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Public perceptions and information sources on genetically modified organisms in Kenya

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Abstract

Public attitudes toward genetically modified organisms (GMOs) in Kenya remain mixed due to limited knowledge, policy gaps, and cultural factors. Despite the 2020 commercialisation of Bt cotton, perceptions of GM technologies are largely unfavourable. This study surveyed 416 respondents across 14 counties to assess awareness and knowledge levels of GMOs. Results showed 49% support GMOs, 27% are uncertain, and 24% oppose them. Misconceptions persist, with 49.3% citing size and 22.4% recognising labelling as a means of identifying GMOs. Awareness of GMO commercialisation was low (24%), though nearly half correctly identified Bt cotton as an approved GMO, and 32.7% unaware of any institution carrying out GM research. Education significantly influenced acceptance ($\chi^2 = 68.322$, $p < 0.001$). Radio was the most trusted information source (29.3%), and scientists were the most credible (46.4%). The findings underscore the need for targeted public communication strategies to address misinformation and enhance understanding of biosafety and biotechnology in Kenya.

1 · Introduction

Agricultural biotechnology and genetically modified (GM) crops have been around for over three decades, promoted as having the potential to address biodiversity loss, climate change, and food and nutritional security [Aerni, 2005; Verma & Saxena, 2021; Ajibade et al., 2025; Koch et al., 2025]. The GM crop traits under commercial cultivation include insect resistance, herbicide tolerance, disease resistance, stacked traits, and output traits such as drought tolerance, improved shelf life, and nutritional enhancement [AgbioInvestor, 2025; Verma & Saxena, 2021]. Insect resistance and herbicide-tolerant crops have played crucial roles in minimising agricultural impact by promoting sustainable farming practices. Studies have shown that GM insect resistance technology has significantly reduced insecticide usage against targeted pests. This is especially true in cotton, which has a history of heavy reliance on pesticides in controlling agriculturally important pests such as the bollworms. Farmers have also embraced no tillage, drastically reducing fossil fuel burning, allowing the retention of carbon in the soils thanks to GM technology [Brookes & Barfoot, 2015, 2020; Brookes, 2022]. Health benefits also include fewer pesticides in food and improved nutritional value of foods [Morris et al., 2008]. In agronomy, the outcome is increased yields while utilising the same amount of input and effort as traditional seeds [Rastogi Verma, 2013].

In 2024, the global area under GM crops increased significantly to reach 209.8 million hectares, where 28 countries cultivated 10 different crops, with GM soybean being the leading crop. Other crops include maize, cotton, canola, alfalfa, sugar beet, sugarcane, wheat, and brinjals [AgbioInvestor, 2025]. Despite this growth, some countries have revised their decision on commercialisation, including maize in Egypt, cotton in Burkina Faso, and most recently, rice in the Philippines [Gakpo, 2019, 2020; Komen et al., 2020; AgbioInvestor, 2025]. Africa has over twenty years of experience with GMOs, where four crops, cotton, maize, soybean, and cowpea, are already approved for cultivation in different countries, which include South Africa, Nigeria, Ethiopia, Sudan, Malawi, Eswatini, Kenya, and Ghana [ISAAA, 2020; Turnbull et al., 2021; Gbashi et al., 2021].

In Kenya, a law was enacted in 2009, paving the way for a stringent regulatory framework to guide both research and commercial activities of GMOs ['The Biosafety Act No. 2', 2009]. GM research has transitioned from the developmental phase under containment to open cultivation following the approval of GM cotton in 2020 [ISAAA, 2020]. The transgenic crop is currently being cultivated in several Counties spread out through six regions in Kenya, which include the Western, Nyanza, Coast, Eastern, Central, and Rift Valley [Obukosia et al., 2022]. Insect-resistant maize was also approved for commercialisation in 2022, but the ongoing court cases challenging the use of GMOs have halted the rollout to the farmers. Other than maize, virus-resistant cassava improved for resistance to the cassava brown streak disease (CBSD) received biosafety approval for performance evaluation in 2021 [Biosafety Clearing-House Kenya, 2025]. The GM cassava has been evaluated for varietal release, and eight varieties have been approved for release to the farmers pending the determination of the court cases.

Despite the benefits claimed, GMOs have faced considerable opposition, citing concerns over human and animal health impacts, thus slowing down their adoption [Brookes & Barfoot, 2017; Gbadegesin et al., 2022; Mmbando, 2024]. Developing countries, such as Zimbabwe, Zambia, Mozambique, and Malawi, rejected GM food aid from USAID and the World Food Programme, citing health concerns, despite experiencing severe food security problems at

the time [Moola & Munnik, 2007]. Environmental risks such as gene flow, the evolution of resistance in the targeted pest populations, impacts on non-target organisms, and food safety are often raised [Carrière et al., 2021]. GMOs are also criticised as being unfamiliar, ungodly, and unnatural [Costa-Font & Gil, 2012; Pino et al., 2016; Cabelkova, 2024; Kunyanga et al., 2024]. Public perceptions of GMOs have been reported to significantly influence debates and policies adopted by governments [Goyal & Gurtoo, 2011]. In developing countries, the outcomes of the respective domestic policies are increasingly affecting international ethical and legal disputes on the use of modern biotechnology in agriculture [Mmbando, 2023; Mustafa et al., 2023]. Studies have been conducted in Kenya, Uganda, Ghana, Zimbabwe, and Nigeria to review the perceptions of the public regarding GMOs [Dexter et al., 2019; Egbe et al., 2019; Ampadu-Ameyaw et al., 2021; Mustafa et al., 2023; Kunyanga et al., 2024].

The sustained resistance towards GMOs, especially in Africa, can be attributed to a lack of awareness, misinformation, limited knowledge of the applications of these technologies, and, to an extent, individual level of education [Gbashi et al., 2021; Munisi, 2020]. The adoption of GMOs has also been negatively affected by public opinion and anti-GM lobby groups in developing countries [Kavhiza et al., 2022]. In Kenya, where GM technology can provide food and nutritional security, increased agricultural output, and decreased reliance on chemical pesticides, public attitudes towards GM technology are vital for well-founded decision-making [Kunyanga et al., 2023]. To address this gap, this study was commissioned to gather information on the level of awareness and willingness to adopt and use GM technologies. The results contribute valuable recommendations for developing appropriate communication strategies and public engagement initiatives by examining public knowledge, support, and concerns towards GMOs. Additionally, the findings will help regulatory bodies develop policies that reflect public concerns while promoting scientifically sound biotechnology solutions that address agricultural challenges.

2 ▪ Methodology

This study was grounded in Risk Perception Theory [Slovic, 1987] and Diffusion of Innovation Theory [Rogers, 2003]. Risk Perception Theory emphasises how individuals assess GMO-related risks based on emotions, trust, and beliefs rather than scientific data, while Diffusion of Innovation Theory explains how perceptions of complexity, compatibility, and relative advantage influence the adoption of new technologies. These theories framed both the survey design and the interpretation of results, allowing the analysis of how trust in information sources, personal values, and perceived benefits shape public attitudes toward GMOs.

A cross-sectional survey design was employed to capture perceptions, knowledge, and attitudes toward GMOs at a single point in time [Creswell & Creswell, 2018]. This design was chosen for its suitability in exploring diverse opinions from a wide sample and for enabling statistical comparisons across socio-demographic groups. The survey covered 14 counties across six regions of Kenya: Nairobi, Makueni, Homabay, Uasin Gishu, Mombasa, Kwale, Elgeyo Marakwet, Busia, Kisumu, Trans Nzoia, Embu, Kirinyaga, Kajiado, and Kiambu. Counties were purposively selected from Kenya's principal geographical regions, which included Central, Eastern, Rift Valley, Western, Nyanza, Coast, and Nairobi, to ensure representation of both urban and rural settings as well as socioeconomic diversity. The selection process considered agricultural significance, exposure to biotechnology initiatives,

and involvement in previous awareness campaigns, thereby assuring a comprehensive inclusion of varied contexts pertinent to GMO-related discussions.

Secondly, within each county, clusters were defined, and simple random sampling was used to select respondents. The sample size justification was based on Yamane's formula [1967] for finite populations, assuming a 95% confidence level and a 5% margin of error. The target of 30 respondents per county was adopted to ensure minimum representation, though it is acknowledged that in some counties the numbers fell slightly below this, which may affect the robustness of county-level comparisons. Data was collected using a structured questionnaire consisting of three sections: demographic information, knowledge and awareness of GMOs, attitudes, beliefs, and perceptions questions. The questionnaire items were adapted from previous validated studies on GMO perceptions in Africa from Egbe et al. [2019], Ampadu-Ameyaw et al. [2021] and Mustafa et al. [2023], then modified for the Kenyan context.

To ensure validity, the tool was pretested with 20 respondents from Kiambu County during the piloting phase. Adjustments were made to the wording, sequencing, and clarity of the questions based on the feedback. The final instrument was then administered for quantitative interviews by enumerators with prior experience in household surveys and who were residents of or familiar with the counties where they worked, which improved rapport with respondents and minimised misinterpretation. The survey was conducted between July and September 2023. Before fieldwork, enumerators received training on ethical considerations, interview techniques, and survey protocols.

Data was coded and entered into Genstat 21st Edition and analysed using STATA [2013]. For descriptive statistics, the frequencies, percentages, medians, and interquartile ranges (IQR) were used to summarise demographic and perception data. For inferential statistics, Chi-square tests were used to examine associations between categorical variables, like education level and GMO support. Additionally, Likert scale coding was utilised where perceptions were rated on a 5-point scale (1 = Strongly Oppose to 5 = Strongly Support). The analysed results were presented using data tables and bar graphs for clarity.

3 ▪ Results

3.1 ▪ *General characteristics of respondents*

A total of 420 questionnaires were administered, out of which 416 were valid for analysis, representing a high response rate of 99.04% (Table 1). Respondents were drawn from diverse educational and occupational backgrounds, allowing for a broader representation of perceptions.

The respondents' ratio was 55% males and 45% females, with the majority (41.3%) falling between the ages of 19 to 54 years, and a few (1.7%) were above 65 years. The sampled population was generally literate (87.8%), where the participants had post-secondary education, while only 3.8% had no formal education, as depicted in Figure 1. With regards to their employment status, 174 respondents (41.8%) reported being in formal employment, 31.7% were working in the informal sectors, 9.4% were university students, and 17.1% were unemployed (Figure 2).

Table 1. Respondents' distribution by county.

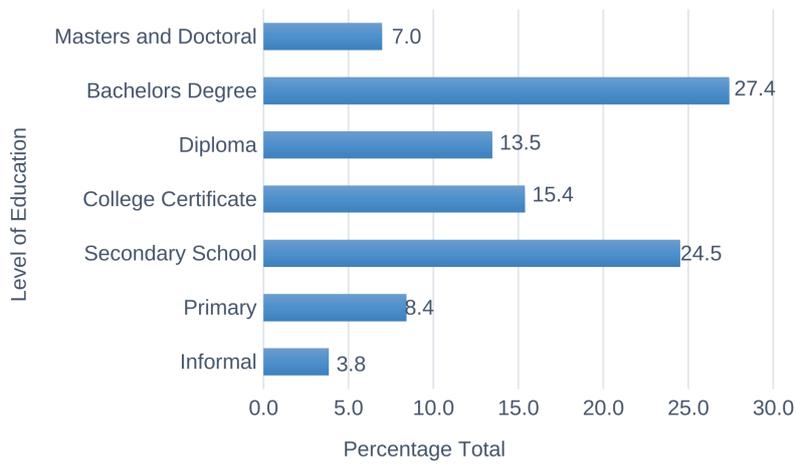| County	Frequency	Percentage frequency
Nairobi	46	11.1
Makueni	35	8.4
Homa Bay	35	8.4
Uasin Gishu	32	7.7
Mombasa	31	7.5
Kwale	31	7.5
Elgeyo Marakwet	30	7.2
Busia	30	7.2
Kisumu	30	7.2
Trans-Nzoia	29	7
Embu	29	7
Kirinyaga	23	5.5
Kajiado	19	4.6
Kiambu	16	3.8
Total	*416*	*100*

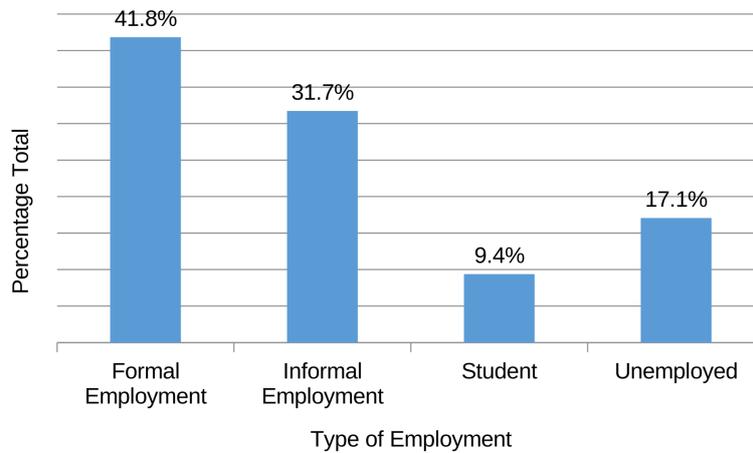**Figure 1.** Respondents' level of education.

Figure 2. Respondents' distribution by occupation.

Table 2. Ways of identifying a GMO.

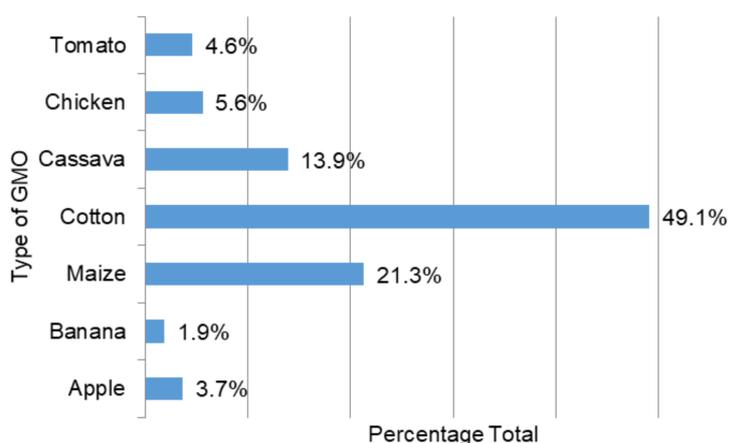| Ways of identifying a GMO	Frequency	Percentage frequency
Size	66	49.3
Labeling	30	22.4
Weight	14	10.4
Texture	11	8.2
Scent	2	1.5
Others	11	8.2
Total	*134*	*100.0*

Figure 3. Level of knowledge on GMOs commercialised in Kenya.

3.2 ▪ *Knowledge and awareness of GMOs*

A significant majority (78.3%) of those surveyed reported having heard of GMOs, compared to 18% who did not and 3.6% who were unsure. To evaluate the respondents' knowledge of Kenya's GMO labelling requirements and their effectiveness, the study sought to understand whether the respondents had a way of identifying a GMO. 49.3% of the respondents reported that they could identify a GMO by size, and only 22.4% could do so through labelling (Table 2). The study also aimed to assess participants' awareness of any GMOs already commercialised in the country. This was intended to evaluate whether the target population could correctly identify GMOs and their specific characteristics. The findings would help to assess the accuracy of information currently available and inform strategies to address misinformation and misconceptions regarding GMOs. Only 24% were aware, out of which 49.1% identified cotton and 21.3% maize (Figure 3). Cassava, which is awaiting varietal release, was also identified (13.9%) as having been approved for commercial release. Other respondents indicated that chicken (5.6%), tomato (4.6%), apple (3.7%), and banana (1%) were also approved for commercialisation.

Knowledge of the agency involved in regulating GMOs was also tested. Most of the participants (58.9%) accurately identified the National Biosafety Authority as the regulator. The research team further set out to understand the level of awareness among the diverse respondents on the research institutions carrying out GMO research in Kenya. The survey results showed that most respondents (32.7%) were unaware of any institution involved in
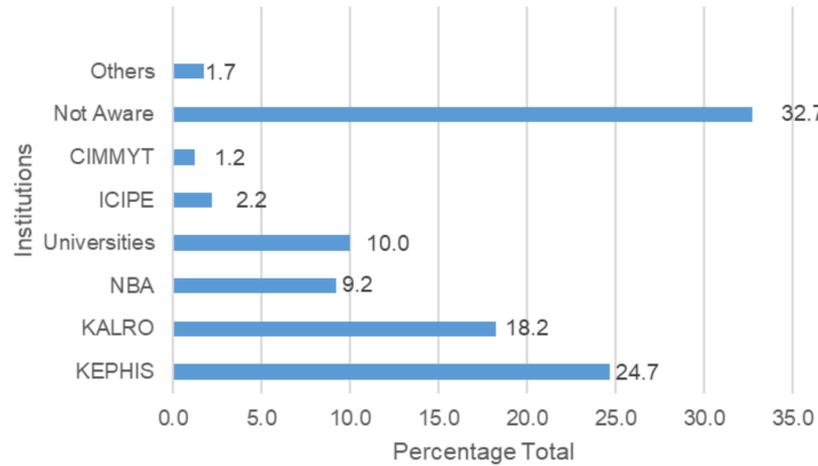
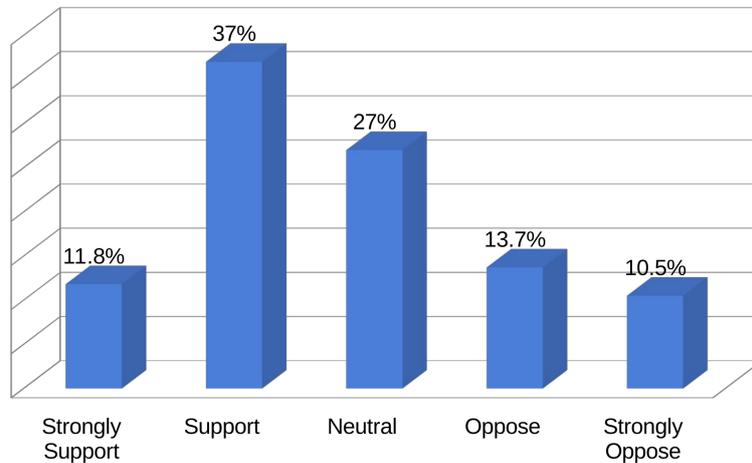**Figure 4.** Institutions involved in GMO research in Kenya.

Figure 5. Support for the use of GMOs.

such work, with KEPHIS and KALRO following closely at 24.7% and 18.2%, respectively (Figure 4).

3.3 ▪ *Public perceptions of GMOs*

When the study set out to understand how the public views GMOs, 48.8% supported, with 27% neutral about their support (Median = 3, IQR = 1), and the rest opposed to the use of GMOs (Figure 5). Most respondents who endorsed the use of GMOs cited its application in pharmaceutical development. The study also established a correlation between the level of education and the support for the use of GM technology in drug development, representing respondents with the highest level of education at 5% level of significance (Chi-square value = 43.418, p-value = 0.009). Most of the respondents who did not have formal education opposed the use of GM technology in drug development.

The study also set out to understand the relationship between the level of education and support for the use of GMOs. The results indicated that the support for the use of GMOs

Table 3. Relationship between the level of education and the support for the use of GMOs.

			Cross tabulation					
			Do you support the use of GMOs?					Total
			Strongly support	Support	Neutral	Oppose	Strongly oppose	
Highest level of education	Informal	Count	0	1	8	2	5	16
		%	0.0%	6.2%	50.0%	12.5%	31.2%	100.0%
	Primary	Count	1	9	10	13	1	34
		%	2.9%	26.5%	29.4%	38.2%	2.9%	100.0%
	Secondary school	Count	10	37	33	16	5	101
		%	9.9%	36.6%	32.7%	15.8%	5.0%	100.0%
	College certificate	Count	10	24	15	10	3	62
		%	16.1%	38.7%	24.2%	16.1%	4.8%	100.0%
	Diploma	Count	4	23	12	4	11	54
		%	7.4%	42.6%	22.2%	7.4%	20.4%	100.0%
	Bachelor's degree	Count	15	44	30	8	15	112
		%	13.4%	39.3%	26.8%	7.1%	13.4%	100.0%
	Postgraduate degree	Count	8	13	2	3	3	29
		%	27.6%	44.8%	6.9%	10.3%	10.3%	100.0%
Total		Count	48	151	110	56	43	408
		%	11.8%	37.0%	27.0%	13.7%	10.5%	100.0%

could be attributed to the respondent's highest level of education at 5% level of significance (Chi-square value = 68.322, p-value = 0.001) (Table 3). Additionally, most of the respondents who did not have formal education opposed the use of GMOs.

On the approvals already granted by the Authority for open cultivation, 65.1% of respondents supported the decision to approve the open cultivation of insect-resistant cotton (Median = 2, IQR = 1, with 6.5% strongly opposing the decision (Figure 6). The team also sought to understand the reasons for supporting or opposing the decision, and 23.2% attributed their support to better yields; this was followed closely by reduced pesticide use and early maturity at 19.3% and 12.1%, respectively (Figure 7). On the other hand, those opposing the commercialisation of Bt cotton in Kenya cited health concerns (42.9%), environmental safety (21.4%), and socioeconomic issues (11.7%) as the main issues (Figure 8).

The study also sought to understand whether the respondents supported or opposed the concept of labelling GMOs; most of the participants (45.9%) supported the labelling (median = 2, IQR = 1). With only 3.5% opposing it. The proponents cited consumer choice (56.3%), traceability (20.9%), and safety issues (20.7% as the main reasons why GMOs should be labelled. Those against labelling cited trade bias (62.7%) and increased costs (22.7%) as the reasons for their stance.

3.4 ▪ *Sources of information on GMOs*

On the sources of information about GMOs, the respondents indicated that their understanding of GMOs mostly comes from Radio (29.3%), closely followed by Television, Internet, and social media, each at 22.1% and 20.6%, respectively (Figure 9).
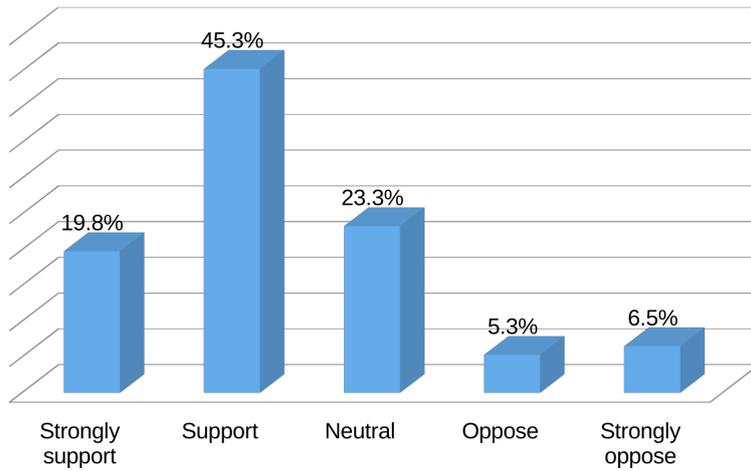
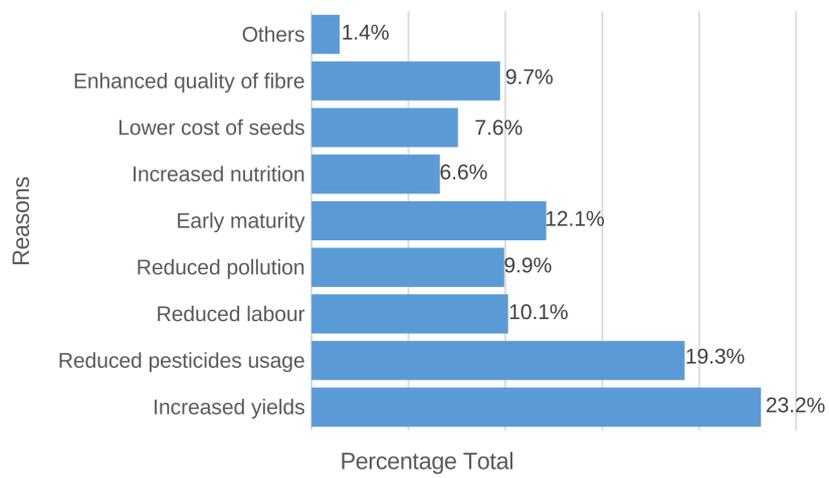**Figure 6.** Support for open cultivation of GMOs.
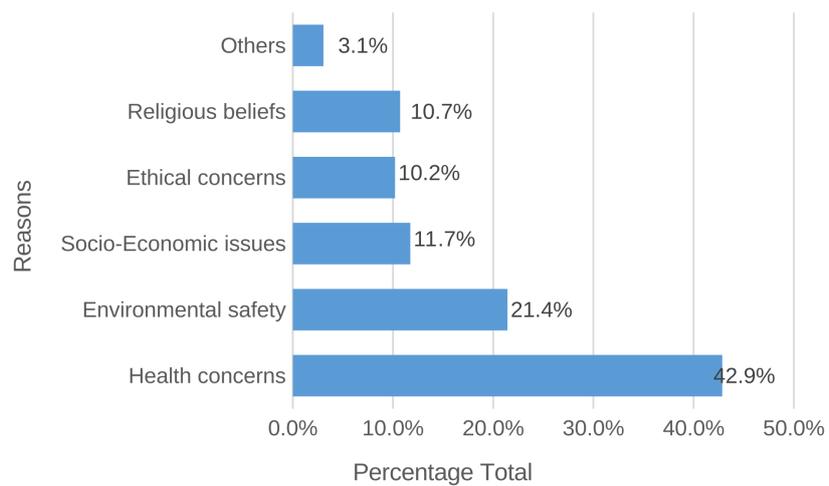

Figure 7. Reasons for supporting the cultivation of GMOs.

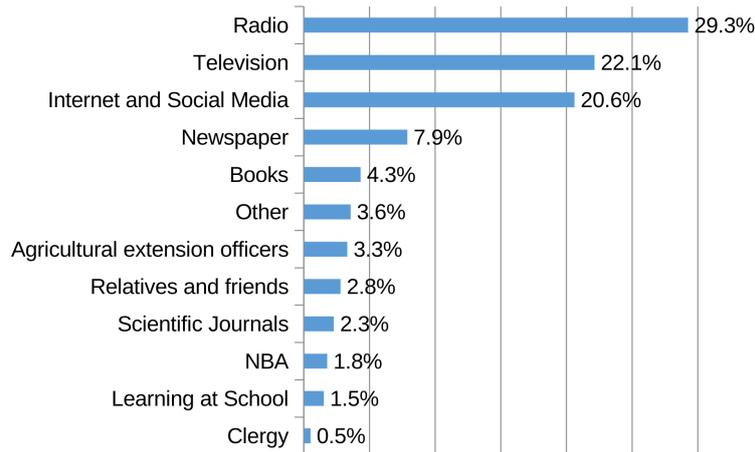**Figure 8.** Reasons for opposing the cultivation of GMOs.

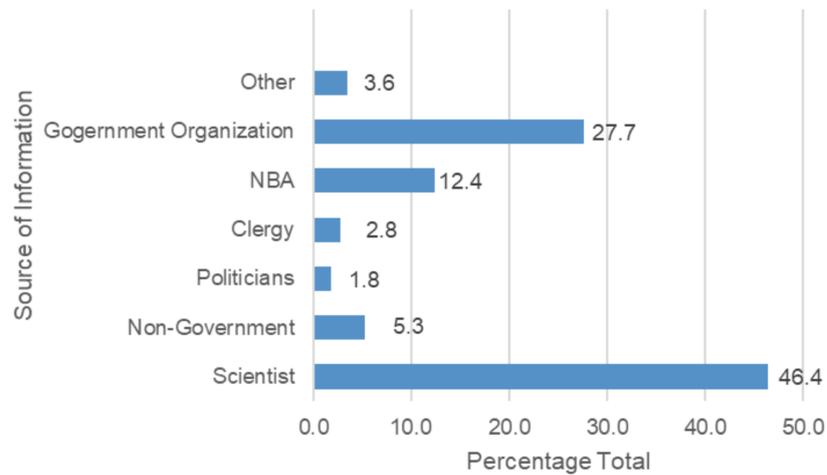**Figure 9.** Sources of information on GMOs in Kenya.

Figure 10. Trusted sources of information on GMOs in Kenya.

Additionally, scientists, standing at 46.4%, appeared to be the most trusted source of information on GMOs, with a small percentage believing in politicians (1.8%) as their trusted source of information (Figure 10).

4 ▪ Discussion

In this study, 78.3% of the subjects claimed to have previously heard about GMOs. These findings are supported by GeoPoll [2022], which indicated that most Kenyans are aware of GMOs (86%), which was a rise from GeoPoll's findings in 2014, which had placed it at 65%. Kunyanga et al. [2024] reported that although 100% of the respondents were aware of GMOs, only 57% indicated that GMOs and GM food were a solution to food security in Kenya and Africa. This high awareness but relatively lower acceptance reflects the distinction between the knowledge stage and the persuasion stages of innovation adoption, where awareness alone does not automatically translate into favorable attitudes or adoption [Rogers, 2003]. The study also established that respondents with the highest levels of education and postgraduate Degrees (Master's and/or Doctoral) supported the use of GMOs

at 72.4% (those supporting and strongly supporting) compared to those with lower levels and the illiterate. These findings support other studies conducted in Nigeria, Ghana, and Kenya, which demonstrated a positive relationship between higher education levels and the acceptance of GMOs [Egbe et al., 2019; Ampadu-Ameyaw et al., 2021; Kunyanga et al., 2024]. This can mean increased exposure of respondents with higher levels of education to information about GMOs [Adenle, 2014; Ampadu-Ameyaw et al., 2021]. According to Rogers [2003], people with more education often become early adopters or opinion leaders because they access information easily, possess strong scientific literacy, and evaluate new innovations based on evidence rather than social pressure.

Perceptions of GMOs are also influenced by social framing, where those with lower education may rely on social paradigms or myths, creating more resistance and scepticism [Adenle, 2014]. The finding of a statistically significant association between higher education and willingness to use GMOs ($\chi^2 = 68.322$, $p < 0.005$) aligns with a study conducted in Kenya to evaluate consumers' understanding of GMOs and their openness to using them. The study revealed that overall awareness of GM crops among the respondents was low, with individuals possessing higher education and higher income levels showing greater familiarity than others [Kimenju & De Groote, 2008]. These findings align with Risk Perception Theory, which posits that familiarity and perceived controllability reduce perceived risk and increase acceptance of emerging technologies [Slovic, 1987].

Although more than half of the respondents identified the National Biosafety Authority as the GM regulator in the country, a significant proportion (32.7%) were unaware of any institution conducting GM research. 24.7% identified the Kenya Plant Health Inspectorate Service (24.7%) and 18.2% the Kenya Agricultural and Livestock Research Organisation. Low level of awareness of the institutions undertaking biotechnological innovations erodes credibility, thereby amplifying the negative attitudes towards GMOs. The perception that GM research is shrouded in secrecy and is carried out without independent oversight heightens fears over safety and further diminishes public trust [Siegrist, 2000].

Kenya requires GMO labelling under the Biosafety Act [2009], and Biosafety (Labelling) Regulations [2012]. Labelling helps consumers identify GMO products and supports their traceability [Bovay & Alston, 2018]. 56.3% supported labelling for consumer choice, and those opposing cited trade implications. Risk Perception Theory suggests that voluntary choices enhance transparency and control, reducing perceived risk [Slovic, 1987]. Labelling opponents contend that it has the potential to introduce trade bias, foster stigmatisation, and result in misinterpretation about safety as well as increased costs for producers and consumers [Bett et al., 2010; Oh & Ezezika, 2014]. In this study, the fact that nearly half (49.3%) of the respondents indicated that GMOs can be identified by size highlights a major knowledge gap and common misconceptions, likely stemming from the belief that GMOs are unnatural or artificially altered. Risk Perception Theory explains this reliance on visual cues as a heuristic response to uncertainty, where individuals substitute scientific understanding with easily observable characteristics when faced with complex or unfamiliar risks [Slovic, 1987]. Governments worldwide have adopted varied frameworks for labelling GMOs to empower consumers to make informed choices [Pouliot & Wang, 2018]. However, consumers struggle to effectively utilize this labeling information due to information gaps on GMOs and their impact on food safety, human health, and the environment [Costa-Font et al., 2008]. Inconsistent application of labeling requirements for GM foods, which are not aligned with international guidelines, may reduce transparency and limit consumers' ability to make informed choices.

Diverse cultural, economic, safety, and environmental factors shape the varying attitudes towards GMOs [Kuada, 2020; Naeem et al., 2023; Mmbando, 2024]. Deep-seated cultural values, such as perceiving GM technology as playing God and as foreign interventions [Schnurr & Gore, 2015; Kunyanga et al., 2024], have led to serious opposition even where scientific data have proven their safety. Slovic [1987] classifies these concerns as dread risks, where moral, ethical, and cultural values amplify anxiety beyond what empirical risk assessments indicate. Furthermore, the regulatory frameworks implemented by different African countries create complex landscapes ranging from strict bans to cautious acceptance, which significantly influences both local farming practices and international partnerships [Muzhinji & Ntuli, 2021; Akinbo et al., 2021; Gbadegesin et al., 2022; Masehela & Barros, 2023; Mmbando, 2023]. Regulatory processes tend to favour risk assessments while neglecting the socioeconomic impacts of GMOs. As a result, the focus shifts to social risks such as corporate dominance over seeds, access to technology, and their impacts on established traditional farming practices [Lukanda, 2020; Cabelkova, 2024]. The absence of clear criteria for evaluating socio-economic factors has greatly hindered the acceptance of GMOs. These assessments tend to be inherently subjective because ethical concerns differ widely and are shaped by cultural backgrounds [Falck-Zepeda, 2009; Muzhinji & Ntuli, 2021; Mustafa et al., 2023].

GM crops are considered a viable means to address hunger, enhance crop resilience, and boost agricultural productivity in areas with ongoing food insecurity [Mmbando, 2024]. Supporters believe that these crops can offer economic benefits through increased yields and higher income [Gbadegesin et al., 2022; Kavhiza et al., 2022]. Only 23.2% supported the cultivation of GMOs, citing increased yields, with nearly half opposed (42.9%) due to health concerns. Hinderances to the application of GM technologies are not new, particularly in the developing nations where safety to humans and the environment, issues of intellectual property rights, trade, and impact on biodiversity have been cited [Kushwaha et al., 2008; Bett et al., 2010; Muzhinji & Ntuli, 2021; Kunyanga et al., 2024]. For example, Kunyanga et al. [2023] note that 46% of the Kenyan population possessed scant knowledge about GMOs, with most people exhibiting nervousness regarding the potential impacts on their health, the environment, and biodiversity. Risk perceptions are shaped by various factors, including the level of education, access to information, and previous experiences with GMOs. Socio-economic conditions further contribute to risk perceptions, as individuals from different economic backgrounds may prioritise certain concerns or benefits associated with GMOs based on their unique circumstances and needs [Zilbermann et al., 2015].

Concerns over potential disruptions to established farming methods, the decline of traditional agricultural knowledge, and financial disparities from seed commercialisation have been cited [Kedisso et al., 2022; Mustafa et al., 2023]. Issues are also raised about the possibility of gene transfer to wild plant species, unintended effects on non-target organisms, and unknown long-term ecological consequences [Muzhinji & Ntuli, 2021; Gbashi et al., 2021; Gbadegesin et al., 2022]. These concerns are heightened in Africa, where its diverse ecosystems, distinct climates, and biodiversity hotspots bring into question how well GM crops can adapt to various environments [Bowie et al., 2023; Chapman et al., 2022]. Public perceptions are not solely based on expert scientific assessments but rather defined by other qualitative factors, such as GMOs being disruptive to the established norms. Consequently, the perceived benefits and risks related to the effects of GM crops play a significant role in shaping public perceptions [Lefebvre et al., 2019; Kunyanga et al., 2024].

In this study, 45.3% of respondents supported the country's decision to approve the open cultivation of insect-resistant cotton, with 6.5% strongly opposing the decision. Those supporting attributed it to better yields (23,2%), followed closely by reduced pesticide use and early maturity at 19.3% and 12.1%, respectively. On the other hand, those opposing cited health concerns (42.9%), environmental safety (21.4%), and socioeconomic issues (11.7%) as the main reasons. These results align with the observations made by Juma [2016], who points out that research indicates that although a significant number of African farmers acknowledge the possible advantages of GMOs, such as enhanced pest control and higher yields, the public sentiment remains varied, with concerns regarding long-term health effects and the risk of undermining traditional farming practices. Diffusion of Innovation Theory interprets this as a polarized transition between early adopters and the early majority, with widespread adoption constrained by perceived risks and limited trust [Rogers, 2003].

GM crops have been met with resistance from the public stemming from concerns about their effects on human and environmental health [Carrière et al., 2021; Gbashi et al., 2021; Cui & Shoemaker, 2018; Bilder, 2016]. Studies from Kenya and Uganda, where 216 and 698 respondents were recruited, respectively, reported cancer, allergenicity, pest resistance, biodiversity loss, and GMOs seen to violate natural order and having inferior taste compared to indigenous crops as the perceived risks for opposition [Mustafa et al., 2023; Kunyanga et al., 2024]. In Zimbabwe, a survey of 301 National Food Festival attendees was sceptical of linking GMOs to private interests and perceived food quality decline [Dexter et al., 2019].

On the sources of information on GMOs, the respondents identified radio (29.3%), followed closely by television, internet, and social media at 22.1% and 20.6%, respectively. Different information channels have varying strengths and affect technology adoption. In this study, radio proved more effective at raising knowledge and awareness of GMOs, supporting Roger's [2003] view that mass media excel at spreading information about innovations. The media plays a crucial role in educating the public, reflecting societal attitudes, shaping perceptions, and influencing policy decisions related to emerging technologies like GMOs [Du & Rachul, 2012; Ojanji & Otunge, 2017]. Insights from African journalists suggest that GMO topics receive less attention compared to areas such as politics, health, economics, and the arts, which hampers a comprehensive understanding of the issue [Ojanji & Otunge, 2017]. The media's focus on sensational stories about GMOs often overshadows scientific facts, resulting in public scepticism and confusion about their safety and effectiveness [Lukanda et al., 2023]. Both traditional and social media have contributed to evolving this debate from a deeply divided perspective to a more constructive global conversation surrounding GMOs by emphasising their potential advantages [Evanega et al., 2022].

While this study found that the internet and social media are key sources of public information about GMOs, Lucht [2015] notes these channels can also spread misinformation and heighten public concern about GMOs. This study found that 46.4% of participants trust scientists most for information on GMOs, aligning with Huang [2020], who reported that people indifferent to GMOs rely more on scientists than on their online research skills. Trust is a key determinant of public attitudes towards GMOs, and a lack of it from sources regarded as credible influences whether the public perceives the risks as high or low [Alli, 2024]. Furthermore, trust in experts is a central determinant of risk acceptance under Risk Perception Theory, as credible sources reduce perceived risk and foster informed attitudes [Slovic, 1987]. The adoption and utilisation of GMOs have been the subject of extensive debate worldwide. Unfortunately, the dialogue has not been balanced with the opponents of

the technology, focusing mainly on the perceived negative effects [Bilder, 2016; Busscher et al., 2020; Rzymski & Królczyk, 2016], leading to current scepticism and resistance.

5 ▪ Conclusions

In this study of public attitudes towards GMOs in Kenya, we found that awareness, sources of information, and attitudes differ across socio-economic groups. This variability necessitates the use of tailored and specific messages as well as targeted delivery of biosafety information. The findings from this study show that public perceptions have played a notable role in shaping the acceptance of modern biotechnology in Kenya. GM technology must meet the standards of protecting health and the environment, while also addressing social and economic impacts, to ensure informed approval and appropriate support. Although the Kenyan law and the Cartagena Protocol mandate public participation, the study revealed that most individuals were not aware of the roles of the principal institutions associated with GMOs. Public engagement is vital in shaping national GMO policies, as demonstrated by the study in Mali [Pimbert & Barry, 2021]. Involving local communities and stakeholders ensures diverse perspectives are included, making policies more reflective of societal values. Such engagements promote transparency, accountability, and enhance the effectiveness of GMO policies.

The Kenyan government has established a strong regulatory framework for GMOs; however, policy inconsistencies, such as the 10-year ban instituted in 2012 and reversed in 2022, have undermined public trust and led to negative perceptions. Critics highlight a lack of meaningful public participation in decision-making, which amplifies mistrust [KLR, 2023]. The exclusion of diverse stakeholder voices contributes to disenfranchisement and resistance to biotechnology. Although there is a law for GMO labelling, poor enforcement raises concerns about consumer rights. These issues foster uncertainty and diminish confidence in regulatory bodies, increasing fears over the safety and socioeconomics of GMOs. Addressing these inconsistencies and enhancing public involvement is crucial for dispelling misconceptions and promoting informed dialogue about GMOs in Kenya. Public awareness campaigns should go beyond simple awareness and provide persuasive information that focuses on the attributes of GM technology, clearly outlining its benefits that outweigh the perceived risks. In the complex biotechnology landscape, Kenya's way forward should entail an informed citizenry, buttressed by a strong institutional and regulatory machinery to enhance human rights protection and the safe and responsible integration of biotechnologies like GMOs for sustainable development.

5.1 ▪ *Recommendations*

There are many applications to modern biotechnology, including applications in the agricultural sector, industry, environmental science, and medicine, but concerns have become common to most, if not all, applications. Article 23 of the Cartagena Protocol on Biosafety obligates Parties to actively facilitate public awareness and participation in GMOs [SCBD, 2000]. In Kenya, the biosafety law outlines the criteria for public participation on GMOs, giving room for stakeholders to share views prior to decisions being made ['The Biosafety Act No. 2', 2009; 'The Biosafety (Environmental Release) Regulations', 2011]. The involvement of stakeholders in GM technologies is needed to solve the reasons behind the

acceptance of these technologies [WHO, 2021; Dicko et al., 2024]. However, effective public participation depends on current general knowledge of biotechnologies [Hartley et al., 2024]. Comprehensive educational Initiatives targeting diverse stakeholders are a key solution to fill the knowledge gaps in GM technologies. It will enrich public debates, guide policymaking, and promote biotechnological innovations. Further research is recommended to determine specific information levels needed among different education cohorts to efficiently prepare messages. The regulatory authority has a responsibility to build biosafety awareness, communicate facts on GMOs to counter misconceptions, and, where available, use data as the basis for public communication strategies. A focused communication plan, with preferred channels identified as outlets to reach the public, can influence the level of biotechnology interest by the public.

5.2 ▪ *Limitations of the study*

One of the limitations of this study was the sample size of 416 respondents, which, while providing valuable insights, may not have fully captured the diversity of perspectives across Kenya's population. Another constraint was the reliance on self-reported data from structured questionnaires, which may have introduced response bias, as participants might have given socially desirable answers rather than their actual views [Creswell & Creswell, 2018]. Our investigation focused on quantitative analysis, which, while good for statistics, couldn't capture the in-depth reasons behind respondents' GMO perceptions. Purposive sampling relied on the researcher's expertise to select information-rich cases, hence directly influencing who is included and excluded. This subjectivity increased the chances of introducing bias [Andrade, 2021]. This study establishes an initial baseline, and future research may enhance these findings through the application of proportional stratified sampling. Aligning county-level sample sizes with national population distributions would enable subsequent studies to strengthen our results with a heightened focus on population-representative distribution.

5.3 ▪ *Ethical considerations*

The study included 416 participants who gave informed consent, understanding all aspects before joining [Creswell & Creswell, 2018]. Participants could withdraw without compensation at any time. No personal identifiers were collected; responses were anonymized, aggregated, and data securely stored to protect privacy [Babbie, 2020].

Authors contribution
The authors contributed equally during the development of this manuscript.

Availability of data and materials
Upon request, the data sets used and analyzed for this study are available from the corresponding author.

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