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Article

Assessment of Public Perceptions and acceptability of Genome-Edited Foods in Nigeria

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Abstract: As genome editing technologies gain traction in agriculture, understanding public perceptions and concerns surrounding gene-edited foods becomes increasingly important. This study examines public perceptions of genome editing technologies, with a particular focus on gene-edited food products. To limit social desirability bias, the study utilize data obtained from a survey of 376 respondents from higher institutions, government parastatal, and private organisations. The research investigates socio-demographic variables, awareness levels, food technology neophobia, and perceived benefits and risks associated with genome editing. The findings reveal diverse attitudes towards genome editing, influenced by factors such as age, gender, education, and income. While the majority acknowledge the benefits of gene-edited foods, concerns remain regarding their environmental impact, health risks, and ethical implications. The findings aim to inform policymakers and stakeholders about the key factors shaping public opinion, providing a foundation for more effective communication strategies, enhanced regulatory frameworks, and ethical considerations in the deployment of genome editing technologies.

Keywords: awareness, genome-editing technologies, GMO, health Risks, Neophobia

1. Introduction

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The rise of genome editing technologies (GETs) such as CRISPR-Cas9 has marked a significant shift in agricultural practices, enabling precise alterations to crop genomes to enhance traits like disease resistance, nutritional value, and enviro0nmental adaptability (Rasheed et al., 2021; Ndudzo et al.,

2024; Ahmad et al., 2021; Erdoğan et al., 2023; Sagar et al., 223). Despite the potential benefits, public acceptance of gene-edited foods remains a challenge, influenced by concerns over safety, ethical implications, and trust in regulatory bodies (Farid et al., 2020; Lindberg, et al., 2023; Cummings and Peters 2022).

Understanding public perceptions is crucial for the successful implementation of genome editing in agriculture (Lindberg et al., 2023; Shineha et al., 2024; Barbosa et al., 2020; Kumar et al., 2018). Misconceptions or lack of awareness can lead to resistance, hindering technological advancements that could address food security and sustainability challenges. This study aims to fill the knowledge gap by providing a comprehensive analysis of public attitudes towards gene-edited foods and estimate parameter that enhances willingness-to-pay for gene-edited food in the study area.

The history of genome editing in agriculture dates to the early 20th century when traditional breeding methods were used to alter the genetic makeup of crops (Xiong, et al., 2015; Ahmad, 2023; Kalaitzandonakes et al., 2023). However, it was not until the advent of recombinant DNA technology in the 1970s that more precise genetic modifications became possible, leading to the development of genetically modified organisms (GMOs) (Narayanan and Glick 2023; Khan, 2023; Dixit et al., 2023). The introduction of CRISPR-Cas9 in the early 21st century marked a significant milestone, allowing for targeted edits at specific genomic locations with unprecedented precision (Küppers, 2022; Gostimskaya, 2022; Van der Oost and Patinios, 2023). This technology has facilitated the creation of crops with enhanced traits such as disease resistance, improved nutritional profiles, and reduced environmental impact. As genome editing continues to evolve, its application in agriculture has expanded, offering new possibilities for addressing global food security challenges (Atia et al., 2024; Joshi, 2023; Akhtar et al., 2023; Sharma, et al., 2023 Raman, 2017).

1.1 The Evolution of Public Perception towards Genetic Modification

Public perception of genetic modification has undergone significant changes over the past few decades. Initially, the introduction of GMOs in the 1990s was met with optimism, as these technologies promised to revolutionize agriculture and solve many food production challenges. However, this optimism was soon overshadowed by widespread public skepticism and opposition, fueled by concerns about potential health risks, environmental impacts, and ethical dilemmas (Raman, 2017; Buiatti et al., 2013; Bawa and Anilakumar, 2013; Islam et al., 2020; Gaharwar et al., 2021; Nayab, 2024). Media coverage and activist campaigns played a critical role in shaping public opinion, often highlighting the uncertainties and potential dangers of GMOs Gakpo and Baffour – Awuah, 2024; Omeje 2019; Wandati, 2024; Maeseele, 2015). Over time, this skepticism has extended to newer genome editing technologies, such as CRISPR, despite their increased precision and potential benefits (Liu et al., 2021). Today, public perception remains mixed, with significant portions of the population expressing both hope and concern regarding the use of genome editing in food production (Bearth et al., 2024; Henderson et al., 2024; FAO, 2022).

Numerous studies have been conducted to gauge public attitudes towards gene-edited foods, revealing a complex landscape of opinions. Studies done has found that while a substantial number of consumers recognize the potential benefits of gene-edited crops, including enhanced nutritional value and reduced pesticide use, many remain wary due to concerns about long-term health effects and environmental consequences (Robbins et al., 2021; Vasquez et al., 2022; Woźniak-Gientka et al.,

2022; Evanega; 2022). Similarly, the role of information sources in shaping attitudes have been highlighted, with individuals exposed to balanced, scientifically accurate information being more likely to support gene editing technologies (Busch et al., 2022; Barbosa et al., 2020; Kato-Nitta et al., 2021; FMI 2020). Conversely, those receiving information from sensationalist media or anti-GMO groups tend to exhibit greater skepticism. These studies underscore the importance of transparent communication and public education in fostering informed opinions about gene-edited foods.

1.2 Ethical and Societal Considerations

The ethical and societal implications of genome editing in agriculture are a significant area of concern for both the public and scholars. Ethical debates often center around the concept of "playing God," with critics arguing that altering the genetic makeup of organisms crosses moral boundaries and could have unforeseen consequences (Van den Belt, 2009; Yashvardhan, 2023; Almeida and Ranisch, 2022; Massmann and Fox, 2021; Van Eyk, 2023). Additionally, there are concerns about the equitable distribution of the benefits of genome editing, particularly in developing countries where access to these technologies may be limited (Subica 2023; Barbosa et al., 2020; Küppers, 2022; Singh, 2021; Lee and Sawai, 2024). The potential for genome editing to exacerbate existing social inequalities is a key issue, with some fearing that large multinational corporations could monopolize the technology, leaving small-scale farmers at a disadvantage (Nuthalapati, 2020; Hurt, 2020; Pixley et al., 2019). Furthermore, societal considerations also include the potential impact on biodiversity, as the widespread adoption of gene-edited crops could reduce genetic diversity in agricultural systems, making them more vulnerable to diseases and pests (Sabat and Tripathy, 2024; Salgotra and Chauhan, 2023; Ndudzo et al., 2024; Heiman, et al., 2011; Hallman, 2003; Nayab, 2024). Addressing these ethical and societal concerns is crucial for the responsible development and deployment of genome editing technologies in agriculture.

1.3 Risk Perception Theory

The theory of Risk Perception combines three core dimensions of risk that were previously mostly viewed separately: cognitive variables (such knowledge), experiential variables (such emotion/affect), and sociocultural variables (such norms, values). These variables accounted for roughly 70% of the variability in risk perception, as determined by empirical research, which might be close to the limit of the explanatory potential of risk perception models (Sjöberg, 2002). Therefore, the framework is used here to assist in organizing, structuring, and evaluating the empirical data for each of the key aspects that have been shown to impact how people view the risks associated with climate change.

2. Materials and Methods

The study was carried out in Nigeria. The country is sub-divided into six geopolitical zones namely: North west, North east, North central, South west, South east and South-south. This research engages the use of primary data, sourced from administration of questionnaire and personal interview to 376 respondents. Globally, gene-edited products have sparked ethical debates and are a contentious subject among stakeholders. This invariably results in social desirability bias, in which individuals express socially acceptable opinions rather than their real ones. We decided to look at this bias among the elite, whom we thought to be knowledgeable about gene editing technology, in order to overcome or lessen it. We randomly sampled twelve educational institutions (universities - 2 each from the six

geopolitical zones in Nigeria), 5 research institutions (one from each zone except south east), 3 Federal government agencies and 8 private organizations from Kano, Port Harcourt, Enugu, Kano, Nasarawa, Abuja, Kaduna, and Adamawa. These represented the population of the study. We adopt the use of Kobotoolbox – an electronic survey device to administer the questionnaire through trained personnel. The socio-demographic variables obtained include age, gender, marital status, educational background, income, and job experience. The survey also assessed awareness of gene-edited foods, food technology neophobia, perceptions of the benefits and risks of genome editing and wilingness-to-pay for gene-edited foods. For questions on food technology neophobia and perceptions of the benefits and risks of genome editing, the respondents were allowed to rate each statement provided in a seven likert scale (1 - 7) from strongly disagree (1) to strongly agree (7) and subsequently the scores for positive statements are converse. Data were analyzed using descriptive statistics to provide insights into public attitudes towards genome editing and the willingness of the respondents to pay for gene-edited foods.

2.1 Sample Size Formula for Finite Population

The formula by Krejcie and Morgan, (83) was adopted to determine the sample size. It is given as:

$$S = \frac{X^2 NP\ (1-P)}{d^2(N-1) + X^2 P\ (1-P)} \quad \text{.....(1)}$$

Where:

S = Required Sample size

X = Z value (e.g. 1.96 for 95% confidence level)

N = Population Size

P = Population proportion (expressed as decimal) (assumed to be 0.5 (50%)

d = Degree of accuracy (5%), expressed as a proportion (.05); It is margin of error

X = 1.96

N = 34,963

P = 0.5

d = 0.05

$$S \Rightarrow \frac{(1.96)^2 * 34963 * (0.5) * (1-0.5)}{(0.05)^2 * (34963-1) + (1.96)^2 * (0.5)}$$

S = 376

2.2 Validity and reliability of the instrument

Validity and reliability of the instrument for the study was tested. Two experts from different university were given the drafted questionnaire for scrutiny. This is to set up the relevance of the content in measuring standards the study intends to measure. Afterward, a pilot study was conducted on a sample of about thirty- five respondents who are working in corporate organization within five major cities in Nigeria. Scale construction has often been based on summation of items – homogeneous weighting. To measure the internal consistency, we adopted the methodology of Cronbach (1951) as cited in Boermans and Kattenberg (2001). Here, internal consistency was simply

referred to as the proportion of the test variance that can be attributed to a group of items. The reliability of the instrument was carried out through a test-retest method to know whether the questions are consistent, not ambiguous, and easy for the respondents to answer. Reliability of questionnaire was checked through Cronbach alpha. Cronbach alpha is a statistical tool used to determine the internal consistency of any construct (DeVellis, (1991) as cited by Guzek and Głabska 2022). Each variable measured has coefficient alpha greater than 0.7 which is considered acceptable in research (see appendix A1).

2.3 Analytical techniques and specification

2.3.1 Probit Regression Model:

The probit model is often used in situation where an individual makes choices between two alternatives which in this case, decision to either have willingness-to-pay or not. From the economist perspective, an individual (i) makes a decision to pay if the utility associated with that choice (V_{1j}) is higher than the utility associated with decision not to pay (alternative choice), (V_{0j}). Following Koop (2003), the different in utilities of the two alternative choices is stated as and the econometric specification of the model is given in its latent as:

$$y_j^* = V_{ij} - V_{0j} \quad \text{.....(I)}$$

$$y_j^* = X_j\beta + e_j \quad \text{.....(ii)}$$

Where y_j^* is an unobserved (latent) random variable that defines respondents' binary (willingness-to-pay) choices, X_j are sets of explanatory variables associated with individual j. β is a vector of coefficients associated with the explanatory variables while e_j represents the random error terms defined as: e~N (0, 1). The relationship between the unobserved variable y_j^* and the observed outcome (yj) can be specified as:

$$y_j = 1 \qquad \text{if } y_j^* \geq 0$$

$$y_j = 0 \qquad \text{if } y_j^* < 0$$

Explicitly, the model is stated as:

$Y = \alpha_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + e$

X_1 = age, X_2 = sex, X_3 = household size, X_4 = marital status, X_5 = income of the household head, nutritional value of the gene-edited food, X_6 = food label, X_7 = risk of increasing allergies, X_8 = food quality and X_9 = religion/cultural believes e = error term

3. Results

The result presented on Table 1 revealed the demographic variables of the respondents. From the result, more than 37% of the respondents were between the age of 41 – 50 years and about 26% were

between the ages of 31 and 40 years. The percentage of female (54.8%) in this survey is slightly higher than that of their male (45.2%) counterpart. About 81% of the respondents were married while only 19.2% were unmarried. With educational information, the result showed that 39.3% had first degree (B.Sc./B.Ed./HND), about 39% also had MSc and fewer (13.3%) had Ph.D. more than half (53.7%) earn between 101,000 – 300,000 monthly and had between 11 – 20 years' experience in their respective job(s).

Table 1: Demographic characteristics of the respondents (N = 376)

Socioeconomic variables	Frequency	Percentage
Age		
≤30	60	16.0
31 - 40	96	25.5
41 - 50	142	37.8
51 - 60	70	18.6
Above 60	8	2.1
Sex		
Female	206	54.8
Male	170	45.2
Marital status		
Married	304	80.8
Unmarried	72	19.2
Educational status		
B.Sc./B.Ed./HND	148	39.3
MSc	146	38.8
NCE/OND	16	4.3
PhD	50	13.3
Secondary	16	4.3
Income		
100,000	132	35.1
101,000 – 300,000	202	53.7
301,000 – 500,000	40	10.7
Above 500,000	2	0.5
Job experience		
≤5	72	19.2
6 - 10	106	28.1
11 - 20	168	44.7
21 - 30	22	5.9
Above 30	8	2.1

Source: Field Survey, 2024

Information and knowledge are essential for determining consumer conduct and mindset about embracing new innovation. This holds true for gene editing technologies as well. The positive or negative data about the technology, its perceived risks and benefits, familiarity with it, and its health and environmental effects are all topics covered by the authors (Zhu et al., 2015; Lusk, 2004; Rose et al., 2019; Rihn et al., 2021; Valente and Chaves, 2018). Based on the results on awareness of gene edited

food in the study area, the result as presented on Table 2 revealed the responses on the subject matter. Exactly 75% of the total population agreed on awareness of gene edited maize, more than 73% acknowledge to the known of gene edited tomato while about 65% were of the known to gene edited dairy products. The illustration of the percentage of awareness of these products as revealed in figure 1 depicted higher percentage of awareness of maize than all other products studied.

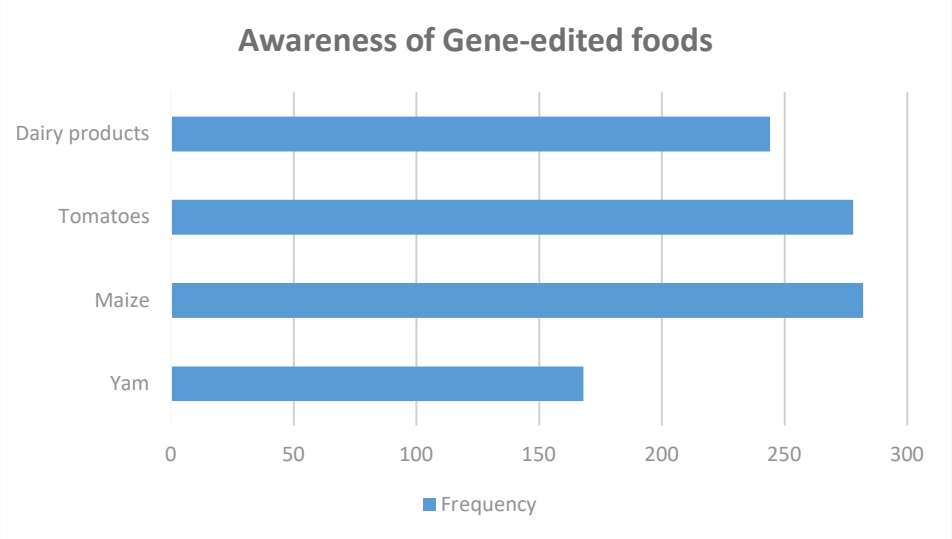

Figure 1: Awareness of Gene-edited foods

Table 2: Awareness of Gene edited food

Food items	**Yes**	**No**
Maize	282	94
	(75.0)	(25.0)
Tomato	278	98
	(73.9)	(26.1)
Yam	168	208
	(44.7)	(55.3)
Dairy products	244	132
	(64.9)	(35.1)

Source: Field Survey, 2024

Table 3: Food technology Neophobia questions

Statement(s)	Strongly Disagree	Disagree	Slightly Disagree	Neither Agree nor Disagree	Slightly Agree	Agree	Strongly Agree
1. New food technologies are something I am uncertain about	88 (23.4)	74 (19.7)	52 (13.8)	14 (3.7)	60 (16.0)	68 (18.1)	20 (5.3)
2. New foods are less healthy than traditional foods	72 (19.2)	134 (35.6)	40 (10.6)	20 (5.3)	42 (11.2)	40 (10.6)	28 (7.5)
3. The benefits of new food technologies are often grossly overstated	31 (16.5)	37 (19.7)	12 (6.4)	34 (18.1)	34 (18.1)	34 (18.1)	6 (3.1)
4. There are plenty of tasty foods around, so we do not need to use new food technologies to produce more	60 (16.0)	110 (29.3)	54 (14.4)	42 (11.2)	24 (6.4)	66 (17.6)	20 (5.3)
5. New food technologies decrease the natural quality of food	66 (17.6)	86 (22.9)	32 (8.5)	20 (5.3)	60 (16.0)	72 (19.2)	40 (10.6)
6. New food technologies are unlikely to have long-term negative health effects	38 (10.1)	94 (25.0)	26 (6.9)	52 (13.8)	28 (7.5)	88 (23.4)	50 (13.3)
7. New food technologies give people more control over their food choices	10 (2.7)	36 (9.6)	6 (1.6)	22 (5.9)	86 (22.9)	130 (34.6)	86 (22.9)
8. New products using new food technologies can help people have a balanced diet.	12 (3.2)	48 (12.8)	12 (3.2)	42 (11.2)	92 (24.5)	98 (26.1)	72 (19.2)
9. New food technologies have long-term negative environmental effects	48 (12.8)	82 (21.8)	58 (15.4)	42 (11.2)	36 (9.6)	72 (19.7)	36 (9.6)
10. It can be risky to switch to new food technologies too quickly	46 (12.2)	54 (14.4)	26 (6.9)	46 (12.2)	64 (17.0)	82 (21.8)	58 (15.4)
11. Society should not depend heavily on technologies to solve its food problems	74 (19.7)	78 (20.7)	42 (11.2)	22 (5.9)	54 (14.4)	68 (18.1)	38 (10.1)
12. There is no sense trying out high-tech food products because the ones I eat are already good enough	50 (13.3)	106 (28.2)	56 (14.9)	28 (7.5)	54 (14.4)	48 (12.8)	34 (9.0)
13. The media usually provides a balanced and unbiased view of new food technologies	32 (8.5)	56 (14.9)	48 (12.8)	76 (20.2)	50 (13.3)	70 (18.6)	44 (11.7)

Source: Field Survey, 2024

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Table 3: Food technology Neophobia questions

Source: Field Survey, 2024

Table 3 illustrate the food technology Neophobia. From the result, more than half (56.9%) of the respondents are very much certain about the new food technologies. About 43% were convinced that new technology foods are less healthy than the traditional foods. No fewer than (42%) opted for the reverse of the grossly overstated of benefits of new food technologies, though, about 39% agrees but more than 18% neither agree not disagree. According to Atsushi et al., (2024), in spite of the presence of gene-edited products in the market, the spread and acceptability is limited based on the knowledge of the consumers. Here, 60% of the respondents disagree that abundance of food around not necessarily necessitate production more food through technology, so this ascertains the need to increase food production through new technologies. There are positive responses from the respondents for balance diet derivation from new technology foods and control of food choices (80.4%) by the people through new food technologies. The result further showed considerable level of concern as about 39% of the participant indicated food technologies have long-term negative environmental effects and that it could be risky to switch to new food technologies very quickly (54.2%). Nevertheless, more than 51.6% of the respondents suggested that the society should depend heavily on technologies to solve its food problems and 56.4% confirm that there is no tension in trying out high-tech food products.

The result presented on Table 4 showed the benefits and risk perception indices towards gene editing technologies. sixteen different statements were identified on the table which were grouped into five (5): perceived benefits, perceived environmental risks, perceived health risks, ethical concerns, and equity concerns. From the statements that pinpoint the perceived benefits of gene editing technologies, most of these statements received positive agreement of the respondents and the aggregated perceived benefit score was 0.46. Gene editing technology can result in insect-resistant crops has the highest score of 1.16 followed by gene editing technology has the potential to create foods with enhanced nutritional value with 1.12. The result simply indicated that gene editing food technology is of significant benefit to human in a way of increasing insect-resistant crop varieties; reduction of pesticide residue on food and environment and in provision of foods with high nutritional content.

Furthermore, both perceived environmental risks and ethical concerns have the same aggregated perceived score of 0.16 respectively, perceived health risks and equity concern also score 0.13 and 0.11 respectively. The respondents differ in answering questions under the perceived environmental risks, though, many respondents dispel prior assumption of the technology being harmful to traditional insects and loss of original plants varieties. This shows that new food technologies are less injurious to the environment. Also, larger percentage of the respondents' opinion negated the assumption of health risks associated with gene editing technologies. it is evidence from the table that gene editing technologies can in no way increase the antibiotics resistance diseases.

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Table 4: Benefits and risk perception indices toward gene editing technology N = 376

	Statement(s)	Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree	WMS	Score
Perceived Benefits	1.Gene editing technology has the potential to create foods with enhanced nutritional value	12 (3.2)	34 (9.0)	12 (3.2)	18 (4.8)	98 (26.1)	122 (32.5)	80 (21.3)	1.12	0.46
	2.Gene editing has the potential to reduce pesticide residue on food	22 (5.9)	20 (5.3)	20 (5.3)	34 (9.0)	70 (18.6)	126 (33.5)	84 (22.3)	1.10	
	3.Gene editing has the potential to reduce pesticide residue in the environment	20 (5.3)	36 (9.6)	10 (2.7)	46 (12.2)	78 (20.7)	114 (30.3)	72 (19.2)	1.01	
	4.Gene editing technology can result in insect-resistant crops	14 (3.7)	22 (5.9)	24 (6.4)	28 (7.45)	58 (15.4)	144 (38.3)	86 (22.9)	1.16	
Perceived environmental risks	5.Gene-edited crops are negative for the environment	42 (11.2)	100 (26.6)	72 (19.2)	50 (13.3)	40 (10.6)	38 (10.1)	34 (9.0)	0.26	0.16
	6.Insect-resistant crops developed using gene editing could cause death of untargeted insects	30 (8.0)	52 (24.5)	30 (8.0)	50 (13.3)	78 (18.1)	76 (20.2)	30 (8.0)	0.59	
	7.Gene editing can lead to a loss of original plant varieties	30 (8.0)	42 (11.2)	42 (11.2)	28 (7.5)	52 (24.5)	82 (21.8)	60 (16.0)	0.69	
Perceived health risks	8.Consuming gene-edited food products can damage human health	54 (14.4)	100 (26.6)	42 (11.2)	36 (9.6)	14 (14.4)	58 (15.4)	32 (8.5)	0.21	0.13
	9.Consuming gene-edited foods products can lead to more allergies	42 (11.2)	86 (22.9)	30 (8.0)	52 (13.8)	44 (11.7)	78 (20.7)	44 (11.7)	0.51	
	10.Consuming gene-edited foods might lead to an increase in antibiotic-resistant diseases	50 (13.3)	62 (16.5)	12 (3.2)	78 (20.7)	70 (18.6)	70 (18.6)	34 (9.0)	0.53	
Ethical concerns	11. Gene editing is tampering with nature	44 (11.7)	86 (22.9)	20 (5.3)	30 (8.0)	56 (15.0)	84 (22.3)	56 (14.9)	0.59	0.16
	12.Gene editing technology makers are imitating God	62 (16.5)	126 (33.5)	28 (7.5)	54 (14.4)	46 (12.2)	38 (10.1)	22 (5.9)	0.13	
	13. Gene-edited food is not natural	32 (8.5)	64 (17.0)	14 (3.7)	42 (11.2)	32 (8.5)	130 (34.6)	62 (16.5)	0.82	
	14.Gene-edited products only benefit multinational producers	10 (2.7)	132 (35.1)	28 (7.5)	44 (11.7)	42 (11.2)	82 (21.8)	38 (10.1)	0.50	

Equity concerns	15.Gene-edited products don't benefit smaller farms	32 (8.5)	96 (25.5)	24 (6.4)	48 (12.8)	40 (10.6)	96 (25.5)	40 (10.6)	0.28	0.11
	16.Gene-edited products are being forced on developing countries by developed countries	37 (10.1)	114 (30.4)	26 (12.2)	42 (11.2)	40 (10.6)	56 (14.9)	40 (10.6)	0.35	

Source: Field Survey, 2024; Percentage in parenthesis

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Concerning the ethical concerns, most of the respondents posited that gene editing technologies tampers with the nature, though, a significant number (39.9%) still debunk the assertion. About 58% of claimed that gene editing makers are imitating God and that gene edited foods are not natural (59.6%). In terms of equity concerns, the result indicated that there is low level of concern as most of the respondents disclaimed gene editing technology favoring only the multinational producers. From the result, it is evidence that gene editing technology benefit both small- and large-scale producers and that the technology is never imposed on the developing countries as claimed.

3.1 Willingness to pay for gene-edited food

The result in Table 5 presents willingness-to-pay for gene-edited food in the study area. The table showed the marginal effect of the coefficient of variables: age, sex, household size, marital status, household size, income of the household head, nutritional value of the gene-edited food, food label, risk of increasing allergies, food quality and religion/cultural believes. The coefficient of age, sex, food label, risk of allergies and religion/cultural believes showed negative sign while other variables as shown on the table were positively related to willingness-to-pay for gene-edited foods in the study area. The coefficient of age was negative and statistically significant at 5% level; household size was positive and significant at 10%. Meanwhile, nutritional value of the food and risks of allergies were significant at 5% level, both households' head income and food quality were significant at 1% level of confidence.

Table 5: Parameter estimate of willingness to pay for gene-edited food

Variables	dy/dx	Std. Err	z	P>|z|
Age	-0.0394235	0.0193557	-2.04	0.042**
Sex (male = 1, otherwise = 0)	-0.0811595	0.2101905	-0.39	0.699
Household size	0.0002858	0.0001538	1.86	0.063*
Marital status (married = 1, otherwise =0)	0.0310962	0.4734228	0.07	0.948
Income (household head income)	0.8263201	0.3377361	2.45	0.014***
Nutritional value (dummy)	0.3570265	0.1837176	1.94	0.052**
Food Label (dummy)	-0.6148487	0.458833	-1.34	0.180
Risk of allergies (dummy)	-0.2453892	0.1096198	-2.24	0.025**
Food quality (dummy)	0.0766621	0.0247698	3.09	0.002***
Religion/cultural believe (affect = 1, otherwise = 0)	-0.0165578	0.0428305	-0.39	0.699
Constant	4.554411	2.069141	2.20	0.028**
Number of obs = 371				
LR chi2(10) = 43.39				
Prob > chi2 = 0.0000				
Pseudo R2 = 0.1584		Log likelihood = -115.27746		

Source: Field Survey, 2024

Note: * denote significance at 10%; ** at 5% and *** at 1%

4. Discussions

The demographic profile of the respondents, as detailed in Table 1, reveals a well-rounded representation, with a significant portion of respondents (37.8%) aged between 41 and 50 years, and a further 25.5% aged 31-40 years. This age distribution suggests that the majority of respondents are

in their prime working years, which could influence their perspectives on the adoption and implications of new food technologies like gene editing. The slight female predominance (54.8% female vs. 45.2% male) aligns with previous research indicating that women often have more pronounced concerns regarding food safety and health implications of genetically modified foods (Heiman et al., 2011; Hallman et al., 2003; Elder et al., 2018; Catherine, et al., 2024). The high proportion of married individuals (81%) suggests a family-oriented demographic, which may heighten concerns about the long-term health effects of gene-edited foods.

The educational background of respondents is notable, with a significant majority having completed postsecondary education—39.3% holding a first degree and 38.8% with a master's degree. This educational profile is indicative of a population likely to have a better understanding of complex scientific concepts, including gene editing. Previous studies, have shown that individuals with higher education levels tend to have greater awareness and understanding of biotechnologies, which might contribute to more informed opinions on the risks and benefits of gene-edited foods (Woźniak-Gientka et al., 2022; Kato-Nitta, et al., 2023; Adeboye et al., 2024; Kato-Nitta et al., 2021). Additionally, more than half of the respondents (53.7%) earn between 101,000 and 300,000 monthly, reflecting an economically stable demographic that may prioritize the safety and affordability of new food products.

Awareness of gene-edited foods, as shown in Table 2, is relatively high among the respondents, with 75% aware of gene-edited maize and 73.9% aware of gene-edited tomatoes (see also figure 1). This level of awareness is likely due to the prominence of these crops in the media and their importance as staple foods. However, awareness is lower for other gene-edited products, such as dairy (64.9%) and yams (44.7%), indicating that certain gene-edited foods are less recognized by the public. This aligns with findings from the Food Standards Agency (2021) in the UK, where awareness of genome-edited foods was generally low, and consumers often confused them with genetically modified foods.

The discussion of food technology neophobia in Table 3 reveals that over half of the respondents (56.9%) express uncertainty about new food technologies, reflecting a cautious attitude toward their adoption. This finding is consistent with earlier research, which suggests that consumers are often skeptical of new food technologies due to concerns about potential health risks and the naturalness of the products Heiman et al., 2011; Siegrist and Hartmann 2020; Román, et al., 2017; Giacalone, 2023). Furthermore, 43% of respondents believe that new technology foods are less healthy than traditional foods, which underscores the persistent skepticism surrounding food innovations. Despite this, a significant portion of respondents (60%) disagrees with the notion that there is no need for new food technologies, indicating recognition of the potential benefits of these innovations in addressing global food security challenges.

Respondents also show a strong belief in the positive impacts of new food technologies, particularly in terms of controlling food choices (80.4%) and contributing to a balanced diet (45.3%). However, concerns about the long-term environmental effects (39%) and the risks of rapid adoption of these technologies (54.2%) highlight the need for careful consideration and transparent communication regarding the implications of these technologies. These concerns align with findings from previous studies, which emphasize the importance of addressing environmental and health risks to gain public trust (Giacalone and Jaeger 2023; Balog-Way et al., 2020; Idris et al., 2023; Lofstedt, 2013).

The perception of the benefits and risks associated with gene editing technology, as outlined in Table 4, shows that respondents generally recognize the significant benefits of gene editing, particularly in creating foods with enhanced nutritional value (WMS = 1.12) and producing insect-resistant crops (WMS = 1.16). These findings are consistent with existing literature that highlights the potential of gene editing to contribute to sustainable agriculture and food security Lofstedt, 2013; Tyczewska et al., 2023; Ndudzo et al., 2024). However, the perceived environmental risks (0.16), including concerns about the death of non-target insects and the loss of original plant varieties, reflect ongoing fears about the unintended consequences of these technologies.

Health risks associated with gene-edited foods are perceived as relatively low (0.13), but concerns remain about potential allergies (0.51) and antibiotic resistance (0.53). These findings suggest that while the public may recognize the benefits of gene editing, there is still significant anxiety about the possible health implications, which mirrors the divided public opinion noted in other studies (Ndudzo et al., 2024; Tripathi, et al., 2022; Baylis, 2019; Allum et al., 2008).

Ethical concerns, such as the belief that gene editing is unnatural or akin to "playing God," were expressed by 59.6% of respondents, reflecting deep-seated moral objections to the manipulation of genetic material. However, the relatively low equity concerns score (0.11) suggests that the public does not strongly perceive gene editing as disproportionately benefiting multinational producers at the expense of smaller farms. This indicates that while ethical concerns are prominent, the public may be more open to gene editing if it is seen as benefiting a broader range of stakeholders.

The result presented on Table 5 was the parameter estimate of willingness-to-pay for gene-edited food in the study area. From the table, the coefficient of age was negative and significant at 5% level, this indicated that increase in age of the respondents will reduce the likelihood of willingness-to-pay for gene-edited food; that is, respondents are less-likely to pay for gene-edited food as their age increases by 3.94%. Meanwhile, household size showed that there will be increase in chance of the respondents' willingness-to-pay for gene-edited food as there is increase in the number of household members. Also, the coefficient of income revealed the willingness of the respondents to pay for gene-edited food with increase in the income of the household head by 82.6%, provided all other variables are held constant, that is, household head with increased income are likely to pay for gene-edited food more than those with low income. Furthermore, it is evidence in the result that more respondents are likely to pay for gene-edited food with increased nutritional value. Though, with higher chance of risk of allergies, there will be reduction in the likelihood of willingness-to-pay for gene-edited foods. But good food quality is said to promote the chance of willingness-to-pay for gene-edited foods. The coefficient of the variable was found positive and significant at 1% level.

5. Conclusions

The discussion of the study's findings reveals a complex and nuanced public perception of gene editing technologies, influenced by socio-demographic factors, awareness levels, and inherent skepticism towards new food technologies. While the respondents recognize the potential benefits of gene editing, particularly in enhancing nutritional value and crop resilience, significant concerns remain regarding the long-term environmental impacts, health risks, and ethical implications. The results indicate that a well-educated and economically stable population is more likely to engage with these technologies, yet their acceptance is contingent upon transparent communication, rigorous testing, and effective regulation.

To build public trust and support the responsible adoption of gene editing in agriculture, it is essential to address these concerns through targeted education and communication strategies. By ensuring that the public is well-informed and that their ethical and environmental apprehensions are taken seriously, stakeholders can foster a more favorable environment for the integration of gene editing technologies into the food system.

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The authors have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors therefore declare that there is no conflict of interests regarding the publication of this article".

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7. Appendix - Reliability of the Constructs

Variables	Average inter-item covariance	Scale Reliability Coefficient
Benefits and risk perception indices toward gene editing technology		
Perceived benefits	0.4521315	0.9718
Perceived environmental risks	0.2483162	0.7223
Perceived health risks	0.3508631	0.8591
Ethical concerns	0.324843	0.8278
Equity concerns	0.491533	0.7839

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