.*
- *These are plants modified from the lab and given to farmers to experiment.*

These definitions mean that farmers may have received information that could be more negative and that could probably be intentionally aimed at making the GM process look dangerous to human health and the environment. It could also mean that farmers cannot tell facts about GMFs from intentionally/unintentionally misleading information that may be easily accessible. For example, it is not uncommon to see, on the internet, a picture of a syringe piercing through, say, an apple, describing what GMOs are. Information like this could have led the farmers in this study to refer to GMF as foods injected with chemicals that could ultimately have adverse effects on human health. This example adds to the unreliability of the information farmers receive, especially from the media and friends, which they also share with others.

The study also revealed that some farmers referred to the ownership of genetic modification technology when defining GMF. For example, these farmers said that *GM food refers to research being tried in Africa by Europeans*. The perceptions of these farmers depicted in their definitions still reflect signs of misinformation about GMFs that GM technology could be a means of exploitation by developed countries on developing countries. They are in line with the argument by Kosgey and Cyrus (2019) that the slow adoption of GM crops could be attributed to the fact that developed countries developed them. African countries may think that developed countries are taking advantage of them (Ezezika et al., 2012; Kosgey and Cyrus, 2019). Connected to this is the observation that African governments are sometimes misinformed that Europe will reject food imports if they start cultivating GM crops (cf., Paarlberg, 2010; Karembu, 2017; Gheysen et al., 2019).

Generally, when defining GMF, farmers based their definitions on several aspects of GMFs and expressed their perception of such aspects. Some farmers' definitions of GMF based on these aspects were correct, while others were incorrect. A theme that dominated most definitions was the benefits GMFs (the idea of increased yields). While this is true regarding GM crops, farmers seem to associate this trait with the possibility of making the food prone to some negative characteristics, hence the likelihood of causing adverse effects on the human body. It became apparent that farmers' reports of awareness about GMF could not be fully reflected in their understanding of the GM process and GMFs. They seemed to exhibit signs of misinformation about GM technology and food, especially regarding its perceived adverse effects on human health. The findings of this study are consistent with several previous studies which reported a mismatch between the public's self-reported awareness of GMFs and their knowledge of the same. For example, Karau et al. (2020) reported that out of 89.3% of respondents who said they were aware of GMOs, only a small portion could correctly explain what GMOs meant, whereas, Changwena et al. (2019) reported that consumers had a poor understanding of GM process and GMF because only 38% of the respondents in their study could give a simple, meaningful definition of GMFs.

This study's findings have revealed that farmers have inadequate knowledge of GMF despite reporting to be aware through reading or hearing information about it from various sources. Indeed, farmers know some aspects of GM technology or foods, but they seem to have incomplete information, or rather, competing sets of information about it. On the one hand, they seem to know the benefits of GM crops (they can increase yield, resist pests and diseases, and tolerate droughts). On the other hand, they seem to strongly believe that, ultimately, this food could destroy human health or the environment. This shows that farmers had a poor understanding of GM technology and food and that it can be associated with the information they received about GMFs.

3.4 Farmers' concerns about genetically modified foods

It seems evident that the information farmers received was unreliable and incomplete. It could have contributed to their inadequate knowledge about GMFs and fueled their scepticism and fears about GMF. Farmers' definitions discussed above show that there could be a lot of issues regarding GMFs that are unclear to the farmers and probably make them more confused about GMFs. We asked farmers if they had any concerns about GMF. As summarised in Figure 2 below, the results revealed that 61.7% of the farmers indicated having concerns about GMF, whereas 34.9% said they had none, and 3.4% gave no response.

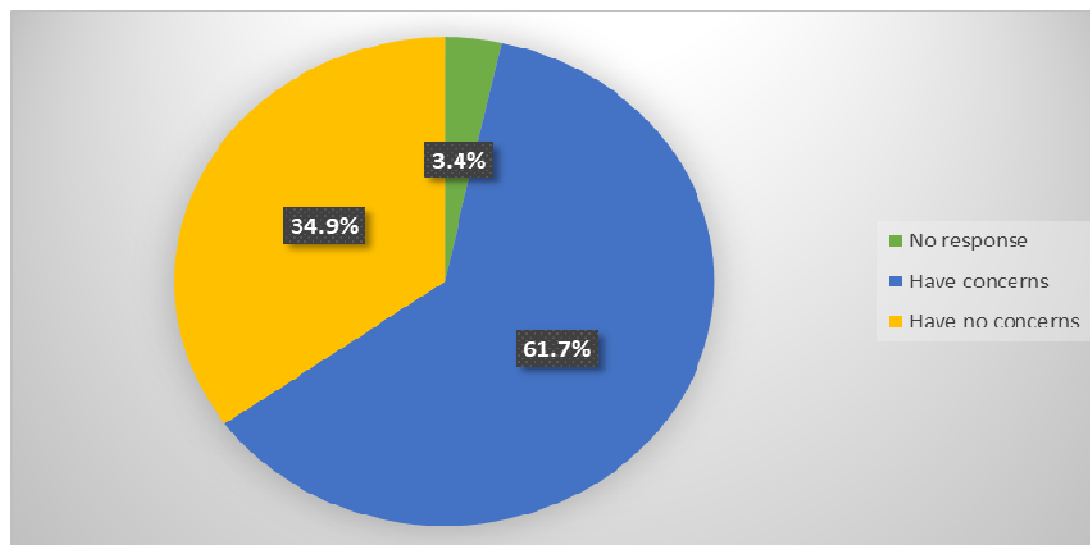


Figure 2. Percentages of farmers concerned about genetically modified foods

It became apparent from the results of this study that farmers identified several concerns about GMF, which we grouped under various common themes. Farmers said their concerns were on the real meaning of GMF; the availability of GM products; benefits of the technology to farmers; perceived health and environmental risks; the food's quality compared with the conventional ones, and whether chemicals are used in genetic modification. Table 3 summarises some of the farmers' shared concerns about GM food.

Table 3. Examples of common farmers' concerns about GM food

The risks on human health –which we have heard but not proven. No information about the risks and the chemicals used.

From hearsay, it grows faster, and it can harm people. This is our reasoning, but no one knows whether it is true. They have rumours that it is the main cause of cancer in our societies.

We want to see it practically. We want to know partners. They should open branches so that we can visit them.

I want to have knowledge of how to grow these crops and their productivity compared with other crops.

Why is it not implemented in our countries? Do its disadvantages outweigh the advantages?

Farmers clarified that most of their concerns came from issues they picked from information communicated to them, primarily through hearsay or rumours. Farmers said they could not ascertain the reliability of these issues and that they had not received help from people they believe have the complete and reliable information, such as scientists. This cements our argument that the farmers' inadequate knowledge of GMF could result from the information farmers received; indeed, this information seems to confuse them more about GMFs. Similar to this study, several previous studies reported on public concerns about GMF (for example, Kimenju et al., 2005; Kagai, 2011; Mbugua-Gitonga et al., 2016; Oladipo et al., 2020), most of which were based on perceived health risks and environmental risks of GM technology and food. Mbugua-Gitonga et al. (2016) associated the public's concerns with inadequate awareness, ignorance, misinformation on biotechnology, and inadequate scientific knowledge. The results of this study have demonstrated that farmers' concerns could be fueled by the unreliability of the information they received about GM technology and food.

Generally, farmers' concerns about GM food were also hinted at in our previous discussion regarding farmers' knowledge of GMFs. The concerns seem to reflect issues that farmers raise in their definitions and, thus, reaffirm our arguments that farmers have inadequate knowledge of GMFs, which can be associated with the information they receive about GMFs. For example, when explaining their concerns, farmers used phrases like "there are rumours..." "from hearsay...." and "no one knows if it is true...." which could speak to the unreliability of the information farmers received and their reason for having concerns and inadequate knowledge of GMFs. Evidently, the lack of precise and reliable information about GM food, primarily on the potential benefits and risks, seems to be at the root of most farmers' concerns. For example, farmers questioned whether the disadvantages outweigh the advantages of GM food to make GMF not adopted in the country. This concern speaks to the nature and the quality of information farmers receive, plus the confusion it causes.

3.5 Farmers' perception of genetically modified foods

Table 4. Farmers' perceptions of genetically modified technology and food

Aspect	Statement	Agree	Disagree	Don't know
Benefits	GM can reduce pesticides in food	69.5	17.1	13.4
	GM technology increases productivity and offers a solution to the world's food problem	90.3	6	3.7
	GM can create foods with enhanced nutritional value	69.1	18.1	12.8
	GM has the potential to reduce pesticide residues in the environment	69.1	16.4	14.1
Risks	People could suffer allergic reactions after consuming GM foods	42.6	37.6	19.8
	Consuming GM foods can damage one's health	45.3	40.6	14.1
	Consuming GM foods might lead to an increase in antibiotic-resistant diseases	36.9	37.9	25.2
	GM foods contain many dangerous chemicals	33.2	54.4	18.1
Ethical issues	GM can lead to a loss of original plant varieties	42.3	48.3	9.4
	GM is tampering with nature	39.3	50.3	10.4
	GM technology makers are playing God	17.4	71.8	10.7
	GM food is artificial	62.4	32.9	4.7
Equity issues	GM products are being forced on developing countries by developed countries	25.2	69.5	5
	GM products only benefit multinationals making them	20.5	70.8	8.7
	GM products don't benefit small-scale farmers	19.1	76.8	4

We also designed the questionnaires to examine farmers' perceptions of GMFs by testing their judgments of various statements regarding GMFs. These statements described GM technology or food based on several issues, including the potential benefits, perceived adverse effects on human health and the environment, ethical/moral issues, and equity issues. We asked farmers to indicate how they felt about such statements by saying whether they agreed, disagreed, or didn't know about each statement's description. The study's results for this are summarised in Table 4 above.

The analysis of the results revealed that farmers were more optimistic about GMF than negative, yet they also expressed mixed feelings on some aspects. It became clear that most farmers agreed with statements about the benefits of GM technology and food. They felt genetic modification could reduce pesticides in food (69.5%) and the environment (69.1%). They also believed that it could increase productivity, offer a solution to food problems (90.3%), and create food with increased nutritional value (69.1%).

On the contrary, farmers had mixed feelings about the potential adverse effect of GM technology and food. While 45.3% of the farmer felt that consuming GMF could damage one's health, 40.6% felt that might not be the case, and 14.1% said they didn't know. They also did not think that consuming GMF has immediate negative effects (69.1%) or could destroy human genes (47.3%). However, they were divided on whether consuming GMF could lead to an increase in antibiotic-resistant diseases; 36.9% felt it could, 37.9% felt it could not, and 25.2% said they did not know.

Regarding the ethical/moral issues, farmers expressed concerns but were more positive than negative toward GM technology and food. For example, more than half (55% and 50.3%) of the farmers did not feel that GM food is either threatening the environment or tampering with nature, respectively. Most farmers (71.8%) did not think GM technology makers were playing God, although 62.4% felt that GM foods are artificial, 32.9% felt it is not, and 4.7% said they did not know. In contrast, farmers were almost divided on their perception of the potential of insect-resistant GM crops causing the death of untargeted insects, in that 47.7% and 34.6% agreed and disagreed, respectively. 48.3% of the farmers felt that GM crops could not lead to the death of original plant varieties, whereas 42.3% thought they could.

Concerning equity issues, 69.5% and 70.8% of the farmers did not feel that genetically modified products were being forced on developing countries by developed countries or would benefit only the multinationals making them. Indeed, 76.8% of farmers felt that the technology could help small-scale farmers. These findings contradict observations made by previous studies (e.g., Kosgey and Cyrus, 2019) that developing countries might be hesitant to embrace GM technology because it was developed in developed countries. Farmers in this study demonstrated a belief that GM technology and food could benefit small-scale and large-scale farmers and

that there might not be problems with who owns the technology.

Generally, although the findings of this study have demonstrated that farmers have inadequate knowledge associated with the information they received, farmers demonstrated a more positive perception of GMFs. Farmers seemed to focus on the benefits rather than the perceived adverse effects of GM technology and food. It seems plausible to argue that farmers' mixed feelings on some of the abovementioned issues mean farmers struggle with unreliable and perhaps incomplete information about GMFs. It could also be argued that more precise communication from reliable sources, which farmers could trust, would make them more positive. These results resonate with our earlier discussion on the farmers' knowledge and concerns about GMF in that farmers seem to lack a clear understanding of GM technology and foods. Altogether, these findings call for more communication on the potential benefits and risks of adopting GM technology and food, especially from reliable sources such as scientists. Farmers need thorough and clear communication about what the GM process entails for them to make informed decisions.

Several previous studies have reported mixed public perceptions of GM crops/food. For example, Lewis et al. (2020) and Nyindodi et al. (2017) reported that participants in their studies were more receptive to the potential use of GM crops. On the contrary, Karau et al. (2020) reported that 54.6% of the respondents were pessimistic about GM products and presumed that GMOs have adverse or harmful effects on human health, whereas 68.8% presumed that GMOs would reduce indigenous crops. Similarly, Deffor (2014) reported the participants' negative attitudes and low intentions to consume GM food. Of interest to note is the fact that contrary to this study, where we associate the perception of the farmers with the information they received, other studies associate public perception with socioeconomic factors. Therefore, despite the farmers' inadequate knowledge and concerns about GMFs, they were more optimistic about GMFs, perhaps because of the potential benefits they had heard or read about GM technology and food.

4. Discussion

4.1 Farmers' inadequate knowledge of GMFs is associated with the information they access

Matters of public awareness, knowledge, and perception of GM technology and foods have been a concern for many researchers in recent years, and their findings are essential in determining the acceptability of the technology and foods. Evidence from the literature shows that the more aware and knowledgeable the public members are, the more likely they are to be more receptive to GM technology and food. For example, Changwena et al. (2019) reported that consumers with increased knowledge of genetic engineering were more receptive to GMFs in their diets. Deffor (2014) calls for promoting awareness and knowledge, pointing to its necessity in the acceptability of GM technology and foods. The present study's findings have shown, similar to several previous studies, that although almost all the farmers in this study (295 out of 298) reported being aware of GMFs, they could not back this awareness when asked to define them GMF. Farmers' definitions of GMF were a mixture of correct and incorrect definitions and focused on some aspects of GM technology and foods, such as benefits, perceived risks, and ownership. These definitions signal that farmers had unreliable and incomplete information or were misinformed about GMF. These findings show that the information farmers received about GMF might not have helped them understand GM food clearly. Indeed, when reporting their concerns about GMFs, farmers mentioned that they rely on hearsay and rumours, which could help explain their inadequate knowledge expressed by their definitions. Besides, farmers' sources of information seemed to warrant possibilities of misinformation since they reported receiving information from friends (52%) and, at the same time, sharing the same information with others. Equally important to note is that very few farmers reported receiving information from sources that could involve direct interaction between farmers and experts involved with GMF, such as scientists. Findings like these could imply that the reliable sources of GMF information, such as scientists and other parties involved, have not done enough to engage the farmers in issues related to GMFs. Scientists may be using the media to communicate with the farmers and the general public. Still, this study found that there is very little regarding scientists directly engaging with the farmers, for example, through barazas and seminars/workshops/training. This situation may have denied farmers first-hand information and an opportunity to have scientists respond to some of their questions, increasing their concerns and scepticism about GMFs.

Previous studies associate the public's poor knowledge of GMF with socioeconomic factors. Conversely, we argue that the inadequate level of farmers' knowledge about GMF demonstrated by the findings of this study could be the function of the nature and quality of information available to them. Farmers seemed to have received unreliable and incomplete information from various sources, some of which could allow misinformation and miscommunication. This situation may contribute to the non-scientific debate about GM food crops among the various members of the public in Kenya, casting more doubts on GMFs.

4.2 Farmers are concerned but optimistic about genetically modified foods

The findings of this study have demonstrated that farmers had concerns about GM food, especially about the perceived risks of GM food on human health and the environment, as well as the availability of GM products

such as seeds. These findings are consistent with those of previous studies (for example, Kimenju et al., 2005; Kagai, 2011; Oladipo et al., 2020), which reported the public is concerned about GM, especially concerning the potential health and environmental risks. The exciting finding regarding farmers' concerns is the country's hesitation to adopt GM technology and food. Farmers questioned if GM food was as good as they had heard; why was the government against its adoption? They thought there was something that the government knew that they did not. This concern may have also contributed to farmers' mixed feelings regarding the perception of some aspects of GMF, as earlier discussed.

We reiterate that the information farmers received was unreliable and thus exacerbated their concerns. This situation was perhaps partly contributed by the lack of direct scientists-farmers interaction, which may have warranted miscommunication and misinformation from unreliable sources. It should also be noted that farmers' concerns and scepticism might also be fueled by the fact that the government and scientists are speaking different languages about GM technology and food.

Nevertheless, it is important to note, as Zhang et al. (2016) remind us in their conclusion of a critical review on the promise and problems of GMF, that many of the concerns about the risks of GM crops are speculative yet scientifically plausible. They also noted that such concerns are offered in good faith; therefore, turning our backs on them in a euphoria of immediate advantage is equally unscientific. However, the authors observe that the immediate advantages of GMF are too "tangible" to ignore or set aside out of fear of the unknown and unintended disadvantages (p. 122). This observation means, therefore, that the public could benefit from clear and proactive communication regarding GMF and the process that leads to it. Any gaps in the communication of scientific facts about GMF may intensify the public's concerns. Scientists should strive to understand what the public knows, their questions, and their fears regarding GMF to ensure that their communication initiatives address these.

Interestingly, the findings further revealed that despite the farmers' concerns, they were more optimistic (63.1%, 188 out of 298 farmers) than negative (36.2%) about GMF, perhaps because they tended to consider the positive things they heard about GMF more than the negative ones. Similar findings were reported by Lewis et al. (2010), who observed a tendency of farmers in their study to focus on the benefits rather than the long-term health effects. These findings imply that proper communication of GMF information from credible sources could help enhance public awareness and knowledge of GMF, allowing them to make more informed decisions about GM technology and food. Although previous studies associated the public perception of GM food/crops with socio-demographic factors (e.g., Anunda et al., 2010; Nyindodi et al., 2017; Deffor, 2014; Changwena et al., 2019), this study found that farmers' perception of GMFs could be associated with the GMF information they received. Suppose farmers get reliable, complete, and understandable information regarding the benefits and the potential risks of adopting GM technology and foods. In that case, they will likely be more knowledgeable and receptive to GM technology and foods.

5. Conclusion

This study has demonstrated evidence for the importance of adequate and reliable information on farmers' awareness, knowledge, and perceptions of GMFs. It has shown that although farmers reported being aware of GM food, they seemed to lack a proper understanding of GM processes and GMF, therefore, had inadequate knowledge of GMF. Farmers gave a mixture of incorrect and correct meanings when defining GMF. The meanings expressed by farmers' definitions seemed to echo the messages of some anti-GMO campaigns that focus on GMF's perceived adverse effects on human health and the environment while ignoring the advantages. Still, farmers were more optimistic than negative about GMFs. Farmers' inadequate knowledge of GM technology and food could have resulted from the nature and quality of information they received about GM food. Thus, we recommend scientists re-strategise to reach farmers with scientific facts about GMFs and help improve their awareness and knowledge. Farmers need complete, reliable, and understandable information (from trustworthy sources) to understand the GM process and the resulting GMFs to make the right decisions when required. Scientists rethinking communication strategies should include communication approaches that allow for more direct interaction with farmers, such as barazas, seminars/workshops, and even visiting farmers in the fields. Direct interaction would help farmers vent their concerns and fears and get much-needed expert clarification and facts.

References

- Anunda, H., Njoka, F., & Shauri, H. (2010). Assessment of Kenyan public perception on genetic engineering of food crops and their products. *Journal of Applied Biosciences*, 33: 2027 – 2036.
- Changwena, D. T., Sithole, B., Masendu, R., Chikwasha, V., & Maponga, C. C. (2019) Knowledge, Attitudes and Perceptions Towards Genetically Modified Foods in Zimbabwe. *African Journal of Food, Agriculture, Nutrition and development*, 19(3). DOI:10.18697/ajfand.85.17140
- Deffor, E. W. (2014). Consumer Acceptance of Genetically Modified Foods in the Greater Accra Region of

- Ghana. *Journal of Biosafety and Health Education*, 2. <http://dx.doi.org/10.4172/2332-0893.1000116>
- De Steur, H., Van Loo, E., Maes, J., Gheysen, G. & Verbeke, W. (2019). Farmers' willingness to adopt late blight-resistant genetically modified potatoes. *Agronomy*, 9(280). Doi:10.3390/agronomy9060280
- Ezezika O.C., Daar A.S., Barber K., Mabeya J., Thomas F., Deadman J., Wang D. & Singer, P.A. (2012). Factors influencing agbiotech adoption and development in Sub-Saharan Africa. *Nature Biotechnology*, 30: 38-40.
- Gheysen, G., Maes, J., Valcke, M., Sanoe, E. I. R., Speelman, S., & Heijde, M. (2019). Well informed farmers and consumers are positive about gm crops in Europe and Africa. *Afrika Focus*, 32(2): 49-56.
- Kagai, K. K. (2011). Assessment of Public Perception, Awareness and Knowledge on Genetically Engineered Food Crops and their Products in Trans-Nzoia County, Kenya. *Journal of Developments in Sustainable Agriculture*, 6: 164-180.
- Karau, M. G., Koech, L. C., & Muugendi, J. J. (2020). Public Knowledge, attitude and perception on safety of genetically modified products: A case study of Kiambu county in Kenya. *IOSR Journal of biotechnology and biochemistry*, 6(6):15-22. Doi: 10.9790/264X-0606021522.
- Karembu, M (2017). How European-Based NGOs Block Crop Biotechnology Adoption in Africa. geneticliteracyproject.org/wp-content/uploads/2017/03/Karembu_edits_v5.pdf
- 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.
- Kimenju, S.C., & De Groote, H. (2008). Consumers' willingness to pay for genetically modified food in Kenya. *Agricultural Economics*, 38: 35-46.
- Kosgey, Z., & Cyrus, K. (2019). Potential Uses, Perceptions and Policy Issues of Genetically Modified Crops in Africa: A Case Study of Kenya. *African journal of food, agriculture, nutrition and development*, 19(1): 13946-13958. DOI: 10.18697/ajfand.84.BLFB1029.
- Lewis, C. P., Newell, J. N., Herron, C. M., & Nawabu, H. (2010). Tanzanian farmers' knowledge and attitude to GM technology and the potential use of GM crops to provide improved levels of food security. A qualitative study. *BMC public health*, 10(407).
- Nisbet, M.C. & Mooney, C. (2007). *Science*, 316(56).
- Nicolia, A., Manzo, A., Veronesi, F. & Rosellini, D. (2013). An overview of the last 10 years of genetically engineered crop safety research. *Crit. Rev. Biotechnol.* 8551, 1-12. Doi:10.3109/07388551.2013.823595
- Nyinondi, P. S., Dulle, F. W., & Nawe, J. (2017). Perception of agricultural biotechnology among farmers, journalists and scientists in Tanzania. *University of Dar es Salaam library journal*, 2005: 106-120.
- Oladipo, O., Ibrahim, R., Adeboye, S., & Kuiper, H. (2020). Readiness of the Nigerian public for the introduction of genetically modified crops into the food market. *African Journal of Biotechnology*, 19(7): 426-438. DOI: 10.5897/AJB2020.17136.
- Oloo, B., Maredia, K., & Mbabazi, R. (2020). Advancing adoption of genetically modified crops as food and feed in Africa: The case of Kenya. *Africa Journal of Biotechnology*, 19(10): 694-701. DOI: 10.5897/AJB2020.17159.
- Oloo, B., Maredia, K., & Mbabazi, R. (2020b). Earning trust and building credibility with a new paradigm for effective scientific risk-benefit communication of biotechnology innovations. *Africa Journal of Biotechnology*, 19(10): 694-701. DOI: 10.5897/AJB2020.17158.
- Paarlberg, R. (2010). GMO foods and crops: Africa's choice. *New Biotechnology*, 27(5): 609-613.
- Wong, A. & Chan, A. (2016). Genetically modified foods in China and the United States: A primer of regulation and intellectual property protection. *Food science and human wellness*, 5: 120-140. Doi: 10.1016/j.fshw.2016.03.002.
- Zhang, C., Wohlhueter, R. & Zhang, H. (2016). Genetically modified foods: A critical review of their promise and problems. *Food science and human wellness*, 5(3), 116-123.