ASSESSMENT OF POST-HARVEST LOSSES OF YAM IN KWALI AREA COUNCIL, FCT, ABUJA

*Ojodomo Emmanuel Yusufu, Musa Egahi and Terna Godfrey Ieren

Department of Mathematics and Computer Science, Benue State University, Makurdi, Nigeria.

*Corresponding authors' email: ojodomoy@gmail.com

ABSTRACT

Postharvest loss of yam has affected food security, economic growth, and the sustenance of millions of farmers particularly in the study area. This study investigates post-harvest losses (PHL) of yam (Dioscorea SPP) in Kwali Area Council, Federal Capital Territory, Abuja. A survey research design was adopted, targeting yam farmers in the study area, with a sample size of 400 participants selected through sampling proportional to size. Primary data were collected using structured quessstionnaires and analyzed using descriptive statistics and ordinal regression logistic analysis. Descriptive statistics was used to summarize the socio-economic characteristics of the yam farmers The result shows that majority of the respondents ((80%) had formal education, 90% of them were more than 20 years of age, 60% of the farmers were male, 90% of the farmers were more than 4 members in a family. Ordinal regression was used to determine the factors contributing to postharvest losses of yam. The result from the ordinal regression and perception of yam farmers showed that factors such as storage infrastructure, pest control, transportation, market conditions, preservation methods and farmers' education and training significantly contributed to postharvest losses of yam in the study area while factors such as, household size, farm size and farmers' experience were not significant and do not contribute to postharvest losses in the study area. Policymakers and agricultural stakeholders are encouraged to implement targeted interventions to mitigate postharvest loss. Further research is recommended to investigate other factors and their combined effects on yam production and loss in the region.

Keywords: Post Harvest Losses, Ordinal Regression, Yam, Food Security

INTRODUCTION

Postharvest loss is a global issue that affects food security, economic growth, and the sustenance of millions of farmers, particularly in developing countries. The Food and Agriculture Organization (FAO, 2021) estimates that around 14% of global food production is lost after harvest, with fruits and vegetables, including root crops such as yam, particularly vulnerable. Postharvest loss refers to the measurable decline in both the quality and quantity of agricultural produce between the time of harvest and the time of final consumption. In Sub-Saharan Africa, these losses are especially severe due to poor infrastructure, lack of access to storage technology, limited knowledge, and weak market linkages (Sugri, et al, 2021).

In Africa, yam is an essential crop, and Nigeria being responsible for over 70% of global yam production, is the world's largest yam producer (Kumar & Kalita, 2017). As a tropical tuber crop, yam is cultivated in Africa, the south Pacific Islands, South America, Asia and the Caribbean. Yam is the most important tuber crop cultivated in Africa after cassava. And while there are over 644 species that belong to the genus Dioscorea, just a handful of that number is cultivated. (Andres *et al*, 2017). However, the postharvest loss of yam remains a substantial challenge, with losses from as much as 20% to 60%, dependent on the region and conditions. As relates to Nigeria, yam is not just a food source but also a crucial player in the economy, as it is a key export product and provides livelihood for millions of farmers. Yet, the factors that contribute to postharvest loss in yam production have not been sufficiently addressed, leading to substantial economic and food security challenges.

One of the primary factors contributing to postharvest loss of yam is storage infrastructure. Proper facilities for storage are crucial for extending the shelf life of yams after harvest, as yams are highly perishable and due to their high moisture content, quite susceptible to spoilage (Ogundele, 2022). In many rural farming areas in the Kwali Area Council of the

Federal Capital Territory (FCT), the lack of modern storage facilities, such as cool rooms or well-ventilated storage sheds, results in the rapid deterioration of harvested yam (Kumar & Kalita, 2017). The reliance on traditional storage methods, such as placing yams in poorly ventilated huts, exposes them to moisture, pests, and diseases, which accelerate spoilage.

Another significant factor contributing to postharvest loss in yam production is pest control. Yams are highly susceptible to pest attacks, including the yam beetle, termites, and rats, as well as various fungal and bacterial diseases. These pests and diseases often cause significant damage to yam tubers during storage, which leads to a substantial loss in the quantity and quality of the harvest. Inadequate pest control measures, such as the absence of proper fumigation, and the reliance on outdated pest management techniques, exacerbate this issue in many farming communities in Kwali Area Council (Ogundele, 2022).

Transportation is another critical factor in the postharvest loss of yam. Poor road infrastructure, particularly in the rural areas of Kwali, affects farmers' ability to transport their yams to markets quickly and efficiently (Mayienga & Cachia, 2021). Delays in transportation result in spoilage due to exposure to heat, moisture, and pests. Inadequate transportation facilities, such as proper vehicles or refrigerated trucks, further contribute to the loss of yam during transit. The high transportation cost and the unavailability of appropriate vehicles also discourage farmers from reaching distant markets, further exacerbating postharvest loss.

Market accessibility is one other significant factor that contributes to postharvest loss in yam production. Farmers in rural areas often face difficulties accessing markets where they can sell their yam produce at fair prices. This problem is often exacerbated by the lack of market information, poor communication systems, and the dominance of middlemen who exploit farmers by offering low prices for their produce (Kumar & Kalita, 2017). The inability to access larger, more profitable markets often forces farmers to sell their yams

locally at mu prices, leading to significant postharvest losses, as yams that do not sell quickly are left to spoil.

Preservation technologies are also vital in reducing postharvest loss of yam. In many rural areas, farmers still rely on traditional preservation methods such as sun-drying, smoking, or storing yams in heaps, which are not effective in preventing spoilage. Modern preservation technologies, such as the use of refrigerated storage or improved packaging methods, can significantly prolong the shelf life of yams and mitigate losses (Ogundele, 2022). However, the high cost of such technologies, as well as the limited awareness and technical skills among farmers, limits their adoption in several areas of the Kwali Area Council.

Farmer education and training are crucial in addressing the factors responsible for the postharvest losses of yam. Many farmers in the region lack the necessary knowledge and skills to implement modern farming and postharvest management techniques, including proper storage practices, pest control methods, and transportation strategies (Mayienga & Cachia, 2021). The absence of adequate training programs, extension services, and access to agricultural information further perpetuates these challenges. Increasing farmers' access to education and training on the best practices for yam cultivation, storage, pest control, and marketing can significantly reduce postharvest losses.

The interrelationship between these variables is complex, as each factor influences and exacerbates the others. For example, poor storage infrastructure can increase the risk of pest and disease infestation, which in turn increases the need for better pest control measures and proper preservation technologies. Similarly, inadequate transportation infrastructure can hinder farmers' ability to access markets, making it difficult to sell their produce before it spoils, thus leading to greater losses (Ogundele, 2022). Furthermore, a lack of farmer education and training can perpetuate poor storage and transportation practices, which ultimately result in increased postharvest losses.

Addressing the issue of postharvest loss in yam production demands a holistic approach that takes all these factors into consideration, as well as their interconnections. A comprehensive strategy that includes improving storage infrastructure, pest and disease control, transportation facilities, market accessibility, the adoption of modern preservation technologies, and farmer education and training is essential for reducing postharvest losses in the Kwali Area Council (Kumar & Kalita, 2017). Governments, agricultural organizations, and researchers must collaborate to implement sustainable solutions that will help farmers mitigate the factors responsible for postharvest loss.

In addition, policymakers need to prioritize investment in agricultural infrastructure and, make modern technologies and market information accessible to farmers. This could include providing subsidies or incentives for the construction of storage facilities, improving road infrastructure, and facilitating the adoption of new preservation technologies (Mayienga & Cachia, 2021). Furthermore, farmer education programs should be expanded to provide training on modern postharvest handling techniques, pest control, and market access strategies.

The postharvest loss of yam in the Kwali Area Council is not only a technical issue but also a socio-economic one, a challenge echoed by studies showing impacts on farmers income and livelihood (Agba et al, 2019). Addressing these challenges can significantly contribute to improving the livelihoods of farmers, enhancing food security, and boosting the local economy. Reducing postharvest loss will not only benefit farmers but also help in achieving broader development goals, such as poverty alleviation, sustainable agricultural practices, and food security (Rutta, 2024). The reduction of postharvest loss in yam production can therefore be viewed as a crucial step towards improving the economic well-being of farmers and ensuring the sustainable development of agriculture in the region.

The study aimed to investigate post-harvest losses of yam in Kwali Area Council, FCT, Abuja.

Several researches were carried out in the literature in other to provide solutions to postharvest losses of yam. various authors such as Filli *et al.,* (2019), Adejo (2017), Mahmud and Idris (2017), and Orjime et al. (2024) concluded that significant postharvest losses of yam are caused primarily by inadequate storage facility, transportation and preservative methods, all of which culminated in significant economic hardship and reduced food security for farming communities.

MATERIALS AND METHODS
Area of the Study
The research was carried out in Kwali Area Council, Federal Capital Territory, Abuja. The study area majorly involved in farming activities. sampling proportional to size was used to select all the 10 wards (Ashara, Dafa, Gumbo, Kilankwa, Kundu, Kwali, Pai, Wako, Yangoji and Yebu) in the study area. Non random sampling was used to select 40 yam farmers from each of the ten wards totaling 400 yam farmers for this study.

Methods of Data Collection
The research instrument for this study was a structured questionnaire comprising closed-ended questions with a 5-point Likert scale (1 = Strongly Agree, 5 = Strongly Disagree). The questionnaire includes sections corresponding to each factor under investigation to assess respondents' perceptions and experiences regarding postharvest loss of yam.

The questionnaire for this study is divided into eight sections and consists of different structured items. The first section or section "A" of the questionnaire dealt with the biographical detail of the respondents that include gender, age, level of education, farming experience, size of farm, size of household, post-harvest loss status, method of yam storage, access to post-harvest training and pest and disease control methods of farmers in the study area. Section B-H measure the perception of farmers regarding factors affecting the post-harvest loss of yam in the study area using a 5-point rating scale. These five points response options are given as follows: Strongly Agree (SA) = 5, Agree (A) = 4, Undecided (UD) = 3, Disagree (D) = 2, Strongly Disagree (SD) = 1. The questions in these sections are clustered to address the following seven main variables.

Section B-Storage infrastructure (5 questions).
Section C-Pest and Disease Control (5 questions).
Section D-Transportation (5 questions).
Section E-Market Conditions (5 questions).
Section F-Preservation Methods (5 questions)
Section G-Farmer education and training (5 questions)
Section H-Post-Harvest loss of yam (5 questions)

Data Analysis
Descriptive statistics and ordinal logistic regression analysis were used to analyze the data. Descriptive statistics were used to summarize the socio-economic characteristics of the yam farmers in the study area while multiple linear regression analysis was used to examine the relationship between the independent variables/predictors and the dependent variable/post-harvest loss of yam.

Ordinal logistic Regression

Ordinal logistic regression is a statistical technique used to examine the relationship between an ordinal response variable and one or more independent/explanatory variables. An ordinal variable is a type of categorical variable that has a distinct order among its category levels. The independent variables can be either continuous or categorical. Essentially, ordinal logistic regression analyzes ordinal, or ranked, categorical variables to determine how independent variables affect the probability of being in a higher category, frequently employing a proportional odds model where the impact of predictors remains consistent across cumulative categories.

In ordinal logistic regression models, a cumulative logit parameterization is utilized. Nevertheless, there are various approaches to achieve this. For this study's purposes, the most widely used model focuses on the likelihood of observing "Y less than or equal to j," with j representing one of the ordered categories of the response variable. The model consists of J-1 cut-offs (also known as intercepts or threshold values), indicated by α_j, along with one parameter for each explanatory variable. This setup permits the intercept to differ for each cumulative logit. However, the model presupposes that each explanatory variable has the same influence on each cumulative logit, which is why the ordinal logistic regression model is also referred to as a proportional-odds model.

It (ordinal logistic regression) models the log odds of the cumulative probability of an outcome falling into a category or a lower category, using the formula:

$$Log\left(\frac{P(Y\leq j)}{P(Y>j)}\right) = \alpha_j + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p \qquad (1)$$

where j represents the category, α_j are distinct intercepts for each category, and β_i are constant slope coefficients for the predictors x_i across all categories. The slope coefficients β are proportional across all levels, hence the name Proportional Odds Model, which is the most common type of ordinal logistic regression.

Also, let $(\pi_0, \pi_1, \dots, \pi_{j-1})$ be the associated probabilities. The cumulative probability of a response less than or equal to j is given below:

$$P(Y \leq j) = \frac{e^{\alpha_{j+}\beta X}}{1+e^{\alpha_{j+}\beta X}} \qquad (2)$$

The cumulative logit model is given below:

$$Log\left(\frac{P(Y\leq j)}{P(Y>j)}\right) = Log\left(\frac{P(Y\leq j)}{1-P(Y\leq j)}\right) = Log\frac{\pi_1+\pi_1+\cdots+\pi_j}{\pi_{j+1}+\cdots+\pi_j} \qquad (3)$$

The expression provided represents the log-odds of the event that Y is less than or equal to j, indicating the likelihood of the response being in category j or lower compared to being in a category above j.

The series of cumulative logits can be defined as:

$$L_1 = Log\left(\frac{\pi_1}{\pi_1+\pi_2+\cdots+\pi_j}\right) \qquad (2)$$

$$L_2 = Log\left(\frac{\pi_1+\pi_2}{\pi_3+\pi_4+\cdots+\pi_j}\right) \qquad (3)$$

$$L_{j-1} = Log\left(\frac{\pi_1+\pi_2+\cdots+\pi_{r-1}}{\pi_j}\right) \qquad (4)$$

And with predictors being incorporated into the model gives:

$$L_1 = \alpha_1 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p \qquad (7)$$
$$L_2 = \alpha_2 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p \qquad (8)$$
$$L_3 = \alpha_3 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p \qquad (9)$$
$$L_{j-1} = \alpha_{j-1} + \beta_1 X_1 + \cdots + \beta_p X_p \qquad (10)$$

From the above expression, it is observed that the intercepts differ, but the slope for each variable are the same across different equations. The proportional odds condition forces the lines corresponding to each cumulative logit to be parallel.

Link functions

The link function is a mathematical transformation that connects the log-odds of cumulative probabilities to a linear model of predictor variables. It serves as a bridge to convert the restricted range of probabilities (0 to 1) into a continuous scale that the linear model can handle, allowing for the interpretation of relationships between predictors and the ordered outcome categories.

The most popular and link function used when fitting ordinal logistic regression model is the logit link function. The logit link function allows for the effects associated with specific predictor variables to be expressed as odds-ratios. Depending on the distribution of the ordinal outcomes.

Table 1: Link Functions and their forms in Ordinal Regression

Link function	Form	Common Application
Logit	$\left(\frac{F_k(X_i)}{1-F_k(X_i)}\right)$	When categories are evenly distributed
Probit	$\phi^{-1}(F_k(X_i))$	Normally distributed latent variable
Cauchit	$\tan(\pi(F_k(X_i))-0.5))$	Outcome with numerous outliers used when the extreme values are present in the data
Complementary log-log	$log[(-\log(1-(F_k(X_i)))]$	Higher categories are more probable. Recommended when the probability of higher category is high.
Negative log-log	$-\log(F_k(X_i))$	This link function is recommended when the probability of the lower category is high.

Assumptions of Ordinal Logistic Regression

The main assumptions of the ordinal logistic regression are:

Test of Parallel Lines (Proportional Odds Assumption)

Ordinal logistic regression presumes that the influence of the independent variables remains consistent across all log-odds. The results will show an intercept for every level of the response variable, excluding one, along with a single slope for each predictor, which reflects this presumption. The odds are considered proportional (known as the proportional odds or parallel lines assumption): this suggests that each independent variable has the same effect at every cumulative division of the ordinal dependent variable. The parallel line assumption indicates that there is a single regression equation for each

category, except for the last category, meaning that the parameters are consistent across all categories of postharvest losses. The hypothesis is given as:

$H_0: \beta_1, \dots, \beta_3 = \theta_1, \dots, \theta_5$
$H_1: \beta_1, \dots, \beta_3 \neq \theta_1, \dots, \theta_5$

If the p> 0.05, this indicates that the location parameters are the same across response categories.

Ordinal Dependent Variable

The variable being measured is ordinal in nature. An essential requirement for ordinal logistic regression is that the variable being analyzed is ordinal. The dataset utilized in this dissertation met this criterion since the dependent variable (postharvest losses of yam) was classified to illustrate the

inherent categorical sequence, demonstrating a ranking of postharvest loss as severe, moderate, and low.

Multicollinearity

It is important to avoid multicollinearity, which means that independent variables should not show a strong correlation with one another. When two or more independent variables are significantly correlated, it can result in unstable regression coefficients and make it challenging to interpret their separate influences. It can be detected by Variance Inflation Factor (VIF).

As a rule of thumb, VIFs scores above 10 are generally indicators of multicollinearity.

Another assumption is that one or more of the explanatory variables may be continuous, categorical, or ordinal. This indicates that the independent or explanatory variables can be either continuous or categorical. This assumption was equally satisfied.

Independence of Observations

The observations (data points) should be independent of each other, meaning the value of one observation should not be influenced by the value of another. Durbin-Watsin statistic can be used to test for this assumption.

Ordinal Regression Model Diagnostic

To test for the overall significance of the regression models, Model Fitting Information, Chi-square Statistic, Pseudo R-squared Measures of fit were used

Model Fitting Information

The significant chi-square statistic was used to establish if the model gives better predictions than predictions based on the marginal probabilities for the outcome categories. Using the significance level (0.05). The hypothesis is given as:

$H_0: \beta_j = 0$ (The coefficient, β_j is not different from zero significantly)

$H_1: \beta_j \neq 0$ (The coefficient, β_j is different from zero significantly)

Goodness-of-Fit Table

The goodness-of-fit table includes the Pearson's Chi-Square statistic for the model along with another Chi-Square statistic derived from the deviance. This statistic was utilized to assess whether the observed data deviates from the fitted model. In this context, a lack of significance is understood as a sign of a good fit.

The test hypothesis is given as:

H_0: model fits the data

H_1: model do not fit the data

This means that the p-value should be greater than the alpha level of significance (5%) to indicate good fit.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Yam Farmers

The table 2 shows that 304 (85%) of the yam farmers were below the age of 50 years and this constitute the majority, 15% of them were above 50 years. This shows that most of the yam farmers were actually in their active age. 240 (60%) of the yam farmers were male, whereas 160 (40%) of the farmers were female which suggests that men were more engaged in yam farming in Kwali Area Council, FCT. This aligns with the findings of Quisumbing & Doss, (2021), who reported male dominance in agriculture across West Africa due to cultural and ownership practices that mostly favour men. 260 (65%) of the yam farmers attended primary and secondary schools, while 60 (35%) of them had tertiary education. This suggests that majority of the farmers did not further their education above secondary education, though they have the basic knowledge and this agrees with the study of Nwaobiala et al., (2025) that education was a significant determinant of farmers' utilization of postharvest management practices. This means that farmers with higher education levels are more likely to adopt improved postharvest techniques. farmers with over 8 years of experience were made of up 240 (60 %), while those with less than 8 years of experience accounted for 160 (40) %. This suggests that most farmers in the study area have considerable experience, which may affect their ability to reduce postharvest losses which is in line with the study of Ohagwu et al, (2024) that farmers with more years of experience had lower postharvest losses compared to less experienced farmers. This was attributed to their better knowledge of storage techniques, market timing, and pest control methods. As regards the size of the farm, the summary shows that, farm sizes varied, with 130 (32.5%) of the respondents cultivating small farms (less than 1 hectares), 120 (30%) cultivating between 1–2 hectares, 60 (15%) of the respondents cultivating between 3-4 hectares, while 50 (12.5%) of the respondents using between 5-6 hectares and 40 (10.5%) managing large farms (above 6 hectares). Farm size may influence postharvest losses, as larger farms may have more resources but also greater storage challenges. The household size shows that majority of the respondents falls between 8 to 9 members representing 120 (30%) followed by 6 to 7 household members which represents 100 (25%). The third highest household size was 4 to 5 members representing 80 (20%) followed by >9 household members which represents 60 (15%). The least household member was <4 and this represents 40 (10%). All things being equal, one could argue that larger households have more readily available and cheaper sources of labour to manage postharvest losses effectively compared to smaller size households. About 265 (66.3%) stored over 1200 yams followed by 50 (12.5%) farmers who stored between 501-700 yams, the next category of farmers 40 (10%) stored between 701 -900 yams, while 25 (6.3%) farmers stored < 300 yams and the last category of farmers 20 (10%) stored between 300-500 yams.

Table 2: Socio-economic Characteristics of the Yam Farmers Age Distribution

Age (Years)	Frequency	Percent (%)	Cumulative Percent (%)
<20	40	10.0	10.0
20-30	120	30.0	40.0
31-40	100	25.0	65.0
41-50	80	20.0	85.0
>51	60	15.0	100.0
Total	400	100.0	
Gender			
Male	240	60.0	60.0

Age (Years)	Frequency	Percent (%)	Cumulative Percent (%)
Female	160	40.0	100.0
Total	400	100.0	
Education Qualification			
No Formal Education	80	20.0	20.0
Primary	120	30.0	50.0
Secondary	140	35.0	85.0
Tertiary	60	15.0	100.0
Total	400	100.0	
Farmers' Experience (Years)			
<5	50	12.5	12.5
5-8	110	27.5	40.0
9-12	100	25.0	65.0
13-16	120	30.0	95.0
>16	20	5.0	100.0
Total	400	100.0	
Farm Size (Hectares)			
<1	130	32.5	32.5
1-2	120	30.0	62.5
3-4	60	15.0	77.5
5-6	50	12.5	90.0
>6	40	10.0	100.0
Total	400	100.0	
Household Size			
<4	40	10.0	10.0
4-5	80	20.0	30.0
6-7	100	25.0	55.0
8-9	120	30.0	85.0
>9	60	15.0	100.0
Total	400	100.0	
Numbers of Tubers of Yam			
>500	25	6.3	6.3
500-700	20	5.0	11.3
701-900	50	12.5	23.8
901-1200	40	10.0	33.8
>1200	265	66.3	100.0
Total	400	100.0	

Test of Assumption/Model Diagnostics

It is important to understand and validate the assumptions of ordinal logistic regression outlined in chapter three above as there are crucial for obtaining meaningful and reliable results. As these can affect the accuracy of parameter estimates and the reliability of statistical inferences. If these assumptions are adequately and carefully adhered to, analysts can enhance the robustness and credibility of the analyses. Some of the assumptions tested in the course of the analysis were the following:

Table 3: Test for Proportional Odd (Test of Parallel Lines)

Model	-2 Log Likelihood	Chi-Square	d.f.	P-Value
Null hypothesis	94.257			
General	76.667	17.590	30	0.965

Link function: Logit

Table 3 presents the test of parallel line also referred to as the test for proportional odds of the ordinal logistics regression model. In ordinal logistic regression, the parallel lines assumption means that the effects of predictor variables on the odds of falling into a higher or lower category of the dependent variable are the same across all categories of the ordinal outcome. A non-significant p-value (p-value > 0.05) gives a valid test of parallel lines and it confirms that a single model equation was appropriate for all thresholds. From the table above, our p-value was 0.965 (p-value = 0.965 > 0.05), which means we fail to reject the null hypothesis, indicating that the ordinal logistic regression model is valid.

Table 4: Multicollinearity Test

Predictors	Tolerance	VIF
Storage Infrastructures	0.976	1.024
Pest control	0.982	1.018
Transportation	0.968	1.033
Market conditions	0.986	1.014
Traditional method of Preservation	0.973	1.028
Farmers Education and Training	0.460	2.174
Household Size	0.640	1.562
Farm size	0.762	1.313
Number of Yam Stored	0.660	1.514
Farmers experience	0.703	1.422

A tolerance value below 0.10 or a Variance Inflation Factor (VIF) above 10 means an existence of significant multicollinearity, indicating a potential issue with the regression model that may require further investigation or correction. The result presented in Table 4 above indicates that none of the tolerance values of the explanatory variables were below 0.1. Similarly, the result also discovered that, none of the Variance Inflation Factor (VIF) values was above 10. This result therefore implies that none of the independent variables are highly correlated or have the problem of multicollinearity.

Table 5: Case Processing Summary

Responses to Yam Post Harvest Losses	N	Percentage
Low	14	3.5
Moderate	9	2.25
Severe	377	94.25
Valid	400	100.0
Missing	0	
Total	400	

Table 5 presents the case processing summary of the post-harvest yam losses. The result revealed that majority of the farmers (377) representing 94.25% experienced severe postharvest loss of yams, 9 farmers which represents 2,2% experienced moderate losses, 14 farmers representing experienced low level of postharvest loss of yam. The result also indicated that there were no missing responses out of the 400 farmers' who responded.

Table 6: Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	d.f.	P-value
Intercept Only	228.065			
Final	94.257	133.808	10	0.000

Link function: Logit

Table 6 presents the model fit statistics, showing the -2 Log Likelihood for both the null model (which has no predictors) and the final model (which includes predictors). It also displays the Chi-Square value along with its significance. The P-value of 0.00, which is below the significance level of 0.05, suggests that the model incorporating predictors fits the data better than the null model.

Table 7: Goodness of Fit

Item	Chi-Square	d.f.	P-value
Pearson	359.605	1394	1.000
Deviance	94.257	1394	1.000

Link function: Logit

Table 7 provides the goodness of fit of the ordinal logistic regression model. The result indicated that, for Pearson the Chi-Square, χ^2 (1394) = 359.605and p – value = 1.000 while for Deviance the Chi-Square, $\chi^2(1394) = 94.257$ and p – value = 1.000, The result indicates that the model fits the data very well.

Table 8: Pseudo R-Square

Cox and Snell	0.284
Nagelkerke	0.654
McFadden	0.587

Link function: Logit

Table 8 displays the pseudo-R-Square values from the ordinal logistic regression model, indicating the extent to which the explanatory variables accounted for variance. The Cox and Snell value, along with the Nagelkerke and McFadden values,

were recorded at 0.284 (28.4%), 0.654 (65.4%), and 0.587 (58.7%) respectively. The findings presented in the table suggest that the ordinal logistic regression model, along with its explanatory variables, accounted for a significant portion of the variance in post-harvest losses of yam in the study area, showcasing its robust explanatory capability.

Table 9: Parameter Estimate

Variables	Estimate	Std. Error	Wald	d.f.	P-value	Lower	Upper
Storage Infrastructures	-2.998	1.245	5.802	1	0.016	-5.437	-0.558
Pest and Disease control	-4.359	1.734	6.321	1	0.012	-7.757	-0.961
Market conditions	5.974	1.177	25.780	1	0.000	3.668	8.281
Farmers Education and Training	-0.858	0.730	1.382	1	0.024	-2.289	0.573
Household Size	1.045	0.888	1.382	1	0.240	-0.697	2.786
Farm size	0.027	0.751	0.001	1	0.972	-1.445	1.498
Farmers experience	-0.519	0.595	0.761	1	0.383	-1.684	0.647

Link function: Logit

Postharvest Loss Determinants

Table 9 shows the determinants/factors causing postharvest losses of yam in Kwali Area Council, FCT. The determinants were identified as storage infrastructure, pest control, market condition, transportation, methods of preservation and farmers' education and training. From the table above, the null hypothesis is that the regression coefficients are equal to zero, while the alternative is that the regression coefficients are not equal to zero. Since the p-values of the predictors mentioned above were less than the 5% level of significance, we reject the null hypothesis and conclude that regression coefficients are not equal to zero.

Storage Infrastructures

The beta coefficient (β) of -2.998 indicates a strong inverse relationship between the quality of the storage infrastructure and the amount of post-harvest yam losses. This means that as storage infrastructure improves, the probability of higher post-harvest losses decreases.

The *p*-value of 0.016 is less than the common significance level of 0.05 (0.016 < 0.05). This means the result was statistically significant, and there is a high degree of confidence that the relationship between storage infrastructure and post-harvest losses is not due to random chance.

Odd ratio = $e^{-2.998} \simeq 0.05$

The odds ratio of 0.05 quantify this inverse relationship. For every one-unit improvement in the storage infrastructure, the odds of experiencing a higher category of post-harvest loss are multiplied by 0.05. This is equivalent to a 95% reduction (1−0.05) in the odds of more severe losses, holding all other variables constant. The study provides statistical evidence supporting the fact that investing in better storage infrastructure is likely to lead to a better outcome in the study area. This research is in accordance with the findings of Abubakar and Nasiru (2017), which indicate that inadequate yam storage leads to post-harvest losses. This issue arises from the characteristics and methods of storage employed by the majority of yam farmers. In the region under study, most farmers relied on traditional techniques for yam storage. Additionally, the study corroborates the research conducted by Falola et al. (2017), emphasizing the importance of effective storage in minimizing deterioration. However, limited access and varying quality of storage facilities among farmers, particularly in rural areas, raise questions about its consistent impact.

Pest and Disease Control

The negative sign of the beta coefficient (β) of -4.359 indicates an inverse relationship. As pest control measures increase in quality or frequency, the log-odds of a higher category of post-harvest loss decrease. The magnitude of the beta coefficient shows that for every one-unit improvement in pest control, the log-odds of being in a higher loss category decrease by 4.359. The P - value of 0.012 was less than the chosen significance level of 0.05 which shows a significant relationship between pest control and postharvest losses of yam

Odd ratio = $e^{-4.359} \simeq 0.013$

The odds ratio quantifies the effect of the variable. An odd ratio less than 1 indicates a reduction in the odds of the outcome occurring. For every one-unit improvement in pest control, the odds of experiencing a higher category of post-harvest loss are multiplied by 0.013 (1−0.013) ×100=98.7%, holding all other variables constant. This means that better pest control is associated with a 98.7% decrease in the odds of having more severe yam losses. This means that pest and disease should be managed properly to reduce postharvest losses of yam

This aligns with the studies of Ano (2019), which reported that pest and disease infestation significantly influences postharvest loss of yam, with fungal pathogens such as *Botryodiplodia theobromae*, *Aspergillus spp.*, and *Fusarium oxysporum* causing dry and soft rot. The study found that poor handling, high humidity, and inadequate storage facilities increase the risk of infestation, highlighting the need for improved postharvest management practices. This is consistent with the findings of Koradaa et al, (2010), which highlighted the role of pest control in postharvest management. To assist farmers in reducing losses, extension agencies should offer integrated pest management programs, storage hygiene education, and reasonably priced fumigation procedures.

Market Conditions

The positive beta coefficient ($\beta = 5.974$) indicates a strong positive relationship between market conditions and post-harvest yam losses. As market conditions worsen or become less favourable, the log-odds of a higher category of post-harvest loss increase.

The p-value = 0.000 which is well below the chosen level of significance (0.000 < 0,05) shows that the relationship between market conditions and post-harvest losses is statistically significant.

Odd ratio = $e^{5.974} \simeq 393.55$

The odds ratio quantifies the strength of this positive relationship. For every one-unit change in market conditions (e.g., from a more favourable market condition to a less favourable one), the odds of experiencing a higher category of post-harvest loss are multiplied by 393.55, holding all other factors constant. This represents an exceptionally large increase in the likelihood of more severe losses.

A higher or "worse" market condition could represent several factors, such as:

Inadequate Market Access
Farmers holding on to their produce for longer period of time leading to deterioration.

Poor Market Infrastructure
A lack of proper facilities for storage and handling at the market level increases damage.

Price Volatility
When prices are low, farmers may hold off on selling, which can increase spoilage.

The model suggests that these poor market conditions are a powerful predictor of increased post-harvest loss severity. The massive odds ratio of 393.55 implies that the state of the market is a critical factor influencing the final outcome of a farmer's harvest.

This implies that better market accessibility is strongly associated with significantly better outcomes. This supports a previous study by Aderibigbe and Oke (2023) that found that long-distance transportation of tomatoes from farms to the market resulted in 10%-20% post-harvest loss, which means that proximity to markets reduced postharvest losses. Similarly, Nwafor et al, (2023) showed that long distances to markets affecting 54% of farmers further exacerbate spoilage risks of yam tubers. Government organizations could improve transportation logistics, offer cold storage at market centres, and coordinate supply chain networks to guarantee the timely delivery of yam output in order to reduce losses.

Farmers Education and Training
The ordinal logistics regression model parameter estimates confirmed that, the coefficient (β) =   -0.858. A negative beta value means that as the independent variable ("farmers' education and training") increases, the log odds of the outcome being in a *higher* loss category (e.g., moderate or high) decrease and p-value = 0.024 < 0.05 was less than the conventional significance level of 0.05 which shows a significant relationship between farmers' education and training and postharvest losses of yam.

Odd ratio = $e^{-0.858} \simeq 0.024$

The odds ratio above indicates that for every one-unit increase in the level of farmers' education and training (e.g., moving from 0 to 1, or attending one additional training session), the odds of a farmer experiencing a higher category of post-harvest loss (e.g., moving from low to moderate, or moderate to high) are 0.424 times the odds of them remaining in a lower category. This means the odds of experiencing higher losses are decreased by 57.6% (1−0.424 = 0.576), 1 minus 0.424 equals 0.576. Generally, the results revealed that farmers' education and training have a statistically significant inverse relationship with the level of post-harvest losses of yam (p=0.024). Specifically, for each one-unit increase in the level of education and training a farmer receives, the odds of that farmer experiencing a higher category of post-harvest losses (e.g., moving from low to moderate, or moderate to high) decrease by 57.6%, holding all other variables in the model constant. This suggests that education and training are effective interventions for mitigating post-harvest losses. This agreed with the study by Ajibare et al, (2022) that discovered that insufficient knowledge impedes efficient postharvest handling. To increase farmers' resistance to losses, training programs in cooperative-based storage, value addition, and postharvest management should be extended.

Household Size
The ordinal logistics regression model affirmed that, the coefficient (β) = 1.045 and p-value = 0.240 > 0.05. This finding indicates that the size of a farmer's household has a positive yet insignificant impact on the post-harvest losses of yam in the area studied. This result contradicts the study conducted by Filli et al. (2019), which suggested that household size plays a role in post-harvest losses of yam, stating that larger household sizes provide more individuals to inspect yam tubers and more contributors to the removal of sprouted stems and sanitizing the storage environment, since the sprouting diminishes both the quality and quantity of yam tubers and a dirty environment can lead to pest infestations and diseases.

Farm Size
The ordinal logistics regression model proved that, the coefficient (β) = 0.027 and p-value = 0.972 > 0.05. This result indicates that, farm size has a positive and insignificant effect on post-harvest loss of yam. This finding disagreed with the study carried out by Audu et tal, 2021 that there was a positive significant relationship between farm size and postharvest losses of yam.

Farmers Experience
The parameter estimates of the ordinal logistics regression model found that, the coefficient (β) = -0.519 and p-value = 0.382 > 0.05. This result indicates that, farmers experience has a negative and insignificant effect on post-harvest loss of yam. The study aligns with Abbass, (2018) that experience alone was not enough to significantly reduce losses, as inadequate storage facilities also contributed greatly to postharvest losses. The study showed that even highly experienced farmers who relied on traditional storage methods still suffered postharvest losses if not provided with appropriate amenities. It is advisable to create effective and affordable technologies that are appropriate for the Nigerian context to tackle the issue of postharvest losses, requiring substantial investment in agricultural research from both the government and agro-allied industries.

However, the finding contradicts the study by Ohagwu et al, (2024) that farmers with more years of experience had lower postharvest losses compared to less experienced farmers. This was attributed to their better knowledge of storage techniques, market timing, and pest control methods.

The findings of this study suggest that factors such as storage infrastructures, pest control, transportation, market condition, traditional method of preservation and as farmers' education and training significantly contributed to postharvest losses of yam in the study area, while factors such household size, farm size, number of yams stored and farmers experience had no significant effect on post-harvest losses of yam in the study area.

Farmers' Perception of Factors Affecting Post-Harvest Loss of Yam in the Study Area
Tables 10-16 below presents the results of farmers' perception of factors affection the post-harvest loss of yam in the study area. These results are from the analysis of section B to H of the research questionnaire considering factors related to inadequate storage infrastructure, pest and disease infestation, transportation challenges, market accessibility, preservation technologies, farmer education and training as well as general post-harvest loss of yam. These results are presented below

Table 10: Mean and Standard Deviation of Farmers' Responses Concerning Storage Infrastructure of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
1. The storage facilities available for yam are inadequate, contributing to post-harvest losses.	4.8675	0.633203	A
2. Poor storage infrastructure increases the rate of yam spoilage.	4.8675	0.633203	A
3. Lack of proper storage facilities is a major cause of post-harvest loss in yam production.	4.605	1.056772	A
4. The temperature and humidity conditions of current storage infrastructure will lead to significant yam decay.	4.8075	0.746214	A
5. Farmers in the Kwali Area Council face challenges with the storage capacity for their yam harvest.	4.905	0.4812	A
			A
Inadequate Storage Infrastructure Index	4.8105	0.710118	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{x}$ =Mean, SD=Standard Deviation

Table 11: Mean and Standard Deviation of Farmers' Responses Concerning Post-Harvest Pest and Disease Control of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
1. Pest and disease infestation is a major cause of post-harvest yam loss in Kwali Area Council.	4.89	0.623596	A
2. Farmers face significant challenges in managing pests and diseases that affect yam crops post-harvest.	4.39	0.793394	A
3. The yam harvest is highly vulnerable to pests and diseases during the post-harvest period.	4.9325	0.44546	A
4. Insufficient pest control measures lead to increased yam losses after harvesting	4.8125	0.730533	A
5. Lack of knowledge about pest management contributes to higher post-harvest yam losses.	4.6875	0.939175	A
Pest and Disease Infestation Index	4.7425	0.706433	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{x}$ =Mean, SD=Standard Deviation

Table 12: Mean and Standard Deviation of Farmers' Responses Concerning Post-Harvest Transportation of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
1. Poor Road infrastructure affects the timely transportation of yam, contributing to post-harvest losses.	4.9525	0.347196	A
2. The long distance between farms and markets increases the likelihood of yam spoilage.	4.8225	0.698006	A
3. Transportation delays result in yam being left in unsuitable conditions, leading to loss.	4.825	0.693236	A
4. Insufficient transport facilities in Kwali Area Council increase the risk of yam deterioration.	4.5725	1.020955	A
5. The lack of refrigerated transportation for yam contributes to significant post-harvest losses	4.5075	0.505552	A
Transportation Challenges Index	4.736	0.652989	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{x}$ =Mean, SD=Standard Deviation

Table 13: Mean and Standard Deviation of Farmers' Responses Concerning Post-Harvest Market Accessibility Challenges of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
1. Limited access to markets results in delayed selling, which increases yam spoilage.	4.7625	0.776273	A
2. Farmers experience difficulty in reaching buyers due to poor road networks.	4.65	0.929872	A
3. Inaccessible markets lead to farmers holding onto their yam for longer, causing it to deteriorate.	4.605	0.980499	A
4. High market costs discourage farmers from accessing more distant markets, increasing losses.	4.51	0.500526	A
5. The distance from markets in Kwali Area Council contributes to higher post-harvest losses.	4.7475	0.748428	A
Market Accessibility Challenges Index	4.655	0.78712	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{X}$ =Mean, SD=Standard Deviation

Table 14: Mean and Standard Deviation of Farmers' Responses Concerning Post-Harvest Preservation Methods of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
1. The use of preservation technologies reduces the rate of post-harvest loss of yam.	4.6475	0.951582	A
2. Many farmers lack access to modern preservation technologies for yam.	4.5125	0.50047	A
3. Preservation technologies such as refrigeration help reduce spoilage of yam after harvest.	4.82	0.666115	A
4. Farmers in Kwali Area Council are not adequately trained in the use of preservation technologies.	4.65	0.929872	A
5. The lack of affordable preservation methods results in high post-harvest loss of yam.	4.5425	0.498814	A
Preservation Technologies Index	4.6345	0.709371	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{X}$ =Mean, SD=Standard Deviation

Table 15: Mean and Standard Deviation of Farmers' Responses Concerning Farmer Education and Training on Post-Harvest Losses of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
Lack of education on best farming practices contributes to post-harvest loss of yam.	4.765	0.781859	A
Training on proper harvesting techniques can reduce post-harvest loss of yam.	4.7975	0.763512	A
3. Farmers in Kwali Area Council would benefit from more training on post-harvest management.	4.9	0.447774	A
4. The lack of education on pest and disease control is a significant factor in post-harvest losses.	4.67	0.698082	A
5. Farmers who receive training in preservation techniques experience fewer losses of yam.	4.43	0.604992	A
Farmer Education and Training Index	4.7125	0.659244	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{X}$ =Mean, SD=Standard Deviation

Table 16: Mean and Standard Deviation of Farmers' Responses Concerning the General Impact of Post-Harvest Losses of Yam in the Study Area

Item	$\bar{X}$	SD	Remarks
1. Post-harvest losses of yam are a major issue in the Kwali Area Council.	4.8725	0.5934	A
2. The amount of post-harvest loss of yam is increasing due to inadequate storage, transportation, and market access.	4.8525	0.633836	A
3. Post-harvest loss of yam in the area is significantly impacted by pests and diseases.	4.87	0.586481	A
4. Effective storage, transportation, and preservation methods can drastically reduce post-harvest loss.	4.8925	0.597357	A
5. There is a high rate of yam spoilage before reaching the market in the Kwali Area Council.	4.9	0.548408	A
Post-Harvest Losses Index	4.8775	0.591896	A

Source: Researcher's Field Survey Results (2025). Legend: SA=Strongly Agree, A=Agree, U=Undecided, D=Disagree, SD=Strongly Disagree. n =Sample Size, $\bar{X}$ =Mean, SD=Standard Deviation

Tables 10-16 show yam farmers' responses to the perceived factors affecting the post-harvest losses experienced on a five points Likert scale (5=Strongly Agree, 4=Agree, 3=Undecided, 2=Disagree, 1=Strongly Disagree) with a cut-off point of 3.0. The result showed that farmers perceived; storage infrastructure ($\bar{X}$=4.81), pest and disease control ($\bar{X}$=4.74), transportation ($\bar{X}$=4.74), market accessibility ($\bar{X}$=4.66), preservation methods ($\bar{X}$=4.63), and farmer education and training ($\bar{X}$=4.71) as risk factors responsible for the post-harvest losses of yam in the study area.

The consensus that environmental factors are a primary cause of post-harvest losses can be linked to elements such as elevated temperatures, relative humidity, air movement, and the composition of the atmosphere (levels of oxygen, carbon dioxide, and ethylene), along with the unpredictable nature of rainfall during the yam production cycle. This conclusion aligns with the research of Atanda et al. (2011), who identified environmental factors as significant contributors to post-harvest losses in perishable crops in Nigeria. Echoing Kader's (2013) perspective, temperature stands out as the critical factor affecting the deterioration of harvested goods.

Additionally, farmers often consider the impact of microbiological processes, such as attacks from bacteria and fungi, to be a secondary but significant contributor to the post-harvest losses of yam tubers, particularly in storage. This can be linked to the lack of suitable chemicals that could prevent or reduce the detrimental effects of these microorganisms on stored yam. This is supported by the findings of Udemezue and Nnabuife (2017), which indicated that yam viruses not only diminish tuber yield and quality but also elevate the costs associated with protective measures.

CONCLUSION

This study aimed to investigate the postharvest losses of yam among farmers in Kwali Area Council of Federal Capital Territory, Abuja. The findings revealed that postharvest losses were a significant concern, affecting the livelihoods of farmers and the overall food security of the area.

Factors such as storage infrastructure, pest control, transportation, market conditions and preservation methods and farmers' education and training significantly contributed to postharvest losses of yam in the study area, but household size, farm size and farmers' experience did not contribute to post harvest losses in the study area. For post-harvest to be reduced to the barest minimum, the following recommendations were made:

Improving storage infrastructure should be looked into. This involves investing in the construction and improvement of modern storage facilities such as well-ventilated sheds, cold rooms, and silos. The Federal Ministry of Agriculture and Rural Development (FMARD) can play a significant role by providing subsidies and incentives to farmers for constructing these facilities. Furthermore, collaboration between NGOs, CBOs, and farmers can facilitate the construction and management of communal storage facilities. Agricultural extension services should also provide comprehensive training to farmers on proper storage techniques and the maintenance of storage facilities.

Enhancing pest management is vital. Implementing integrated pest and disease management strategies is essential. This includes the use of bio-pesticides, promoting the cultivation and distribution of pest- and disease-resistant yam varieties, and emphasizing proper sanitation practices. The National Agricultural Seeds Council (NASC) can play a crucial role in promoting the availability of resistant varieties. Agricultural extension services should provide training to farmers on identifying and controlling pests and diseases, including the safe and effective use of pesticides. Research institutions should also actively engage in developing and promoting eco-friendly pest control methods for yam.

Improving market access for farmers is crucial. This involves enhancing road infrastructure to facilitate the timely transportation of yam to markets. The Federal Government should invest in improving rural road networks to ensure efficient and timely transportation. The FMARD should establish and maintain market information platforms to provide farmers with crucial information on market prices, demand, and available buyers. Strengthening farmer cooperatives and marketing boards can empower farmers to collectively market their produce and negotiate better prices.

Promoting the adoption of modern preservation technologies is essential. This includes technologies such as controlled atmosphere storage and modified atmosphere packaging to extend the shelf life of yams. Organizing workshops and demonstrations to educate farmers on the benefits and proper use of these technologies is crucial. Providing access to affordable and appropriate equipment, such as solar-powered cold storage units, is vital. Collaboration with research institutions is necessary to develop and adapt low-cost, locally appropriate preservation technologies for yam.

REFERENCES

Abbas, A. (2018). Reducing postharvest losses in Nigeria's Agricultural sector: pathway to sustainable agriculture. *Journal of Stored Products Research, 57,* 49-57

Abubakar, M., & Nasiru, M.I. (2017). Assessment of post-harvest losses of yam (dioscorea spp.) in selected districts of karu local government area, Nasarawa state. 2(1A), 213-219

Aderibigbe, O.R., & Okae, A. (2023). Scooping and Mapping of Post-Harvest Losses. Horti Nigeria, Internal Fertilizer Development Company https://ifdc.org/wp-content/uploads/2024/01/Scoping-and-Mapping-of-Postharvest-Losses-HortiNigeria.pdf.

Agba, S.A., Ode, I., Ugbem, C., & Nwafor, S.C, (2019). Impact of yam postharvest Activities on standard of living of yam farming Households in North-East zone of Benue srate, Nigeria. *Journal of Applied Life Sciences International*, 21(1), 1-9

Ajibare, D. B., Anthony, L., Alabi, O. O., Njoku, V. O., Ukaoha, C. A., & Oluleye, O. D. (2022). Resource use efficiency and profitability analysis of tomato production (Lycopersicum esculentum species) in Federal Capital Territory, Nigeria. *European Journal of Food Science and Technology, 4(5)*, 75-82

Ajiboye, A., & Afolayan, O. (2019). The impact transportation on agricultural production in a developing country: a case of kolanut production in Nigeria. *International Journal Agricultural Economics and Rural Development*, 2, 49-57

Ano, Q. U. (2019). Natural Plant Extracts and Post-Harvest Management of Yams in Storage: A Review. *Nigeria Agricultural Journal.* 50(2), 241-246

Falola, A., Salami, M. F., Bello, A. A., & Olaoye, T. A. (2017). Effect of yam storage techniques usage on farm income in Kwara State, Nigeria. *Agrosearch,* 7(1), 54– 65

Filli F. B., Audu, I. A., Igbodor F. O. & Zhema E. (2019). Socio-economic determinants of yam post-harvest losses among farmers in Wukari local government area of Taraba State, Nigeria. *Direct Research Journal of Agriculture and Food Science. 7(8),* 215-221

Food and Agriculture Organization, (2021). The State of Food and Agriculture. Making agrifood systems more resilient to shocks and stresses. Rome, FAO. https://doi.org/10.4060/cb7351en

Koradaa, R. N. (2010). Insect pests and their management in yam production and storage: a world review International. *Journal of Pest Management.* 56(4) 337–349

Kumar, D., & Kalita, P. (2017). Reducing Postharvest Losses during Storage of Grain Crops to Strengthen Food Security in Developing Countries. *Foods. 15(6),*1-8

Mayienga, S., & Cachia, F. (2021). Research on the measurement of post-harvest losses: Minimum losses by commodity and region: *Insights from the literature (FAO*

Statistics Working Paper 21/26). FAO. https://doi.org/10.4060/cb6126en

Nwafor, S. C., Odor, P. C., & Ebere, O. S. (2023). Yam Postharvest Losses and Food Security in North Central Zone of Nigeria. *International Journal of Agricultural Research, Sustainability, and Food Sufficiency (IJARSFS).* 10 (01), 625-638

Nwaobiala, C.U., Azubuike, O.C., & Godwin, H.O. (2025). Determinants of Farmers' Utilization of Post-Harvest Management Practices in Rice-Producing Areas of Abia State, Nigeria. *Nigeria Agricultural Journal. 55(1).* 66-73

Ogundele, F. (2022). Postharvest losses and food security in Nigeria: An empirical review. *African Journal of Agriculture and Food Science, 5(3),* 77-89.

Ohagwu, V.A., Iwuchukwu, J. C., & Nwobodo, C.E. (2024). Knowledge of farmers on post-harvest handling of tomato in Enugu State, Nigeria. *Journal of Agricultural Extension.* 28 (4), 80-91

Orjime, E. V., Ahule, B., Akpehe, G. A., & Gbaka, S. (2024). Indigenous Preservation Practices and Shelf Life of Stored Yams in Benue State, Nigeria: Implication for Post-Harvest Management and Food Security. *Management And Economic Review.* 9(1), 25-40

Quisumbing, A.R. and Doss, R.C. (2021). Chapter 82 - Gender in agriculture and food systems. *Handbook of Agricultural Economics,* 5, 4481-4549.

Rutta, E. W. (2024). Postharvest food loss reduction and agriculture policy framework in Tanzania: Status and way forward. *Agriculture & Food Security, 13, 36-61*

Sugri, I., Abubakari, M., Owusu, R. K., & Bidzakin, J. K. (2021). Postharvest losses and mitigating technologies: Evidence from Upper East Region of Ghana. *Sustainable Futures, 3, 100048* https://doi.org/10.1016/j.sftr.2021.100048