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**Original Article**

# Determinants of the adoption of improved packaging materials amongst tomato farmers in Ogun State, Nigeria

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**ABSTRACT**

The sustainability of tomato freshness relies heavily on improved packaging materials, which protect tomatoes from physical damage during transportation and storage. This study examines the determinants of the adoption of improved packaging materials among tomato farmers in Ogun State, Nigeria. Using a multi-stage random sampling technique, 120 respondents were selected from three Local Government Areas known for tomato cultivation. Data were collected through structured questionnaires administered to randomly chosen farmers. Descriptive statistics (frequency, percentage, standard deviation, and mean) and a Tobit econometric model were utilized for data analysis. The Tobit model results indicated that education (p = 0.0241), farming experience (p = 0.017), group membership (p = 0.038), access to extension services (p = 0.007), distance to the nearest market (p = 0.001), and training (p = 0.095) positively correlated with the adoption and intensity of improved packaging material use. On the other hand, off-farm income (p = 0.076) negatively affected adoption, showing statistical significance at 1%, 5%, and 10% levels. In conclusion, adopting improved packaging materials can significantly enhance the quality and safety of agricultural products while reducing postharvest losses. To encourage wider adoption, targeted interventions such as training, access to affordable financing, and improved infrastructure are essential.

K E Y W O R D S : *Freshness, Sustainability, Tobit, Transportation*

## INTRODUCTION

Among the various vegetable crops cultivated worldwide, tomato (*Solanum lycopersicum*) stands out for its culinary versatility, nutritional benefits, and economic significance. Tomatoes play a crucial role in the agricultural sector, contributing significantly to economic returns. Globally, approximately 181 million tons of tomatoes are produced annually (FAOSTAT, 2019), with Nigeria contributing 2.2 million metric tons each year (FAO, 2018). However, the Nigerian tomato industry faces critical challenges, particularly concerning postharvest losses.

Managing postharvest losses in the tomato supply chain is a significant issue for many agricultural producers and distributors. One primary cause of these losses is the improper use of packaging materials, which can result in physical damage such as bruising, cracking, and crushing during handling, transportation, and storage (Onu *et al.*,

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2022). In Nigeria and other developing countries, common packaging materials for vegetable transport and storage include woven palm baskets, jute sacks, wooden crates, and nylon bags (Bugatti *et al.*, 2019; Gebeyehu, 2018). While these materials help preserve produce quality, they have limitations that contribute to substantial postharvest losses, estimated at over 40% due to inadequate storage and poor transportation.

Studies indicate that many farmers continue to rely on traditional packaging methods that can lead to physical damage, and lack of proper structure and ventilation because of the availability and affordability (Mibulo *et al.*, 2020; Laranjeira *et al.*, 2022). Innovations in packaging, particularly the use of crates, have shown promise in reducing food losses. Crates provide structured packing, minimizing direct contact and preventing crushing, which helps maintain the quality of tomatoes during transport and storage. Although crates are durable, ventilated, and reusable, their adoption remains low due to financial constraints and limited access.

To address postharvest losses, there is a growing interest in improved packaging technologies. However, smallholder farmers face significant financial barriers, often operating on tight budgets that make it difficult to invest in advanced packaging materials like plastic crates. Inadequate infrastructure and limited awareness of the long-term benefits of improved packaging further hinder adoption. Despite the growing interest in postharvest technology, empirical evidence on the factors influencing the adoption of improved packaging materials among tomato farmers remains limited. Therefore, this study aims to explore the determinants of the adoption of improved packaging materials in Ogun State, Nigeria. Identifying these factors will inform strategies to reduce postharvest losses, enhance packaging methods, and ensure a more stable supply of fresh tomatoes, ultimately benefiting both farmers and consumers.

## MATERIAL AND METHODS

### Study Area

This study was carried out in Ogun State, located in Southwestern Nigeria. The is a region rich in cultural heritage and agricultural potential. It was created in February 1976 from the former Western State and has a population of approximately 6,379,500, with a population density of 280 persons/km² (361.3/sq mi) (Nigeria Informer, 2022). It is bordered to the north by Oyo and Osun States, to the east by Ondo State, to the south by Lagos State, and to the west by the Republic of Benin. Ogun State lies at latitude 7°00' North and longitude 3°35' East (Zaccheus Onumba Dibiaezue Memorial Libraries, 2024). The state features diverse geographical characteristics, including fertile plains, river valleys, and forested areas, covering a total land area of 16,409.26 km². Its tropical climate, with a bimodal rainfall pattern, supports a variety of agricultural activities. The favorable climate and soil conditions make Ogun State ideal for cultivating crops such as cassava, maize, and tomatoes. The state is divided into four Agricultural Development Zones: Abeokuta, Ikenne, Ilaro and Ijebu-Ode Zones.

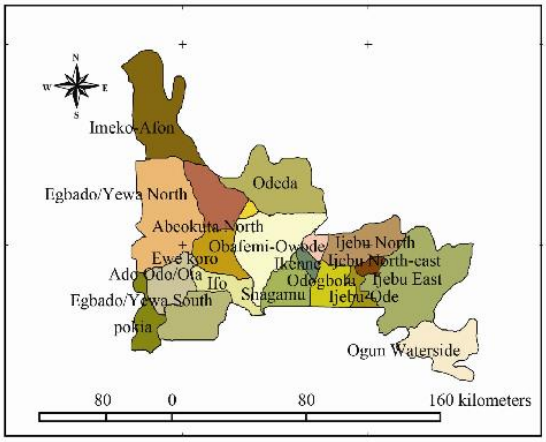


**Figure 1: Map of Ogun State showing the Local Government Area**

### Sampling Techniques and Sample Size

A multistage sampling technique was employed to select 120 respondents for the study. The first stage involved the purposive selection of two Local Government Areas, Ado-Odo/Ota and Imeko-Afon, from the Agricultural Development Zones, due to the prevalence of tomato production in these areas. In the second stage, two villages were selected from each local government area, making a total of four villages. In the third stage, fifteen tomato farmers were randomly selected from each village, resulting in a total sample size of 120 respondents for the study.

### Method of Data Collection

Data were primarily collected using a structured questionnaire aligned with the study's objectives and relevant literature. The questionnaire was employed to gather appropriate information and was pre-tested before being administered to ensure clarity and reliability. The data collection instrument underwent content validation

through consultations with experts in the field to ensure its relevance and accuracy.

**Analytical Techniques**

Descriptive statistics such as tables, percentages, and means were used to describe the socio-demographic characteristics of the tomato farmers in the study area. A Tobit model was employed to determine the factors influencing the adoption of improved packaging materials for tomatoes. The Tobit model has been widely used by researchers to analyze factors influencing technology adoption and intensity in farming (Cholo *et al.,* 2023; Gebre *et al.,* 2022). This model is specifically suited for situations where the dependent variable is censored, meaning some values are clustered at a limit, typically zero. In the context of improved packaging material adoption, some farmers may not adopt the technology at all (zero adoption), while others adopt it to varying extents.

Following Guye *et al.,* (2020), the Tobit model is generally specified as follows:

$Yi* = Xi\beta+\varepsilon i$ (1)

$Yi = 0$; if $Yi* \leq 0$; $Yi = Yi*$; if $Yi* > 0$ (2)

$ui \sim IN(0, \sigma 2)$; $i = 1, 2, \ldots\ldots, m$

$Y_{i*}$ is the latent variable representing resenting the **extent of adoption** (i.e., how much a farmer adopts improved packaging materials)., $Y_i$ is the observed adoption rate (measured as the proportion or count of improved material adopted), $X_i$ is a vector of independent variables (factors influencing the adoption), $\beta$ represents the parameters to be estimated, $\varepsilon i$ is the error term, assumed to be normally distributed.

**RESULTS AND DISCUSSION**

**Socio-Demographic Characteristics of the Respondents**

Table 1 presents the socio-economic characteristics of respondents in the study area. The results show that most of the respondents (40.83%) fall within the age range of 41-50 years, with an average age of 44. This indicates that the respondents are predominantly middle-aged and still in their productive years. These findings align with Popoola *et al.,* (2023), which found that farmers in this age range actively engage in agriculture activities, reflecting their energy and experience. The majority of the respondents were male (65%), while 35% were female, with 42.5% of the respondents having completed secondary education. This educational background likely enhances their ability to understand and adopt new agricultural practices. This is congruent with the study of (Onyemma *et al.,* 2020) that a higher education level equips farmers with the skills necessary to interpret information and seek innovations. The respondents had an average of 24 years of farming experience, indicating a significant expertise in agricultural practices. The average household size is 7 members, suggesting ample labor availability for farming activities. Additionally, over 85% of respondents are member of farmer groups, reflecting strong social organization and collective action, which enhances their access to resources, information, and innovations.

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**Packaging Material Adopted by the Respondents**

The results in Table 2 show the various packaging materials used among the respondents in the study area. The findings reveal that the majority (75.8%) of respondents use raffia baskets as their primary means of packaging tomatoes. This indicates that traditional packaging methods are still deeply entrenched and widely accepted by the farmers in the study area. Plastic crates are used by 21.7% of respondents, indicating a growing adoption of modern packaging options. These crates might offer better durability and protection for tomatoes during transportation. Polythene bags are used by a small percentage (2.5%) of respondents, primarily for short-term transportation to nearby markets. Cardboard boxes are not used at all, likely due to their lack of durability and inability to adequately protect tomatoes during transport.

**Table 1: Socio-demographic characteristics of the respondents (n = 120)**

Source: Field Survey, 2023

| Variable | Frequency | Percentage % | S.D | Min | Max | Mean |
|---|---|---|---|---|---|---|
| **Age** | | | | | | |
| 21-30 | 13 | 10.83 | 9.94 | 21 | 60+ | 44 |
| 31-40 | 31 | 25.83 | | | | |
| 41-50 | 49 | 40.83 | | | | |
| 51-60 | 22 | 18.33 | | | | |
| 60 + | 5 | 4.17 | | | | |
| Total | 120 | 100 | | | | |
| **Gender** | | | | | | |
| Male | 78 | 65 | 0.476 | 0 | 1 | 0.65 |
| Female | 42 | 35 | | | | |
| Total | 120 | 100 | | | | |
| **Educational level** | | | | | | |
| No formal education | 14 | 11.67 | 0.87 | 0 | 4 | 1.59 |
| Primary | 38 | 31.67 | | | | |
| Secondary | 51 | 42.50 | | | | |
| Post-secondary | 17 | 14.17 | | | | |
| Total | 120 | 100 | | | | |
| **Household size** | | | | | | |
| 1-5 | 35 | 29.17 | 3.05 | 1 | 16 | 7.05 |
| 6-10 | 74 | 61.67 | | | | |
| 11- 15 | 9 | 7.50 | | | | |
| Above 15 | 2 | 1.67 | | | | |
| Total | 120 | 100 | | | | |
| **Farming experience** | | | | | | |
| ≤ 10 | 10 | 8.33 | 10.73 | 0 | 40 | 24 |
| 11-20 | 31 | 25.83 | | | | |
| 21- 30 | 47 | 39.17 | | | | |
| 31-40 | 20 | 16.67 | | | | |
| ≥ 40 | 12 | 10.00 | | | | |
| Total | 120 | 100 | | | | |
| **Group membership** | | | | | | |
| Yes | 102 | 85 | 0.357 | 0 | 1 | 0.85 |
| No | 18 | 15 | | | | |
| Total | 120 | 100 | | | | |

***Source:*** *Field Survey, 2023*

**Table 2: Packaging Material Adopted among the Respondents (n = 120)**

| Variables | Frequency | Percentage % |
|---|---|---|
| Raffia baskets | 91 | 75.8 |
| Plastic crates | 26 | 21.7 |
| Polythene bags | 3 | 2.5 |
| Cardboard boxes | 0 | 0 |

**Determinants of Adoption of Improved Packaging Materials**

The results of the Tobit model presented in Table 3 reveal a highly significant chi-square likelihood ratio test (P < 0.0000), indicating a strong fit for the data. Among the predictors included in the model, seven variables were found to be significant in determining the adoption of improved packaging materials for tomatoes among the respondents in the study area. The significant variables were education, farming experience, group membership, access to extension services, distance to the nearest market, training, and off-farm income. Education had a positive and statistically significant effect on adoption at a 5% level, as it equips farmers with the knowledge and skills to recognize the benefits of improved packaging materials. This finding is consistent with Ullah *et al.,* (2022), which emphasized that education increases farmers' awareness of postharvest management practices. The farming experience was found positive and statistically significant at a 1% level, suggesting that more experienced farmers are likely to adopt improved packaging materials. Experienced farmers are likely to have encountered various challenges in postharvest handling, which helps to understand the importance of using better packaging materials to mitigate losses (Godebo, 2020). The coefficient for group membership was found to be positive and statistically significant at a 5% level, reflecting the importance of social networks in facilitating information exchange and shared learning. This aligns with Molina *et al.,* (2021), who found that group participation enables farmers to learn from each other's experiences and innovations. Access to extension services positively influenced the adoption of improved packaging materials and was statistically significant at a 1% level. This services introduce farmers to innovative technologies. This finding is supported by Ikoyo-Eweto, (2024), stating that extension services provide essential knowledge for adopting improved practices. Distance to the nearest market was found to positively influence the adoption of improved packaging materials, being significant at a 1% level. This indicates that greater distances encourage farmers to adopt better practices to minimize losses during transport. Training was also found to positively influence adoption at a 10% level, equipping farmers with problem-solving skills to navigate challenges in adopting new practices. This finding supports the study by Campos *et al.,* (2020), which emphasizes the critical role of training in enabling farmers to recognize and utilize innovative agricultural techniques effectively. Off-farm income, however, was found to have a negative and statistically significant influence on the adoption of improved packaging materials at a 10% level. This finding suggests that farmers with significant off-farm earnings may not prioritize farming as their primary livelihood, leading to less motivation to adopt innovations. This finding contradicts the study by Tadesse & Gebremedhin (2022) which reported that off-farm income provides a reliable and stable source of supplementary earnings that can help mitigate risks and contribute to the overall financial resilience of farming families.

**Table 3: Maximum likelihood estimates of the Tobit model**

| Variables | Coefficient | Standard error | Z | P-value |
|---|---|---|---|---|
| Age of the farmers | - 0.02477 | 0.06228 | - 0.597 | 0.552 |
| Gender | - 0.06376 | 0.05416 | - 1.177 | 0.241 |
| Education | 0.02736 | 0.03379 | 0.810 | 0.025** |
| Household size | 0.03462 | 0.07036 | 0.492 | 0.492 |
| Farming experience | 0.07641 | 0.04729 | 2.425 | 0.017*** |
| Group membership | 0.06669 | 0.08465 | 0.787 | 0.038** |
| Access to credit | 0.00942 | 0.08627 | 0.163 | 0.871 |
| Access to extension | 0.19237 | 0.05576 | 3.449 | 0.007 *** |
| Distance to the nearest market | 0.09753 | 0.02483 | 1.928 | 0.001*** |
| Training | 0.05966 | 0.03560 | 1.675 | **0**.095* |
| Off-farm income | - 0.06083 | 0.03667 | -1.462 | 0.076* |
| Quantity of harvested tomatoes | -0.04942 | 0.06148 | 0.804 | 0.423 |
| Constant | 0.42036 | 0.64923 | 0.648 | 0.518 |
| Number of observation = 120 Pseudo R2 = 0.0463 LR $\chi 2$ (22) = 118.34 | | | | |
| Prob > $\chi 2$ = 0.0000 | | | | |
| ***, represents a level of significance of 1%, **, 5% and * 10%, respectively. | | | | |

***Source:*** *Field survey, 2023*

**Effects of Changes in Significant Explanatory Variables on the Probability and Intensity of Adoption of Improved Packaging Materials**

The Tobit model analysis reveals that changes in significant explanatory variables exert varying marginal effects on the adoption and intensity of improved packaging materials. The marginal effect of education indicates that when farmers are educated, the likelihood of adopting improved packaging materials increases by **5.74%**, while the intensity of adoption rises by **2.56%**. This positive relationship reflects how education enhances decision-making skills and access to information, influencing both adoption rates and usage levels. The analysis of the marginal effect of farming experience shows that each additional year increases the probability of adoption by 61.12% and the intensity of use by 8.75%. This suggests that more experienced farmers are generally more adaptable and resilient, making them more open to new technologies and practices. Group membership leads to a 1.33% increase in adoption probability and a 5.82% increase in intensity, indicating the importance of social networks for information exchange. Access to extension services has a substantial impact, with probabilities increasing by 38.4% and intensity by 19.5%. This emphasizes the role of extension services in educating farmers about new practices. The analysis indicates that an increase in distance to the market results in a 7.80% rise in adoption probability and a 6.97% increase in intensity, as farmers farther from markets may adopt better packaging to ensure produce quality. Training enhances both adoption probability and intensity by 7.60% and 8.07%, respectively. However, as farmers engage more in off-farm income, the probability and intensity of adopting improved packaging materials decrease by 8.25% and 6.81%. This suggests that while off-farm income provides additional revenue, farmers may prioritize immediate financial needs over investing in improved packaging materials, reflecting a potential conflict between short-term financial pressures and long-term agricultural investments.

**Table 4: Marginal effect of the Explanatory Variables**

| Independent Variables | Change in probability of adoption | Change in the intensity of adoption | Total change in the effect |
|---|---|---|---|
| Education | 0.05472 | 0.02563 | 0.09075 |
| Farming experience | 0.61128 | 0.08757 | 0.98443 |
| Group membership | 0.01337 | 0.05823 | 0.06654 |
| Access to extension service | 0.38474 | 0.19576 | 0.58769 |
| Distance to market | 0.07804 | 0.06965 | 0.68090 |
| Training | 0.07596 | 0.08069 | 0.43255 |
| Off-farm income | -0.08249 | -0.06812 | -0.15661 |

**Source:** Field Survey, 2023

**Constraints Faced by Farmers in the Adoption of Improved Packaging Materials**

Figure 1 presents the constraints faced by farmers in adopting improved packaging materials. The majority (40%) of respondents identified cultural and traditional practices as the most significant problem. About 23.33% of respondents revealed that the high cost of packaging materials is a major concern, indicating that financial constraints make improved materials too expensive for many farmers. Twenty percent (20.00%) of respondents indicated a lack of finance as an additional obstacle. Furthermore, 9.17% of the respondents identified infrastructural problems, particularly in rural areas where inadequate roads and transportation systems limit the movement of goods, forcing farmers to rely on locally available, traditional packaging materials. Moreover, 7.50% of the respondents stated a lack of awareness or information about the benefits of the material.

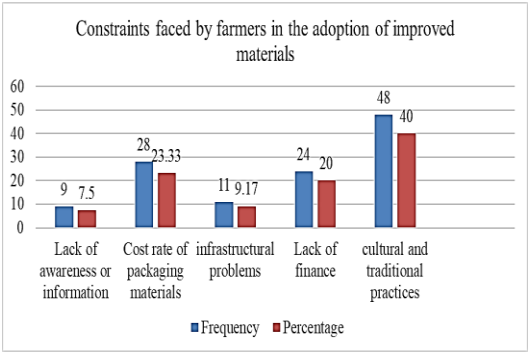


**Figure 1: Constraints Faced by the Respondents**

**CONCLUSION AND RECOMMENDATIONS**

This study found that raffia baskets, plastic crates, and polythene bags are the most commonly used packaging materials among tomato farmers, with a strong preference

for raffia baskets due to cultural practices. Key problems hindering the adoption of improved packaging materials include high costs, cultural influences, limited finances, infrastructure issues, and lack of awareness. To increase the adoption and intensify the usage of improved packaging materials, the study recommends targeted training programs to increase awareness of the benefits of improved packaging materials, engaging community leaders to address cultural barriers, and providing low-interest loans or flexible credit schemes to support farmers in purchasing improved packaging materials

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**Authors' Contributions**

Author TRA prepared the manuscript, data collection, analysis, and interpretation of the results, FIO was involved in the statistical analysis, data interpretation, reviewing, and editing of the manuscript. LTO helped in the literature review, data interpretation, and revising the final draft of the manuscript for submission.

**Ethical Statement**

Not applicable

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