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Research Article

Factors Influencing the Choice of Aflatoxin-inhibiting Technologies Among Smallholder Groundnut Farmers in Elgeyo Marakwet and Baringo Counties in Kenya

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Abstract

Access and use of Aflatoxin-inhibiting technologies among smallholder farmers can improve their livelihoods and reduce post-harvest losses due to Aflatoxin contamination. However, the use of technologies including drying technologies, shelling, hermetic storage, resistant seeds, Aflasafe, and Good Agricultural Practices (GAP) remains low among smallholder groundnut farmers. This study assesses the factors influencing the choice of Aflatoxin-inhibiting technologies for increased production and marketability of groundnuts in farming households. Data analysis was conducted using SPSS and STATA 18. Descriptive statistics were used to examined current practices, while a multi-stage sampling approach was used to select 384 smallholder farmers from Elgeyo Marakwet and Baringo Counties in Kenya. A multivariate probit model was used to determine the factors influencing the choice of Aflatoxin inhibiting technologies. The study highlights that farmers' decision to adopt Aflatoxin-inhibiting technologies was significantly influenced by gender, sales price, group membership, fertiliser use, household size, land size, household income, extension access, use of improved groundnut varieties and distance to market. The study provides insights into the dynamics of adoption of Aflatoxin-inhibiting technology. It underscores the need for strengthening group membership, extension service delivery and social network programs for farmer information dissemination to promote adoption and enhance agricultural productivity to improve the livelihoods of smallholder farmers in Kenya.

Keywords

Groundnuts, Aflatoxin-inhibiting Technologies, Adoption, Smallholder Farmers, Kenya

1. Introduction

In Kenya, groundnuts play a vital role in enhancing household food security, generating employment, and providing income that surpasses the earnings from an equivalent area planted with maize [1]. They are used as a source of edible oil, and animal feed, and are consumed in different forms such as roasted, blanched, raw, or processed into peanut butter. Despite their significance to food security and livelihood enhancement in Kenya, groundnuts are a major source of human exposure to aflatoxins. The susceptibility of groundnuts to aflatoxins is linked to suitable growth condi-

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tions for fungi such as optimum temperatures and high humidity [2]. Aflatoxin contamination can occur either in the field or after harvest, with poor storage practices being a key contributor to fungal growth that leads to mycotoxin production [3]. Other causes of aflatoxin contamination are production practices and poor post-harvest handling techniques.

The primary fungi responsible for producing aflatoxins are Aspergillus flavus and Aspergillus parasiticus, which thrive in warm and humid environments [3]. These fungi commonly infect crops such as maise, groundnuts, cottonseed, pearl millet, wheat, and various tree nuts. Environmental factors that contribute to aflatoxin contamination include plant stress from drought, high temperatures, and insect damage, all of which promote fungal development in the soil [4]. Visible signs of aflatoxin contamination in groundnuts include mould growth, discolouration, shrivelling, deformation, and insect damage.

Consequently, the quality of groundnut is lowered, and productivity is significantly affected. It suppresses the immune system, causing cancer retard growth in humans and livestock. It affects the economic value of groundnuts and the revenue earned by smallholder farmers. Other constraints affecting groundnut productivity are the limited availability of improved tolerant and low-yielding varieties. However, information regarding the adoption of multiple innovations and technologies in Elgeyo Marakwet and Baringo counties is not well documented.

Existing studies show that the adoption of aflatoxin-inhibiting technologies is influenced by a combination of institutional, personal, household, demographic, and broader socioeconomic factors. Previous studies have identified key factors driving the adoption of groundnut technologies, including input costs, landholding size, access to extension services, training, availability of credit facilities, fertiliser use, and the overall economic status of the household [5-8]. In addition, variables such as education, age, and the level of income generated from farming activities also play a significant role in influencing adoption [8]. Similarly, off-farm income, experience, price of groundnuts and group membership affect the decision to adopt groundnut technologies [9].

Although existing studies have provided evidence on some of the factors influencing technology adoption. The above-mentioned studies assumed adoption was binary or categorical, ignoring the simultaneous adoption of multiple technologies. Additionally, the determinants of the adoption of Aflatoxin-inhibiting technologies remain under-explored. The available literature focused on factors influencing the adoption of improved groundnut seeds [7, 10], hermetic storage [11, 12], drying technologies [6], disinfestation, detoxification, inactivation, filtration, and use of binding agents [13]. According to [14], shelling and the use of Alfasafe and GAP are also key Aflaton-inhibiting technologies. Understanding the drivers of low adoption among farmers is important for upscaling and welfare improvement for Kenya and many developing countries with similar challenges of low adoption. Therefore, this study assesses the factors influencing the adoption of Aflatoxin-influencing technologies in Elgeyo Marakwet and Baringo Counties, which are among the leading producers of groundnuts in Kenya.

2. Materials and Methods

2.1. Study Area

The study was undertaken in Keiyo South Sub-County of Elgeyo Marakwet County and Baringo Central Sub-County of Baringo County, as illustrated in Figure 1. The selection of these counties was informed by evidence from Farmer Trends (2024), which identifies them as among the leading producers of groundnuts in Kenya, thus providing a relevant context for investigating issues related to groundnut production.

Elgeyo Marakwet County, situated in Kenya's Rift Valley region, covers approximately 3,029.6 square kilometers, and lies between latitude 0°20′ to 1°30′ North and longitude 35°00′ to 35°45′ East. It is bordered by West Pokot County to the north, Baringo County to the east, Trans Nzoia County to the northwest, and Uasin Gishu County to the west (CIDP, 2018-2022). According to the 2019 Kenya Population and Housing Census, the county has a population of approximately 454,840 individuals. It comprises four administrative sub-counties: Keiyo North, Keiyo South, Marakwet East, and Marakwet West.

Climatic conditions in the county vary with altitude. According to data from the Elgeyo Marakwet County Meteorological Department (2022), the highland areas experience mean annual temperatures ranging between 18 ℃ and 22 ℃, while the Kerio Valley records higher temperatures, ranging between 25 ℃ and 28 ℃. Annual rainfall ranges from 700 mm in the drier Kerio Valley to 1,700 mm in the wetter highlands, particularly around the Cherangany Hills. The county's economy is predominantly agrarian, with over 80% of the population engaged in mixed farming. Major crops include maise, beans, groundnuts, wheat, and millet [15]. Approximately 40% of the county lies within the Kerio Valley, which is particularly suitable for livestock production and the cultivation of annual crops such as groundnuts [16]. The county also hosts the largest groundnut cooperative, located near Kapkayo market in Soy South ward, within Keiyo South Sub-County [17]. Given this agricultural significance, Soy South and Soy North wards were purposively selected for the study.

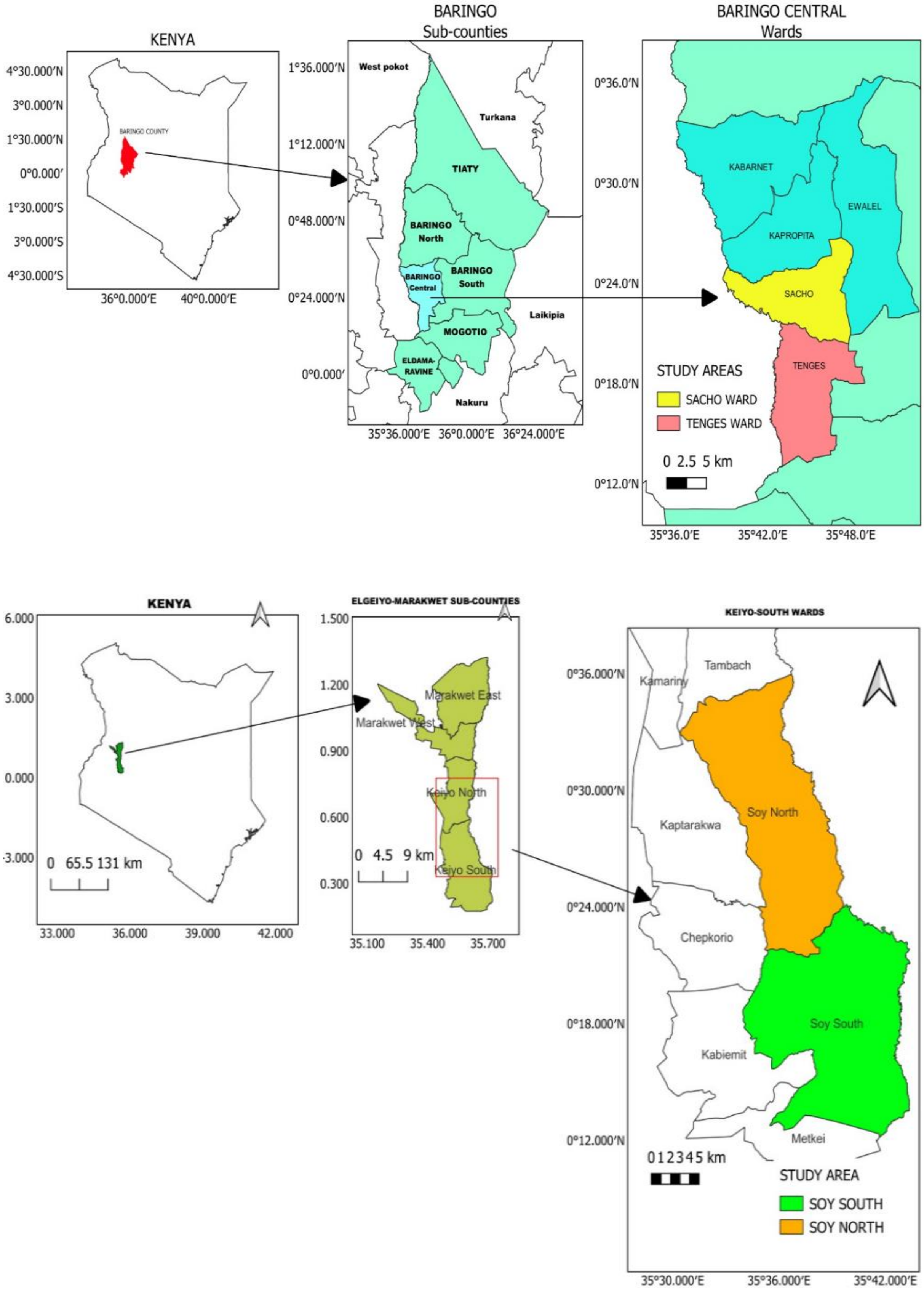

Figure 1. *Map of the Study Area.*

Baringo County, also located in the Rift Valley region, covers an estimated area of 11,075.3 square kilometers. It shares borders with Turkana County to the north, Samburu and Laikipia Counties to the east, Nakuru County to the south, Kericho and Uasin Gishu Counties to the southwest, West Pokot County to the northwest, and Elgeyo Marakwet County to the west. Geographically, it lies at approximately latitude 0.8555° North and longitude 36.0893° East. The 2019 national census recorded a population of approximately 666,763 residents. The county consists of six sub-counties: East Pokot, Marigat, Baringo North, Baringo Central, Koibatek, and Mogotio.

Climatically, Baringo County experiences annual temperatures ranging from 10℃ to 35℃. Rainfall patterns are generally low and erratic, averaging between 300 mm and 500 mm, with precipitation decreasing progressively from the southern to the northern parts of the county. Agriculture remains the backbone of the county's economy, with residents engaging in dairy farming and the cultivation of crops such as maise, groundnuts, coffee, and cotton. According to the Baringo County Integrated Development Plan (CIDP 2023-2027), Baringo Central Sub-County is prioritised for investment in oilseed and groundnut value chains, given its comparative advantage in these crops. Consequently, Tenges and Sacho wards in Baringo Central were selected as focal areas for the study.

2.2. Sampling Procedure

A multistage sampling technique was employed in the study. The smallholder groundnut producers using innovations and technologies for managing aflatoxin contamination are widely spread thus making the construction of a sampling frame costly. In the first stage, Keiyo South in Elgeyo Marakwet and Baringo Central in Baringo counties were purposively selected because they are among the leading producers of groundnuts in Kenya. In the second stage, two wards from each sub-county were purposively selected because of having the largest groundnut cooperative in Elgeyo Marakwet and targeted by Baringo CIDP for groundnut projects respectively. The third stage involved a systematic sampling of smallholder groundnut producers within the chosen wards. A list obtained from the agricultural officers of the respective sub-counties were used to identify the respondents in the two wards that were considered. The respondents were selected using systematic sampling using the Kth interval to give a total of 384 respondents as per list provided.

2.3. Sample Size

The determination of the sample size followed the proportionate sampling methodology specified by Cochran [18] as follows:

$$n = \frac{z^2\,pq}{e^2} \quad (1)$$

Where: n = sample size, p= implies maximum possible variance q = 1-p, z = the standard value at a given confidence level (α = 0.05), e = the acceptable error (precision). The study desired a 95% confidence level and a 5% precision level with a z score of 1.96. In addition, the study assumed that p=0.5, since the number of smallholder groundnut farmers in the study area is not known.

The sample was determined as:

$$n = \frac{(1.96)^2\,(0.5)(0.5)}{(0.05)^2} = 384 \quad (2)$$

The derived sample size for the study will be 384 respondents.

2.4. Sampling Procedure

A multistage sampling technique was employed in the study. The smallholder groundnut producers using innovations and technologies for managing aflatoxin contamination are widely spread thus making the construction of a sampling frame costly. In the first stage, Keiyo South in Elgeyo Marakwet and Baringo Central in Baringo counties were purposively selected because they are among the leading producers of groundnuts in Kenya. In the second stage, two wards from each sub-county were purposively selected because of having the largest groundnut cooperative in Elgeyo Marakwet and targeted by Baringo CIDP for groundnut projects respectively. The third stage involved a systematic sampling of smallholder groundnut producers within the chosen wards. A list obtained from the agricultural officers of the respective sub-counties were used to identify the respondents in the two wards that were considered. The respondents were selected using systematic sampling using the Kth interval to give a total of 384 respondents as per Table 1.

K th = N/n where N is the total population and n is the desired sample size.

Table 1. *Sample size per selected ward.*

Sub county/Ward	Number of Households	Proportion to size (%)	Sample
Elgeyo Marakwet			
Keiyo South Sub County			
Soy South ward	8,140	47	180
Soy North ward	2,791	16	61
Total	10,931	63	241
Baringo County			
Baringo Central			
Tenges ward	3,058	18	69
Sacho ward	3,340	19	73
Total	6,398	37	143

Sub county/Ward	Number of Households	Proportion to size (%)	Sample
Overall Total	17,329	100	384

Source: KNBS (2019)

Data Collection

Primary data collection was collected through interviews using a semi-structured questionnaire which was administered to smallholder groundnut producers. Questionnaires contained both open-ended and closed-ended questions that allow the researcher to collect data on the use of innovations and technologies for managing aflatoxin contamination and their effect on the productivity of groundnuts in Elgeyo Marakwet and Baringo Counties in Kenya.

2.5. Analytical Strategy

This study considered the 8 commonly used innovations and technologies namely drying techniques, threshing, mechanical shelling, hermetic storage bags (e.g., PICS bags), GAPs, irrigation technologies, quality/resistant seed variety, and biological agents. The study used a Multivariate Probit (MVP) model to analyse the factors that influence the choice of different aflatoxin-inhibiting technologies among smallholder farmers in Elgeyo Marakwet and Baringo counties, Kenya. The multinomial logit (MNL) model and the logit model are also appropriate for this research, as the dependent variables have more than two outcomes or categories. The MNL model is suitable when the decision maker chooses one alternative from a set of different choices [19]. It is also employed when farmers can choose an outcome from a set of mutually exclusive alternatives. However, in this study, aflatoxin-inhibiting technologies are not mutually exclusive, and smallholder farmers can choose more than two technologies.

In this study, the choice of aflatoxin-inhibiting technologies used by smallholder groundnut producers represents a multiple response that is not mutually exclusive. This implies that the MVP model was applied in this research as smallholder farmers can choose to use aflatoxin-inhibiting technologies simultaneously. The econometric model of this study is characterised by a set of dependent variablesY_{it}. The functional form of the MVP model is specified as follows:

$$Y_{it}^{*} = \beta_{it}X_{it} + \varepsilon_{it} \text{ with } (t=1, 2, \ldots 8). \tag{3}$$

Where (t=1, 2,…8) represents the choice of aflatoxin-inhibiting technologies including drying techniques, threshing, mechanical shelling, hermetic storage bags (e.g., PICS bags), GAPs, irrigation technologies, quality/resistant seed variety, and biological agents, X_{it} is a 1× k vector of all factors that affect the choice of aflatoxin-inhibiting technologies, β_{it} represents k × 1 vector of the parameter to be estimated, i[th] farmer is given I (1, 2,...., n) to choose aflatoxin-inhibiting technologies and ε_{it} (t= 1,…., m) represents error terms. The observed outcome for choosing the different aflatoxin-inhibiting technologies was modelled as follows,

$$Y_{it}\ [1\ if\ Y_{it}^{*} > 0\ 0\ otherwise \text{ t= 1, 2 8; 0 = otherwise}$$

In this study, smallholder groundnut farmers choose aflatoxin-inhibiting technologies based on the expected maximisation of utility. Since the choice of aflatoxin-inhibiting technologies is not mutually exclusive, the choice of the technologies can include a simultaneous use of 8 different technologies. Consequently, the system of equations for each technology becomes:

$$Y_i^{*} = \beta_i X_i + \varepsilon_i \tag{4}$$

where, Y_i^{*} = aflatoxin-inhibiting technology.

The unknown parameters of equation (4) are estimated by simulated maximum likelihood. Consequently, the implicit functional form was estimated to determine the factors that influence the decision to choose aflatoxin-inhibiting technologies by smallholder groundnut farmers will be given:

$$Y_i = \beta_0 + \beta_1\text{Age} + \beta_2\text{Gend} + \beta_3\text{Educ} + \beta_4\text{Exp} + \beta_5\text{HHsize} + \beta_6\text{Train} + \beta_7\text{Group} + \beta_8\text{Credit} + \beta_9\text{Mktdst} + \beta_{10}\text{Exten} + \beta_{11}\text{Price} + \beta_{12}\text{Usefullness} + \beta_{13}\text{Fmize} + \beta_{14}\text{Variety} + \beta_{15}\text{Ownland} + \beta_{16}\text{Fertlza} + e_i \tag{5}$$

where, Y_i represents the choice of the aflatoxin-inhibiting technologies used by smallholder groundnut farmers. β_0 is a constant, β_1 to β_{15} are coefficients and e_i is the error term. Table 1 presents the variables used in the study.

Table 2. *Variables used in the MVP model.*

Variable	Description of variables	Priori assumptions
Dependent		
Aflatoxin-Inhibiting Technologies	Drying techniques (1- Yes, 0 - No) Threshing (1- Yes, 0 - No) Mechanical shelling (1- Yes, 0 - No)	

Variable	Description of variables	Priori assumptions
	Hermetic storage bags (e.g., PICS bags) (1- Yes, 0 - No)	
	GAPs (1- Yes, 0 - No)	
	Irrigation technologies (1- Yes, 0 - No)	
	Quality/resistant seed variety (1- Yes, 0 - No)	
	Biological agents (1- Yes, 0 - No)	
Independent		
Age	Age of the farmer in years	+/-
Gender	Gender of the farmer (1 - Male, 0 - Female)	+/-
Education	Level of education of the farmer (Number of years in school)	+/-
Household income	Income per year in KES	+/-
Experience	Level of experience of the farmer (In years)	+
Household size	Number of members in a household	+/-
Training	Access to training by the farmer (1-Yes, 0-No)	+
Group membership	Membership to group (1- Yes, 0 - No)	+
Credit	Access to credit by the farmer (1-Yes, 0-No,)	+
Market distance	Distance in Kilometers to the market	+/-
Extension	Access to extension services (1-Yes, 0-No,)	+/-
Buying price	Cost of technology in KES	+/-
Usefulness	Time-saving and quality improvement ability of the technology (1 - Yes, 0 - No)	+/-
Farm size	Size of the farm in acres	+/-
Variety grown	Use of improved or traditional seeds (1 - Yes, 0 - No)	+/-
Land ownership	Land tenure system (Owned - Yes, Rented- No)	+/-
Fertiliser use	Use of fertiliser in growing groundnuts (1 - Yes, 0 - No)	+/-

3. Results and Discussions

3.1. Diagnostic Tests

3.1.1. Multicollinearity Test

Table 3. Test for multicollinearity among explanatory variables.

	VIF	1/VIF
Age	1.803	.555
Farming Experience	1.755	.57
Education	1.518	.659
Income	1.225	.816
House size	1.182	.846
Fertiliser use	1.153	.867

	VIF	1/VIF
Group Membership	1.14	.877
Land Size	1.136	.88
Income farming	1.127	.888
Improved variety	1.112	.899
Sales Price	1.104	.906
Cost of Technologies	1.09	.918
Gender	1.084	.923
Distance to Market	1.076	.93
Extension access	1.065	.939
The usefulness of the technologies	1.042	.96
Mean VIF	1.226	.

A Variance Inflation factor (VIF) was used to determine multicollinearity among the explanatory variables. The VIF mean value is 1.3, which is below the acceptable threshold value of 5 (Table 2). This implies that multicollinearity is not a problem; all values are below the recommended threshold of 5.

3.1.2. Pairwise Correlation for Categorical Variables

A pairwise correlation was used to test for correlation among the categorical variables. All values were below the threshold of 0.5, indicating that the variables are not correlated (Table 3).

Table 4. *Pairwise correlation for categorical variables.*

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Gender	1.000					
(2) Credit access	0.039	1.000				
(3) Fertiliser use	-0.049	0.077	1.000			
(4) Extension access	0.069	0.067	-0.054	1.000		
(5) Training	0.067	0.168	0.170	0.305	1.000	
(6) Group membership	0.039	1.000	0.077	0.067	0.168	1.000

3.1.3. Heteroscedasticity Test

The Breush-Pagan test was used to test for heteroscedasticity. The test indicated the presence of heteroscedasticity due to a significant p-value. Heteroscedasticity was addressed using robust standard errors in the models.

3.2. Factors Influencing the Adoption of Different Aflatoxin-inhibiting Technologies

A multivariate probit model was used to achieve this objective. Table 4 presents the socioeconomic factors influencing the adoption of different Aflatoxin-inhibiting technologies. These technologies include drying, shelling, hermetic storage, resistance seeds, Afla safe, and good agricultural practices. The model is highly significant (Prob > chi2 =0.0000) indicating that the variables used in the model explain the variation in the dependent variable.

Age of the respondents emerged as a significant factor with a negative influence on the adoption of resistant seeds achieving a notable significant level of 5%. The findings posits that a decrease in the likelihood of adopting the use of resistant seeds with an increase in the age of farmers. Plausibly, because older farmers prefer to maintain a status quo on adopting mainly due to continuous appraisal and the risks associated with the new technologies. Young farmers on the contrary are better placed on adopting new technologies due to a wide knowledge diffusion and increased ease of integrating new technology. The finding corroborated with the findings by [20] which posited a negative correlation between age and the adoption of improved rice varieties in Ghana, asserting it to risk aversive nature of older farmers as compared to their young counterparts.

Table 5. MVP estimates for determinants of uptake of technologies.

Drying			Shelling		Hermetic storage		Resistant seeds		Alfla safe		GAP	
	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.	Coeff.	Std.
Age	-0.252	0.162	-0.257	0.340	-0.247	0.205	-0.588**	0.251	0.156	0.175	-0.308	0.190
Gender	-0.083	0.150	-0.561*	0.320	-0.063	0.183	-0.165	0.205	0.674***	0.188	0.013	0.172
Household size	0.042	0.037	-0.060	0.062	0.071	0.044	-0.121***	0.046	0.069***	0.041	-0.065	0.044
Household Income	-0.236	0.276	0.917**	0.439	-0.033	0.394	0.640*	0.358	0.252	0.312	0.849***	0.312
Education	-0.008	0.107	-0.176	0.174	0.156	0.145	-0.116	0.144	-0.003	0.122	0.015	0.131
Experience	0.014	0.010	-0.003	0.024	0.008	0.015	0.023	0.014	-0.017	0.012	0.009	0.012
Sales Price	-0.072	0.081	0.215	0.202	0.041	0.105	-0.344**	0.099	-0.250***	0.088	-0.193**	0.090
Group Membership	-0.013	0.189	1.364***	0.406	0.846***	0.230	0.787***	0.209	0.037	0.219	0.722***	0.213
Fertiliser	0.126	0.216	-1.052*	0.562	-1.092***	0.402	-0.616**	0.261	0.140	0.255	-0.566**	0.286
Extension	0.598**	0.152	0.137	0.273	0.143	0.199	-0.153	0.196	0.811***	0.168	-0.085	0.177
Land size	-0.010	0.035	0.134***	0.043	0.025	0.054	0.110**	0.045	-0.105**	0.048	0.124***	0.043
Groundnut Variety	0.041**	0.019	0.287	0.369	0.029	0.024	-0.029	0.023	0.037	0.024	-0.024	0.020
Distance	0.024*	0.014	-3.778**	1.519	0.079***	0.019	-0.033	0.022	-0.035*	0.021	0.002	0.018
_cons	0.237	0.650	-0.257**	0.340	-3.902***	0.846	0.591	0.759	-1.317*	0.713	-0.764	0.781
Number of observations												
Prob > chi2 = 0.0000												
Wald chi2 (77) = 332.75												
Log pseudolikelihood = -703.97686												

***, **, * denotes significant at 1%, 5% and 10% respectively

Group membership exhibited a positive correlation with the adoption of shelling, hermetic storage, resistant seeds, and GAP at the 1% significance level. As a farmer becomes a group member individual participation significantly accelerates the uptake of these technologies. This effect is likely attributable to the role of group membership in facilitating information dissemination among farmers, thereby enhancing the ease of adoption and implementation. [21] emphasised that group membership serves as a conduit for knowledge diffusion and awareness creation, fostering a greater propensity among farmers to adopt new agricultural technologies as a strategy for mitigating post-harvest losses in Kenya.

Fertiliser use exhibited a negative relationship with the adoption of Good Agricultural Practices (GAP) and hermetic storage at a 1% significance level, resistant seed varieties at a 5% significance level, and improved shelling techniques at a 10% significance level. The study found that an increase in fertiliser usage reduced the likelihood of adopting these technologies, likely because resource constraints force farmers to prioritise inputs perceived as more immediately beneficial. Notably, the increased expenditure on agricultural inputs can create financial trade-offs, limiting the adoption of alternative technologies. These findings align with [22], who emphasised the importance of agricultural input subsidies in enhancing the adoption of improved technologies. Agricultural inputs are vital, as they influence farm productivity and profitability, which in turn affects farmers' capacity and willingness to invest in complementary innovations.

The study established a positive and significant relationship between income generated from the sale of agricultural produce and the adoption of Good Agricultural Practices (GAP), improved shelling techniques, and resistant seed varieties, with significance levels of 1%, 5%, and 10%, respectively. Higher income levels increased the likelihood of adopting these technologies among groundnut farmers, likely because income serves as a financial buffer, mitigating potential risks associated with adopting new agricultural innovations. These findings are in line with the study by [23] in Nepal on the adoption of post-harvest techniques, the study posits that income from agricultural produce plays a vital role on adoption of new technology among farmers.

Household size exhibited a dual effect on technology adoption, showing a negative correlation with the adoption of resistant seed varieties and a positive correlation with the adoption of Alfla safe, both at the 1% significance level. Specifically, larger households were less likely to adopt resistant seed varieties but more inclined to adopt Afla safe. This dynamic may be attributed to household decision-making processes and the availability of disposable income, which influence the prioritisation of agricultural technologies. Contrary to these findings, Melesse *et al.* [24] observed that households with a larger number of active members tend to adopt agricultural technologies more readily, as increased family participation enhances information sharing and collective decision-making.

The study established a significant relationship between gender and technology adoption. Gender was positively correlated with the adoption of Alfla safe at a 1% significance level but negatively correlated with the adoption of shelling. The findings indicate that male farmers were more likely to adopt Aflasafe, whereas female farmers exhibited a higher propensity to adopt shelling as a strategy for reducing post-harvest losses. This trend is likely driven by differences in resource access and household labour responsibilities. Male farmers generally have greater access to financial and technical resources, facilitating the adoption of Aflasafe. Meanwhile, cultural factors may influence female farmers to prioritise shelling as a practical and cost-effective method for minimising post-harvest losses. The findings are in line with [7], on adoption of improved technology in Tanzania, who found out that male farmers have access to productive resources and that decision making is mandated by male farmers while crowding out their female counterparts.

The study revealed that extension services had a significant positive impact on the adoption of Alfla safe and drying technologies among groundnut farmers, at the 1% and 5% significance levels, respectively. Farmers with access to extension services demonstrated greater efficiency in adopting aflatoxin inhibiting technologies compared to those with limited or no access. This underscores the critical role of extension services in raising awareness and disseminating information on the applicability and benefits of agricultural innovative technologies. These findings are consistent with [25] who emphasised the pivotal role of extension services in facilitating the adoption of improved technologies among groundnut farmers in Eastern Ethiopia.

The study revealed a positive correlation between land sizes owned by groundnut farmers and the choice of shelling and GAP at a 1% level of significance, the use of resistant seeds at 5% significance level, while Afla safe had a negative effect at 5% level of significance. An increase in the size of land under groundnut production by 1 unit increased the probability of adopting shelling, GAP and the use of resistant seeds, while decreasing the likelihood of using Afla-safe technology. Large tracts of land enhance farmers economies of scale, risk aversion and thus positively reduce the costs associated with agricultural inputs making it easy for farmers to integrate other technologies. The findings corroborated with [26] who posited that land size positively influenced the incorporation of agricultural technologies in farming.

The study found a significant positive relationship between the variety of groundnuts used and the adoption of drying technologies as a strategy to reduce post-harvest losses at the 5% significance level. Access to improved groundnut varieties serves as a catalyst for adopting new technologies, as farmers seek to enhance productivity. This is because improved varieties often offer higher yields, better resistance to pests and diseases, and shorter maturation periods, making them more attractive to farmers who are willing to invest in complementary technologies such as drying to maximise their benefits. These findings align with Vabi *et al.* [27], who reported that improved groundnut varieties played a key role in influencing the adoption of groundnut technologies in Nigeria.

4. Conclusion and Recommendations

The use of aflatoxin-inhibiting technologies has the potential to significantly improve the livelihoods of smallholder groundnut farmers by reducing post-harvest losses and increasing the marketability of groundnuts. Despite these benefits, the adoption of technologies such as proper drying and shelling methods, hermetic storage, resistant seed varieties, Aflasafe, and Good Agricultural Practices (GAP) remains low among farmers in Elgeyo Marakwet and Baringo Counties. The study reveals that farmers' decisions to adopt these technologies are influenced by a variety of factors, including gender, household size, land size, off-farm income, access to extension services, group membership, use of improved seed varieties, and the distance to markets. These findings highlight the importance of well-structured extension programs and strong social networks in disseminating knowledge, building farmer confidence, and fostering collective learning. By leveraging these platforms, stakeholders can effectively promote the uptake of aflatoxin mitigation strategies, ultimately leading to improved food safety, reduced post-harvest losses, and enhanced livelihoods for smallholder farmers.

To enhance the adoption of aflatoxin-inhibiting technologies, there is a need to strengthen agricultural extension services. Improved extension support can facilitate the timely dissemination of information and build farmers' capacity to adopt recommended practices and technologies. It is also essential to implement gender-inclusive strategies that ensure both men and women have equal access to agricultural information, training, and inputs.

Furthermore, efforts should be made to improve farmers' access to critical inputs such as hermetic storage bags, resistant seeds, and Aflasafe. This can be achieved through the provision of subsidies, access to affordable credit, or by promoting cooperative purchasing models. In addition, improving rural infrastructure and market access will reduce the distance and logistical challenges farmers face, enabling them to access better market opportunities and receive incentives for producing aflatoxin-safe groundnuts.

Promoting income diversification through off-farm activities can also enhance farmers' ability to invest in improved technologies. Lastly, strengthening farmer groups and cooperatives can play a vital role in facilitating knowledge sharing, joint investments in technology, and collective marketing efforts.

Overall, these measures will not only promote the adoption of aflatoxin-inhibiting technologies but also contribute to safer food systems, increased incomes, and sustainable agricultural development in the region.

Abbreviations

CIDP	County Integrated Development Plan
Ha	Hectare
MT	Metric Tonnes
KNBS	Kenya National Bereau of Statistics
PH	Post-harvest
PPB	Parts per Billion
GAP	Good Agricultural Practices
Ug/Kg	Microgram per Kilogram
VIF	Variance Inflation Factor

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Author Contributions

Buba Daffeh: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Writing – original draft

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Ethical Approval

Data collection began following clearance from the National Commission for Science, Technology and Innovation (NACOSTI).

Informed Consent

Informed consent was obtained from the respondents verbally.

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Data Availability Statement

Data associated with this study will be made available upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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