Effects of the Adoption of Improved Fish Processing Technologies on Food Security among Artisanal Fish Processors in Ondo State, Nigeria

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Abstract

Agricultural post-harvest challenges remain a critical but under-explored dimension of food security in developing countries. This study examined the effects of adopting improved fish processing technologies on the food security status of artisanal fish processors in Ondo State, Nigeria. A multi-stage sampling technique was employed, utilizing a structured questionnaire administered through an interview schedule. Data collected were analyzed using descriptive statistics, the Foster-Greer-Thorbecke (FGT) food security index, and binary logistic regression. Four major fishing communities were purposively selected based on the intensity of artisanal fishing activities, after which respondents were randomly selected, yielding a total of 121 valid observations. The results revealed that the majority of respondents were male (52.9%), within the economically active age group, and possessed considerable processing experience. Most respondents operated at a moderate level of technology adoption (66.1%), while 63.6% were classified as food-secure. Traditional processing methods remained dominant, although improved technologies such as chorkor ovens and solar dryers were gradually being adopted. The major constraints to adoption included a lack of storage facilities, high cost of equipment, pest infestation, and weak extension services. The findings further showed that adoption of improved fish processing technologies had a significant positive effect on food security status, while access to storage facilities also improved the likelihood of being food-secure. Conversely, marital status exerted a negative influence on food security. The study concludes that the adoption of improved fish processing technologies plays a crucial role in enhancing household food security and reducing post-harvest losses. Therefore, it is recommended that the government and relevant stakeholders strengthen extension services, improve access to affordable processing technologies, and invest in storage infrastructure to promote wider adoption and ensure sustainable livelihoods among artisanal fish processors.

Keywords: Processing technologies, technology adoption, food safety, fish processors.

Efeitos da adoção de tecnologias aprimoradas de processamento de pescado na segurança alimentar entre processadores artesanais de pescado no estado de Ondo, Nigéria

Resumo

Os desafios pós-colheita na agricultura continuam sendo uma dimensão crítica, porém pouco explorada, da segurança alimentar em países em desenvolvimento. Este estudo examinou os efeitos da adoção de tecnologias aprimoradas de processamento de pescado sobre o status de segurança alimentar de processadores artesanais de pescado no estado de Ondo, Nigéria. Uma técnica de amostragem em múltiplos estágios foi empregada, utilizando um questionário estruturado aplicado por meio de entrevistas. Os dados coletados foram analisados utilizando estatística descritiva, o índice de segurança alimentar de Foster-Greer-Thorbecke (FGT) e regressão logística binária. Quatro comunidades pesqueiras principais foram selecionadas intencionalmente com base na intensidade das atividades de pesca artesanal, após o que os respondentes foram selecionados aleatoriamente, resultando em um total de 121 observações válidas. Os resultados revelaram que a maioria dos respondentes era do sexo masculino (52,9%), pertencia à faixa etária economicamente ativa e possuía considerável experiência em processamento. A maioria dos respondentes operava em um nível moderado de adoção de tecnologia (66,1%), enquanto 63,6% foram classificados como tendo segurança alimentar. Os métodos tradicionais de processamento permaneceram dominantes, embora tecnologias aprimoradas, como fornos chorkor e secadores solares, estivessem sendo gradualmente adotadas. As principais restrições à adoção incluíram a falta de instalações de armazenamento, o alto custo dos equipamentos, a infestação por pragas e a precariedade dos serviços de extensão rural. Os resultados mostraram ainda que a adoção de tecnologias aprimoradas de processamento de pescado teve um efeito positivo significativo na segurança alimentar, enquanto o acesso a instalações de armazenamento também aumentou a probabilidade de segurança alimentar. Por outro lado, o estado civil exerceu uma influência negativa na segurança alimentar. O estudo conclui que a adoção de tecnologias aprimoradas de processamento de pescado desempenha um papel crucial no aumento da segurança alimentar das famílias e na redução das perdas pós-captura. Portanto, recomenda-se que o governo e as partes interessadas relevantes fortaleçam os serviços de extensão rural, melhorem o acesso a tecnologias de processamento acessíveis e invistam em infraestrutura de armazenamento para promover uma adoção mais ampla e garantir meios de subsistência sustentáveis entre os processadores artesanais de pescado.

Palavras-chave: Tecnologias de processamento, adoção de tecnologia, segurança alimentar, processadores de pescado.

1. Introduction

Fish is a vital source of protein for Nigeria's large population, supplying approximately 40% of dietary animal protein intake. According to Amao *et al.* (2024), fish and fish products account for more than 60% of total protein intake among adults, especially in rural areas. Beyond its protein content, fish provides essential nutrients including sulphur, amino acids (lysine, leucine, valine, and arginine), omega-3 polyunsaturated fatty acids, fat-soluble vitamins (A, D, and E), water-soluble vitamins (B complex), and minerals such as calcium, phosphorus, iron, iodine, and selenium (Oladipo *et al.,* 2015). These nutritional properties make fish an ideal complement to carbohydrate-heavy diets common in developing countries.

Global fish production, including both wild-capture and aquaculture, reached an all-time high of 154 million tonnes in 2011, with aquaculture projected to exceed 60% of production by 2020 (FAO, 2010). Africa, while ranked as the fourth largest fish producer globally, faces competitive pressure from large-scale international fishing operations. The fisheries sector plays a dual role in Nigeria as a nutritional resource and as a livelihood for millions of people, particularly in riverine and coastal communities.

Despite Nigeria's vast fisheries resources, encompassing over 14 million hectares of reservoirs, lakes, floodplains, ponds, and rivers (FAO, 2014), domestic production has been unable to meet local demand. Artisanal fisheries contribute between 85.5% and 89.5% of total local fish production (Federal Department of Fisheries [FDF], 2009), yet the subsistence nature of artisanal fishing operations, combined with limited access to modern processing technologies, has perpetuated significant post-harvest losses and food insecurity. The global demand for fish continues to rise due to population growth and growing recognition of fish as a safe, affordable animal protein. In Nigeria, rapid population growth has widened the gap between fish supply and demand, contributing to nutritional insecurity (Kumolu-Johnson and Ndimele, 2011). Traditional fish processing methods, including cylindrical drum ovens, mud ovens, and box kilns, remain dominant, despite their association with poor product quality and elevated levels of polycyclic aromatic hydrocarbons (PAHs), raising public health concerns (George *et al.,* 2014; Olaoye *et al.,* 2015). Post-harvest losses represent a major challenge for the artisanal fish sector. Eyo (2001) estimates that spoilage accounts for 10–12 million tonnes of fish losses annually, with a further 20 million tonnes discarded at sea. These losses exacerbate the demand-supply gap and necessitate costly fish importation. Bolorunduro *et al.* (2005) note that improved handling and processing methods could substantially reduce these losses; however, adoption of improved technologies remains low due to limited awareness, inadequate extension services, and financial constraints.

The general objective of this study is to examine the effects of the adoption of improved fish processing technologies on the food security status of artisanal fish processors in Ondo State, Nigeria. Specifically, the study aims to:

1. Identify the available varieties of improved fish processing technologies in the study area;

2. Estimate the level of adoption of improved fish processing technologies.
3. Characterize respondents by their level of adoption and food security status;
4. Examine the effects of technology adoption on food security status; and
5. Identify constraints militating against the adoption of improved fish processing technologies.

1.1. Hypothesis

H_0: There is no significant relationship between food security status and the adoption of improved fish processing technologies among artisanal fish processors in the study area.

Literature indicates that the majority of smoked fish processors in Nigeria rely on traditional techniques and processing equipment that have existed for several decades, including cylindrical metal or oil-drum ovens (full or half drum), mud ovens, box ovens, and brick kilns (Davies & Bekibele, 2008; George *et al.,* 2014; Olaoye *et al.,* 2015; Odediran & Ojebiyi, 2017). However, a major shortcoming of these traditional smoking methods is the poor quality of smoked fish, as evidenced by elevated concentrations of polycyclic aromatic hydrocarbons, which pose significant public health and safety concerns. Fish processing encompasses all activities from harvest to the delivery of the final product to the consumer (George *et al.,* 2014). Because fish is highly perishable, processing and preservation are critical for extending shelf life and minimizing economic losses (Okonta & Ekelemu, 2005). Common preservation methods include freezing, smoking, drying, and heat treatment. In many rural areas of Nigeria, refrigeration is often unavailable, making traditional smoking and drying the primary preservation techniques (Agbon *et al.,* 2002). To address these limitations, improved processing technologies, such as the Chorkor oven and modern smoking kilns, have been introduced by research institutes to enhance product quality and reduce contamination. Despite these innovations, adoption rates remain low. Davies (2009) attributes this to the continued dominance of traditional technologies and insufficient investment in mechanization. Moreover, the lack of modern infrastructure, particularly cold chain storage, limits both the availability and affordability of fish in rural markets (Ayuba & Omeji, 2006). Several studies have examined the adoption of fish processing technologies and their implications for food security in Nigeria. Odediran and Ojebiyi (2017) assessed awareness and adoption among fish processors in Lagos State and found generally low adoption, with limited access, high costs, and inadequate training identified as key barriers. Olaoye *et al.* (2016) reported that adoption of improved aquaculture technologies in Lagos was influenced by socio-economic factors, including access to credit through cooperative societies. Similarly, Olatunji and Ogunremi (2016) observed that fish farming and processing in Rivers State generated income and employment, demonstrating potential for poverty alleviation. At the continental level, Aworh (2008) found that the slow modernization of traditional food processing technologies in West Africa significantly contributes to food and nutrition insecurity. Mwangi and Kariuki (2015) further demonstrated that technological, economic, and institutional factors collectively determine the adoption rates of agricultural technologies in Kenya. These findings collectively highlight the need for multi-faceted interventions to accelerate the adoption of improved technologies within Nigeria's artisanal fisheries sector.

Despite the extensive literature on fish processing technologies and food security in developing countries, most studies have largely emphasized the role of improved technologies in reducing post-harvest losses, enhancing product quality, and increasing income among small-scale processors. Evidence shows that the adoption of improved fish processing techniques such as smoking kilns, solar dryers, and hygienic handling practices can significantly improve livelihoods and contribute to household food security (Akinola *et al.,* 2018; Olaoye *et al.,* 2020). Similarly, empirical studies suggest that technological adoption in fisheries value chains is influenced by socioeconomic factors such as education, access to credit, extension services, and market linkages. However, despite these contributions, the existing body of literature remains largely fragmented and predominantly descriptive, with limited integration of technology adoption levels and multidimensional food security outcomes. Many studies have focused either on the determinants of technology adoption or on general livelihood outcomes, without explicitly linking varying levels of adoption to household food security status using rigorous econometric approaches. Furthermore, in the Nigerian context particularly within coastal and riverine communities, there is a paucity of empirical studies that simultaneously examine (i) the degree of adoption of improved fish processing technologies and (ii) their differential effects on food security outcomes. Most prior studies rely on binary measures of adoption (adopters versus non-adopters), thereby overlooking the heterogeneity in adoption intensity and its implications for welfare outcomes. This study addresses these gaps by providing a more nuanced analysis of the relationship between the level of adoption of improved fish processing technologies and household food security status. Specifically, the study advances existing knowledge in three key ways. First, it moves beyond binary classification to examine varying levels of adoption, thereby capturing the intensity effect of technology use. Second, it employs robust econometric techniques, including binary logistic regression, to establish the relationship between adoption levels and food security outcomes. Third, it contributes context-specific evidence from riverine communities in Nigeria, an area that remains underrepresented in empirical literature. By integrating technology adoption intensity with food security analysis, this study provides deeper insights into how improved fish processing technologies can enhance household welfare, thereby offering valuable implications for policy design and intervention strategies aimed at improving food security in coastal regions.

1.2. Conceptual Framework

The conceptual framework for this study situates fish processing technology adoption within the broader context of food security. Domestic fish production in Nigeria has consistently failed to meet demand, forcing the country to import large quantities of frozen fish at considerable foreign exchange cost (Oyediran *et al.,* 2016). Women play a central role in fish processing and marketing in fishing communities, contributing significantly to household food security and economic empowerment (Fakoya *et al.,* 2012). However, limited access to modern processing technologies, information, and capital constrains women processors' productivity and income.

Bolorunduro and Adesehinwa (2007) emphasised that the development of improved technologies must be complemented by efficient dissemination and capacity-building to stimulate adoption. Previous research indicates that technology adoption in the fisheries sector has been considerably lower than in other agricultural subsectors, owing to technical, environmental, and social factors (Bolorunduro and Faleye, 2003).

1.3. Theoretical Framework

1.3.1. Diffusion of Innovation Theory

This study is grounded in Rogers' (2003) Diffusion of Innovations Theory, which posits that technology adoption is a sequential decision process comprising five stages: knowledge, persuasion, decision, implementation, and confirmation. Adopters are categorised as innovators, early adopters, early majority, late majority, and laggards based on the time of adoption relative to others in a social system. This framework is appropriate for analysing the adoption of fish processing technologies as it accounts for social influence, information flow, and the role of change agents such as extension workers.

Complementary frameworks include the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975), which emphasises that adoption decisions are driven by attitudes and subjective norms, and the Theory of Planned Behaviour (TPB) (Ajzen, 1991), which extends TRA to incorporate perceived behavioural control. These theories collectively underscore the importance of individual beliefs, social pressure, and self-efficacy in shaping adoption behaviour.

1.3.2. *Double Hurdle Model*

Adoption studies in agriculture frequently employ the Tobit model. However, this model is restrictive in assuming that the same variables determine both the probability and intensity of adoption. The Double Hurdle (DH) model, originally proposed by Cragg (1971), overcomes this limitation by treating adoption and intensity of use as two distinct decisions. This study employed a binary logistic regression as the analytical equivalent for the adoption decision stage, which is consistent with recent empirical applications in Nigeria (Adewale *et al.,* 2020).

2. Materials and Methods

The study was conducted in Ondo State, located in the South West geopolitical zone of Nigeria, between longitudes 2°42'E and 3°22'E and latitudes 6°22'N and 6°42'N (Oyediran *et al.,* 2016). Ondo State has extensive water resources, including lagoons, rivers, creeks, and swamps, which support a significant artisanal fishing industry. Fishing constitutes the primary livelihood of indigenous coastal communities in the state.

2.1 Sample Size Determination

The sample size for this study was determined using the Cochran (1963) formula for estimating sample size for large populations at a 95% confidence level and 5% margin of error. The formula is expressed as:

$$n_0 = \frac{Z^2 p(1-p)}{e^2}$$

where $\mathbf{n_0}$ is the initial sample size, **Z** is the standard normal deviation (1.96 at 95% confidence level), **p** is the estimated proportion of the population with the desired characteristics (assumed to be 0.5 in the absence of prior information to maximize sample size), and **e** is the level of precision (0.05). This yielded a statistically adequate sample size for the study population.

A multi-stage sampling procedure was subsequently employed. In the first stage, four major artisanal fishing communities (Ayetoro, Igbokoda, Ugbonla, and Awoye) were purposively selected based on the intensity of fish processing activities. In the second stage, a proportionate-to-size random sampling technique was used to select respondents within each community, ensuring representativeness across locations. Due to logistical, financial, and time constraints associated with field data collection in dispersed riverine communities, one-third of the initially calculated sample size was implemented. This resulted in 128 respondents, of which 121 valid responses were retained for analysis after data cleaning. Although the reduction in sample size may limit the statistical power of the estimates, the final sample remains adequate for econometric analysis, particularly for binary logistic regression, which is robust with moderate sample sizes. However, this adjustment introduces some limitations. First, the reduced sample size may affect the generalizability of the findings beyond the study area. Second, it may reduce the precision of parameter estimates and the ability to detect smaller effect sizes. These limitations are acknowledged and considered in the interpretation of results. Despite these constraints, efforts were made to maintain methodological rigor through appropriate sampling techniques, careful questionnaire design, and the use of robust analytical tools. Primary data were collected through a structured interview schedule designed in accordance with the study objectives. The instrument captured information on socio-economic characteristics, fish processing technologies in use, sources of information, levels of adoption, food security status, and constraints to adoption. Descriptive statistics (frequency counts, percentages, and means) were used to characterise respondents' socio-economic profiles. A composite score technique with cross-tabulation analysis categorised respondents into low, moderate, and high adopter groups. The Foster-Greer-Thorbecke (FGT) index was used to classify respondents as food-secure or food-insecure, based on a threshold of two-thirds of mean monthly per capita household food expenditure. Binary logistic regression was employed to examine the determinants of food security status, with the adoption index as the primary explanatory variable alongside other socio-economic covariates.

2.2 Binary Logistic Regression Model Specification

According to Hosmer *et al.* (2013), the binary logistic regression model is an appropriate technique for analysing relationships where the dependent variable is dichotomous. Unlike linear regression, logistic regression ensures that predicted probabilities lie within the unit interval (0–1). Papke and Wooldridge (1996) further emphasised the importance of specifying a nonlinear functional form for the conditional mean, expressed as:

$E(Y|X) = G(X\beta)$

where $G(\cdot)$ is a logistic cumulative distribution function that constrains predicted values within the admissible probability range.

In this study, food security status is treated as a binary outcome (food-secure = 1, food-insecure = 0). The logistic regression model is therefore specified as:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + \mu \quad \text{Equation (1)}$$

where:

- $Y = 1$ if food-secure, 0 otherwise
- b_0 = intercept
- X_1 = Adoption index

- X_2 = Age (years)
- X_3 = Gender (1 = male, 0 = female)
- X_4 = Marital status
- X_5 = Education level
- X_6 = Extension access (1 = yes, 0 = no)
- X_7 = Market access
- X_8 = Social network
- X_9 = Cooperative membership
- X_{10} = Storage access
- μ = random error term

3. Results

3.1 Socio-Economic Characteristics of Respondents

This section explains the socio-economic characteristics of the artisanal fish processors (Table 1).

3.1.1 Gender

The findings presented in Table 1 indicate that 53% of the sampled artisanal fish processors were male and 47% were female.

3.1.2 Age

Table 1 indicates that most respondents were between 26 and 35 years of age, while the least proportion (4.1%) fell within the 36–45 age category.

3.1.3 Marital Status

The findings revealed in Table 1 that 61.2% of the respondents were married, indicating a higher level of family responsibility, while 22.3% were single, 13.2% were divorced, and 3.3% were separated.

3.1.4 Household size

The household size indicated that 30.6% of respondents had household sizes ranging from 5 to 10 members, 25.6% had between 2 and 5 members, while 23.1% had more than 10 members.

3.1.5 The level of education of the respondents

For educational attainment, the results indicated that 26.5% of respondents had completed secondary education, 21.5% had primary education, 22.3% had attempted secondary education, 9.1% did not complete primary education, 10.7% had no formal education, and 26.5% had tertiary education.

3.1.6 Farming experience

The result reveals that, 15.7% had between 16 and 20 years and above 20 years of experience, respectively, while only 4.1% had between 11 and 15 years of experience. This suggests that the respondents are generally experienced in fish processing.

3.1.7 Income Distribution

For income distribution, the findings revealed that 33.9% of respondents earned between ₦151,000 and ₦250,000, while 32.2% earned between ₦50,000 and ₦150,000. Additionally, 14.9% earned between ₦351,000 and ₦450,000 as well as ₦451,000 and above, while only 4.1% earned between ₦251,000 and ₦350,000.

Table 1. Socio-economic characteristics of artisanal fish processors (n = 121)

Characteristics	Category	Frequency (Percentage)
Gender	Male	64 (52.9)
	Female	57 (47.1)
Age Group (years)	≤ 25	37 (30.6)
	26–35	41 (33.9)
	36–45	5 (4.1)
	46–55	19 (15.7)
	≥ 56	19 (15.7)
Marital Status	Married	74 (61.2)
	Single	27 (22.3)
	Divorced	16 (13.2)
	Separated	4 (3.3)
Household Size	≤ 2	25 (20.7)
	2–5	31 (25.6)
	5–10	37 (30.6)
	≥ 10	28 (23.1)
Religion	Christianity	63 (52.1)
	Islam	41 (33.9)
	Traditionalist	10 (8.3)
	Others	7 (5.8)
Education	No formal education	13 (10.7)
	Primary incomplete	11 (9.1)
	Primary complete	26 (21.5)
	Secondary incomplete	12 (9.9)
	Secondary complete	27 (22.3)
	Tertiary	32 (26.5)
Processing Experience (yrs)	< 5	37 (30.6)
	6–10	41 (33.9)
	11–15	5 (4.1)
	16–20	19 (15.7)
	≥ 21	19 (15.7)
Monthly Income (₦)	50,000–150,000	39 (32.2)
	151,000–250,000	41 (33.9)
	251,000–350,000	5 (4.1)
	351,000–450,000	18 (14.9)
	≥ 451,000	18 (14.9)

Source: Field survey, 2025.

3.2. Fish Processing Technologies and Information Sources

The result in Figure 1 presents the distribution of respondents according to the fish processing technologies employed. The results show that the majority of respondents rely on traditional processing methods, such as open smoking and sun drying, while only a small proportion utilizes improved technologies.

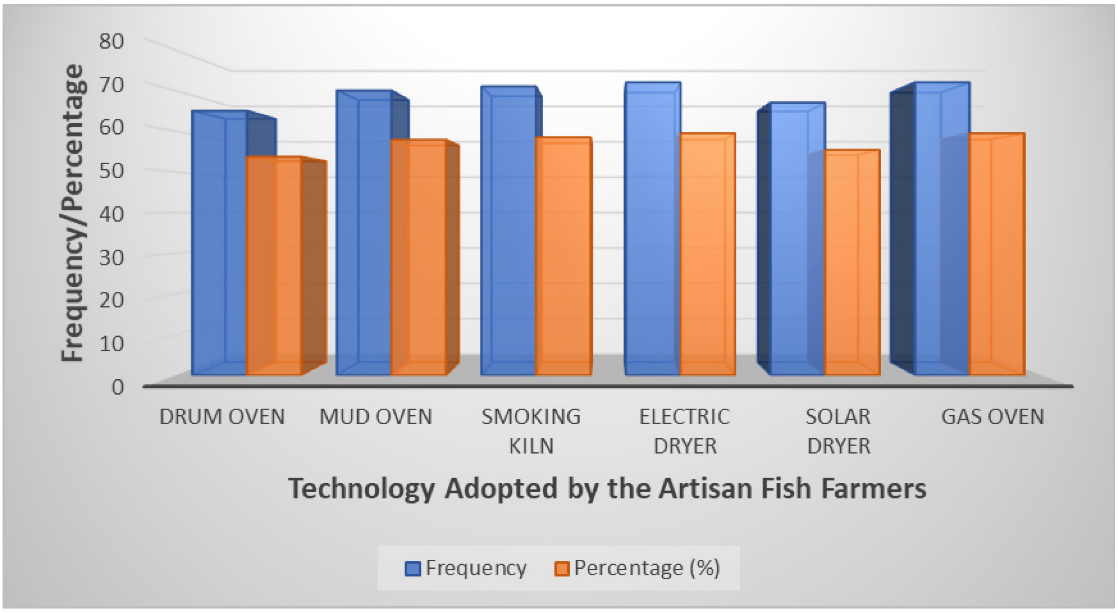

Figure 1. Distribution of respondents by fish processing technology used.

3.3 Sources of information on Improved Fish Processing Technologies

Figure 2 presents the distribution of respondents according to their sources of information on improved fish processing technologies. The results indicated that approximately 64% of respondents identified newspapers as a major source of information, making it the most prominent channel. This is closely followed by the internet (about 62%) and cooperatives (about 60%), highlighting the growing importance of digital platforms and social organizations in information dissemination. In addition, about 61% of respondents rely on religious organizations and personal experience, while approximately 59–60% obtain information from friends/peers and research institutions. Radio also accounts for about 60%, suggesting that traditional media continues to play a significant role in reaching fish processors. Conversely, relatively lower proportions were recorded for extension agents (about 58%), television (about 57%), and market contacts (about 56%), indicating comparatively less reliance on these sources.

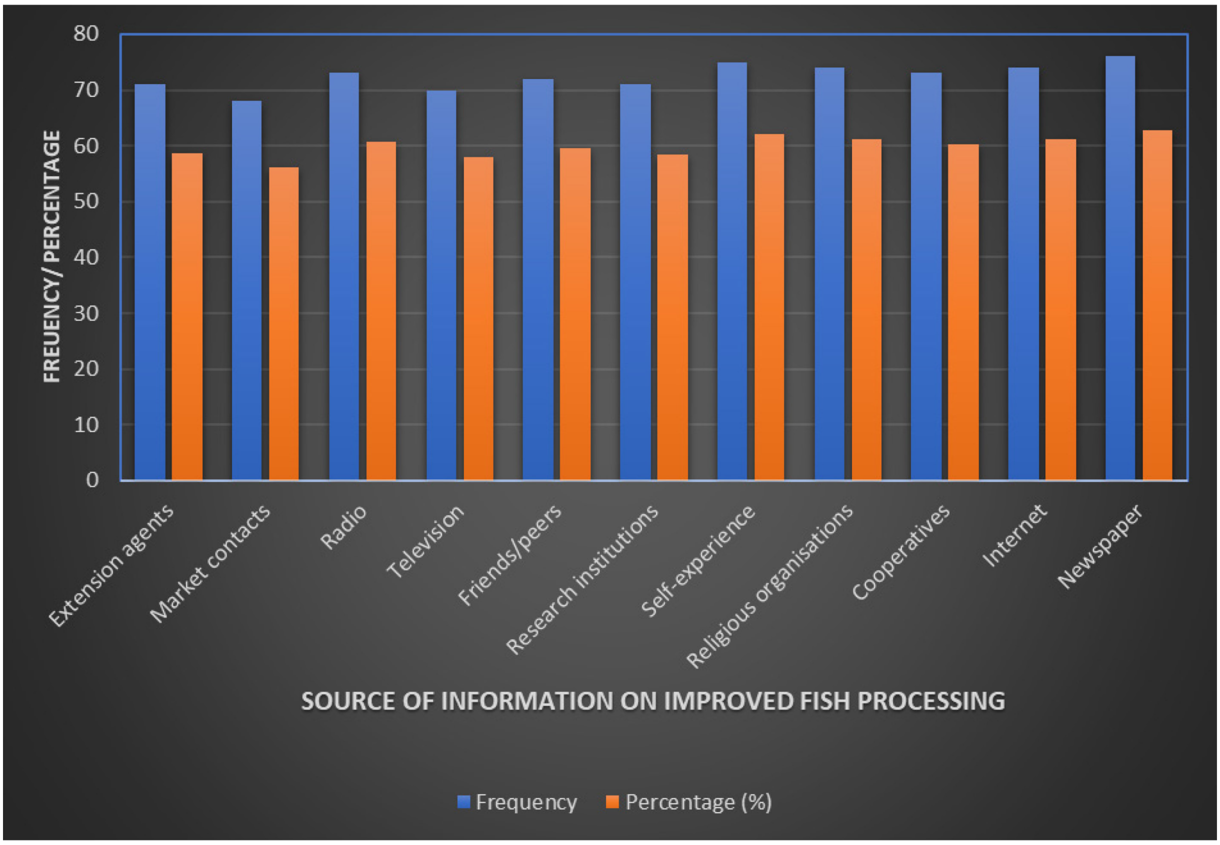

Figure 2. Distribution of respondents by source of information on improved fish processing.

3.4 Adoption Level and Food Security Status

The distribution of respondents according to their level of technology adoption in fish processing was shown in Table 2. **About 66.12%** of the respondents fall within the moderate level of adoption, indicating that the majority have adopted some improved fish processing technologies but not to a full or optimal extent. In contrast, **18.18%** of the respondents exhibit a low level of adoption, implying limited use of improved technologies.

3.5 Distribution of Respondents by Level of Adoption and Food Security Status

Table 2 presents the distribution of respondents according to their level of adoption of improved fish processing technologies and their food security status in the study area. The results are expressed as percentages, which were calculated using row totals as denominators to ensure that each row sums to 100%. The denominators correspond to the total number of respondents within each adoption category (Low = 22, Moderate = 80, High = 19), allowing for meaningful comparison within each group. The findings revealed a clear pattern across adoption levels. Among respondents with **low adoption**, a higher proportion (54.55%) were food-insecure, while only 45.45% were food-secure while respondents with **moderate adoption** exhibited improved outcomes, with the majority (65.00%) being food-secure and 35.00% food-insecure.

Table 2. Distribution of Respondents by level of Adoption and food security status

Level of Adoption	Food-Secure n (%)	Food- Insecure n (%)	Total
Low (n = 22)	10 (45.45%)	12 (54.55%)	22 (100%)
Moderate (n = 80)	52 (65.00%)	28 (35.00%)	80 (100%)
High (n = 19)	15 (78.95%)	4 (21.05%)	19 (100%)
Total	77	44	121
Chi-square $\chi2 \approx 5.12$			

Source: Field survey, 2025.

3.5 Effects of Technology Adoption on Food Security: Logistic Regression Results

Table 3 presents the logistic regression results showing the determinants of food security status among respondents in the study area. The results indicate that the adoption index has a positive and statistically significant effect on food security status at the 5% level ($p < 0.05$). The coefficient (2.9622) and marginal effect (0.5587) suggest that an increase in the level of adoption of improved fish processing technologies significantly increases the probability of being food-secure. The result further shows that marital status has a negative and statistically significant effect on food security status at the 5% level ($p < 0.05$). The coefficient (−0.5377) indicates that being married reduces the likelihood of being food-secure. Although age**,** gender, and education had the expected signs, they were not statistically significant. Age (−0.2286) shows a negative relationship with food security. Gender (0.7115) has a positive coefficient. Similarly, education (0.2215) has a positive relationship with food security. However, extension access (0.3967) and social networks (0.5219) show positive relationships. Conversely, market access (−0.4147) and cooperative membership (−0.0856) show negative relationships. Furthermore, **storage access** positively affects food security and is statistically significant at the 10% level ($p < 0.10$). The coefficient (0.5751) and marginal effect (0.1085) indicate that improved storage facilities increase the likelihood that households are food-secure, likely due to reduced post-harvest losses and greater food availability. The constant term is negative (−2.760) and statistically significant at the 10% level.

Table 3. Logistic regression results showing determinants of food security status

Variable	Coefficient	Marginal Effect	Std. Error	Z-value	p > |z|
Adoption index	2.9622	0.5587	1.3946	2.12	0.034**
Age	−0.2286	−0.0431	0.1649	−1.39	0.166
Gender	0.7115	0.1342	0.4433	1.60	0.109
Marital status	−0.5377	−0.1014	0.2477	−2.17	0.030**
Education	0.2215	0.0416	0.1385	1.59	0.111
Extension access	0.3967	0.0746	0.4653	0.85	0.395
Market access	−0.4147	−0.0782	0.4358	−0.95	0.341
Friends/social network	0.5219	0.0983	0.4953	1.05	0.293
Cooperative membership	−0.0856	−0.0159	0.4717	−0.18	0.858
Storage access	0.5751	0.1085	0.3139	1.83	0.067*
Constant	−2.760	—	1.568	−1.76	0.079*

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Source: Field survey, 2025.

3.6 Constraints to the Adoption of Improved Fish Processing Technologies

Table 4 presents the distribution of constraints to the adoption of improved fish processing technologies among respondents in the study area. The results revealed that several factors were identified as major, minor, or non-constraints, indicating varying degrees of influence on technology adoption. The findings show that lack of storage facilities constitutes the most severe constraint, with 49.6% of respondents identifying it as a major constraint, followed by 32.2% as a minor constraint and only 17.4% as not a constraint. Similarly, high procurement cost (40.5%) and pest infestation (40.5%) were reported as major constraints by a substantial proportion of respondents. In addition, no relative advantage over existing practices (39.1%), poor marketing structure (38.0%), and incompatibility with existing practices (37.2%) were also identified as major constraints, indicating that economic and structural factors play a critical role in limiting adoption. Furthermore, poor extension service delivery (36.4%), complexity of technology (34.7%), lack of technical skills (33.1%), and non-availability of technologies (33.1%) were reported as major constraints by a considerable number of respondents. These include lack of easy access to technologies (43.0%), complexity of technology (42.1%), and lack of technical skills (39.7%), suggesting that while these factors pose challenges, they may not be as critical as others. Conversely, inadequate capital (52.9%) and poor transportation facilities (41.3%) were predominantly reported as not being constraints by the majority of respondents.

Table 4. Distribution of constraints to adoption of improved fish processing technologies (n = 121).

Constraint	Major n (%)	Minor n (%)	Not a constraint n (%)
High procurement cost	49 (40.5)	47 (38.8)	25 (20.7)
Complexity of technology	42 (34.7)	51 (42.1)	28 (23.1)
Incompatibility with existing practice	45 (37.2)	47 (38.8)	29 (24.0)
No relative advantage over existing practice	48 (39.1)	45 (37.2)	28 (23.1)
Lack of easy access to technologies	31 (25.0)	52 (43.0)	38 (31.4)
Non-availability of technologies	40 (33.1)	45 (37.2)	36 (29.8)
Technologies not ideal for fish processing	40 (30.6)	43 (35.5)	39 (32.2)
Lack of storage facilities	60 (49.6)	39 (32.2)	21 (17.4)
Pest infestation	49 (40.5)	43 (35.5)	28 (23.1)
Inadequate capital	21 (17.4)	36 (29.8)	64 (52.9)
Poor marketing structure	46 (38.0)	46 (38.0)	29 (24.0)
Lack of technical skills	40 (33.1)	48 (39.7)	33 (27.3)
Poor extension service delivery	44 (36.4)	44 (36.4)	32 (26.4)
Poor transportation facilities	32 (26.4)	38 (31.4)	50 (41.3)

* Multiple responses; Source: Field survey, 2025

4. Discussion

4.1 Socio-economic characteristics of respondents

4.1.1 Gender

The observed result suggests that males in the study area have relatively greater access to fish processing activities. The study is not gender-focused. This finding contradicts the assertion of Oyediran *et al.* (2016), who reported female dominance in fish processing and emphasized its role in women's economic empowerment, poverty reduction, and food security. However, the result implies that men who participate in fish processing may be motivated to adopt improved technologies with potential nutritional benefits. It also indicates a growing involvement of women in fish processing, challenging earlier views that the activity was predominantly a female responsibility within the fisheries sector. The higher male participation observed in this study may reflect differential access to productive resources, including capital, processing equipment, and market opportunities. From an economic standpoint, such access likely enhances men's capacity to invest in improved fish processing technologies, thereby increasing productivity and income. Socially, this near balance in gender participation points to evolving roles within the fisheries sector, potentially altering intra-household dynamics related to labour allocation and income control. From a policy perspective, these findings underscore the need for gender-responsive interventions that ensure equitable access to credit, training, and extension services. The observed pattern may be driven by underlying mechanisms such as resource accessibility, perceived profitability of fish processing, and changing socio-cultural norms. Furthermore, the results showed the age distribution of artisanal fish processors in the study area. The findings indicate a predominance of individuals within the economically active age group.

4.1.2 Age

The result suggests that fish processing in the study area is largely dominated by young and energetic individuals who are capable of coping with the physical demands of the activity and are more likely to adopt new technologies. This finding is consistent with Kumar *et al.* (2018) but contrasts with Fapojuwo *et al.* (2018), who reported a lower average age among farmers. This highlights the importance of youth-focused policies, such as improved access to finance and technical training, to sustain innovation in the sector. The mechanism underlying this relationship likely relates to greater adaptability and openness to new technologies among younger individuals.

4.1.3 Marital Status of the Respondents

Married individuals typically have dependents and therefore require a stable source of income. This implies that the majority of respondents have significant household responsibilities, which may influence their level of engagement in fish processing activities. This finding aligns with Adebayo *et al.* (2017), who reported similar results in South-West Nigeria.

4.1.4 Household size

This suggests relatively large household sizes among respondents, which may indicate limited adoption of family planning practices. Larger households can provide family labour, thereby enhancing the adoption of innovations compared to smaller households. This is consistent with the findings of Danso-Abbeam *et al.* (2018), who reported similar results in Ghana.

4.1.5 The level of education of the respondents

For educational attainment, the results indicated that 26.5% of respondents had completed secondary education, 21.5% had primary education, 22.3% had attempted secondary education, 9.1% did not complete primary education, 10.7% had no formal education, and 26.5% had tertiary education.

4.1.6 Farming experience

The result reveals that, 15.7% had between 16 and 20 years and above 20 years of experience, respectively, while only 4.1% had between 11 and 15 years of experience. This suggests that the respondents are generally experienced in fish processing.

4.1.7 Income Distribution

For income distribution, the findings revealed that 33.9% of respondents earned between ₦151,000 and ₦250,000, while 32.2% earned between ₦50,000 and ₦150,000. Additionally, 14.9% earned between ₦351,000 and ₦450,000 as well as ₦451,000 and above, while only 4.1% earned between ₦251,000 and ₦350,000.

The null hypothesis is therefore rejected: there is a significant relationship between the adoption of improved fish processing technologies and the food security status of artisanal fish processors in the study area.

5. Conclusions

This study examined the adoption of improved fish processing technologies and its implications for food security among artisanal fish processors in the study area. The findings revealed that although respondents possess diverse socio-economic characteristics, a substantial proportion still rely on traditional fish processing methods, indicating a relatively low level of adoption of modern technologies. The study further showed that access to information is largely driven by informal networks and mass media channels rather than formal institutional sources such as extension services. This suggests gaps in the effectiveness of formal agricultural information delivery systems. In addition, the results demonstrated a clear relationship between technology adoption and food security status, with higher levels of adoption associated with improved food security outcomes among respondents. The logistic regression analysis confirmed that the adoption of improved fish processing technologies significantly increases the likelihood that households are food-secure. Other factors such as marital status and access to storage facilities also play important roles in determining food security status. However, several socio-economic variables, including age, gender, education, and access to extension services, were not statistically significant, although they showed expected directional relationships. Furthermore, the study identified key constraints limiting the adoption of improved technologies. Prominent among these are lack of storage facilities, high cost of processing technologies, pest infestation, weak extension service delivery, and limited technical skills. These constraints highlight critical infrastructural, economic, and institutional gaps that hinder effective technology uptake. The study concludes that while improved fish processing technologies have strong potential to enhance food security and livelihoods, their adoption remains constrained by multiple interrelated factors. Addressing these constraints through improved infrastructure, affordable technologies, effective extension services, and capacity building will be essential for increasing adoption rates and achieving sustainable improvements in food security among artisanal fish processors.

6. Recommendations

Based on the findings of this study, the following recommendations are proposed to enhance the adoption of improved fish processing technologies and improve food security among artisanal fish processors:

Provision of Storage Infrastructure: Government and relevant stakeholders should invest in the provision of modern storage facilities such as cold rooms and improved drying/storage systems. This will reduce post-harvest losses, improve product quality, and encourage the adoption of improved processing technologies.

Subsidization and Access to Affordable Technologies: The high cost of improved fish processing technologies was identified as a major constraint. Therefore, government agencies, NGOs, and development partners should provide subsidies, credit facilities, or soft loans to enable fish processors to acquire modern equipment at affordable rates.

Strengthening Extension Service Delivery: Extension services should be strengthened and made more accessible to fish processors. Extension agents should be adequately trained and equipped to provide practical demonstrations, technical guidance, and continuous support on the use and benefits of improved fish processing technologies.

Capacity Building and Training Programmes: Regular training workshops and skill acquisition programmes should be organized to enhance the technical capacity of fish processors. This will reduce the challenges associated with the complexity of technologies and improve their effective utilization.

Promotion of Information Dissemination Channels: Since mass media and informal networks were found to be major sources of information, stakeholders should leverage platforms such as radio, internet, cooperatives, and social groups to disseminate information on improved technologies. At the same time, formal channels should be strengthened to complement these sources.

Improvement of Marketing Systems: Efforts should be made to develop efficient marketing structures for processed fish products. This includes establishing better market linkages, improving pricing systems, and supporting value chain development to ensure that processors receive fair returns on their products.

Encouragement of Cooperative Formation and **Participation**: Fish processors should be encouraged to form and actively participate in cooperatives, as this can improve access to credit, shared resources, training opportunities, and collective marketing, thereby enhancing adoption of improved technologies.

Development of User-Friendly Technologies: Research institutions and technology developers should focus on designing fish processing technologies that are compatible with local practices, easy to use, and adaptable to the socio-economic conditions of small-scale processors.

Pest Control and Quality Management Support: Relevant agencies should provide guidance and support on pest control measures and hygienic processing practices to reduce losses and improve the quality and safety of processed fish.

7. Authors' Contributions

Deborah Tosin Fajobi: conceptualisation, designed the experiment, and analyzed the data. *Olasunmbo Kafilat Jubreel* and *Janet Temitope Ojediran* experimented and interpreted the data. Damilola Toluse Adeomi: wrote the first draft, contributed to the analysis tools, and corrected the draft

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Not applicable.

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