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Adoption effect of improved fish processing technologies on food security: Experience from artisanal fish processors in Lagos state, Nigeria

[1,2]Amoo, Ifeoluwa Folasade, [1]Okunola, Solomon Olufemi, and [1]Olawuyi, Seyi Olalekan
[1]Department of Agricultural Economics, Ladoke Akintola University of Technology, Nigeria
[2]Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria
Correspondence details: ifemiee@yahoo.com, +2348137676264

Abstract: Fish is a highly perishable food product, necessitating effective preservation methods to mitigate food loss. Traditional preservation techniques often pose health risks, underscoring the need for improved, environmentally safe processing technologies suitable for human consumption. This study examined the effects of adoption of improved fish processing technologies on food security among artisanal fish processors in Lagos State, Nigeria. A two-stage sampling procedure was adopted in the random selection of 121 fish processors across the selected fishing communities. The dataset elicited was analyzed using descriptive statistics to depict the demographic and socio-economic characteristics of the processors. The study used composite score analysis to categorize processors based on their level of technology adoption, and Foster, Greer, and Thorbecke approach to measure food security status. Fractional logistic regression was applied to examine the effects of technology adoption on food security. Findings indicate that 62% of the sampled processors were female, with an average age of approximately 46 years. Commonly used processing techniques included charcoal ovens (57.9%), smoking kilns (64.5%), electric dryers (45.5%), solar dryers (37.2%), and gas ovens (55.4%). Information sources for respondents included extension agents, research, personal experience, religious organizations, friends, internet, and newspapers. Approximately 66.1% of respondents showed moderate adoption of improved technologies, while 16% and 18% exhibited high and low adoption levels, respectively. Notably, 63.6% were food-secure, while 36.3% were food-insecure. Significant factors affecting food security included marital status ($p=2.17$), access to storage facilities ($p=1.83$), and the adoption of improved fish processing technologies ($p=2.12$). The study concludes that adoption of improved fish processing technologies significantly boosts food security among processors. Recommendations include enhancing storage facilities and encouraging the adoption of advanced processing methods to reduce spoilage and extend shelf life, ensuring safe food and improved food security.
Keywords: Artisanal, fish processing technologies, fractional logistic regression, Lagos, Nigeria

INTRODUCTION

Fish is a good source of protein to large population of Nigeria as it provides 40% of the dietary intake of animal protein of the average Nigerian. According to Oladipo *et al.* (2015), fish and fish products constitute more than 60% of the total protein intake in adults, especially in rural areas. Fish has a nutrient profile superior to all terrestrial meats (beef, pork and chicken), an excellent source of high-quality animal protein and highly digestible energy. Fish is a good source of Sulphur and essential amino acids such as lysine, leucine, valine and arginine. It is therefore suitable for supplementing diets of high carbohydrates contents; fish is also a good source of thiamine as well as an extremely rich source of Omega-3 polysaturated fatty acids, fat-soluble vitamins (A, D and E) and water-soluble vitamins (B complex) and minerals (Calcium, Phosphorus, Iron, Iodine and Selenium) (Oladipo *et al.,* 2015).

Fish also have a high content of Polyunsaturated Omega III fatty acids, which are important in lowering blood cholesterol level and high blood pressure. It can mitigate and alleviate platelets of cholesterol aggregation and various arteriosclerosis conditions in adult populations. However, it reduces the risk of sudden death from heart attacks and reduces rheumatoid arthritis, Omega-3 fatty acids also lower the risk of age-related muscular degeneration and vision impairment; it decreases the risk of bowel cancer and reduces insulin resistance in skeletal muscles (Kudi *et al.,* 2011).

The significance of fish, particularly to people living in emerging countries, has been well acknowledged in the literature. Fish is one of the economical sources of dietary protein, especially in secluded fishing communities; source of employment as the fishery sector generates employment for over 70% of persons living in rural areas (Federal Department of Fisheries (FDF), 2013). It is also of medicinal value and further useful for industrial purposes such as in the production of fish meal. The use of fish as a source of protein to aid growth and development of both humans and livestock cannot be over-emphasized. Quite a sizeable proportion of the Nigerian population depends on fishing as a source of income. Apart from being an income earner to many Nigerians especially people in coastal, river-rine and lake areas of the country. Some people earn their living from fish processing and marketing while others engaged in fishery research. It is therefore necessary to ensure that improved fish processing technologies that have been developed and disseminated are adopted, in order to increase fish processing and improve food security. A number of fish processing technologies that have been developed and disseminated to processors in Nigeria include the electric dryer, gas oven, chorkor oven, solar dryer and smoking kiln. Effective dissemination of these technologies to processors, their adoption and diffusion are expected to bring about increase in fish

processing and enhance food security in Nigeria. The roles of fish processing technologies are to simplify and make fish processing more effective and efficient. It is therefore pertinent to investigate the extent to which fish processing technologies have been transferred to processors and the extent to which the technology end-users have taken advantage of these technologies in fish processing.

The global demand for fish as food is increasing not only due to increased population growth but because it is a safe source of animal protein that is widely available and affordable for all regardless of socio-economic status (Olaoye *et al.,* 2015). More so, Nigeria is a highly populated country; hence, the demand for fish and fish products continues to increase, and the supply has failed to meet the demand. This thereby creates a gap between the fish demand and supply thereby causing nutritional and food insecurity (Kumolu-Johnson and Ndimele, 2011). Bearing in mind that fish is a perishable product, processors employed various techniques for its preservation to avoid food loss; owing to this, traditional processing of fish remains a pivotal means of making cured fish available to Nigerians and many other Africans over a long time which not only preserves the fish but also protects against income loss by the fish processors (Sakyi *et al.,* 2019). Literatures have shown that majority of smoked fish processors in Nigeria employed traditional techniques and processing equipment that have been in existence for several decades such as cylindrical metal or oil-drum oven (full or half drum), mud oven, box oven, and brick kiln (Davies and Bekibele, 2008; George *et al.,* 2014; Olaoye *et al.,* 2015; Odediran and Ojebiyi, 2017). However, the major shortcoming of traditional smoking ovens hinged on the poor-quality smoked fish as evidenced by higher polycyclic aromatic hydrocarbons concentration which raise public safety and health concerns. Bolorunduro *et al.,* (2005) noted that post-harvest losses could be reduced by simply improving the handling and processing methods. Equally, Davies (2005) submitted that the development of appropriate fish machinery and technologies that employ effective handling, harvesting, processing and storage cannot be over-emphasized, especially in the age when aquaculture development is fast gathering momentum in Nigeria. In line with this view, the Federal Government of Nigeria, in collaboration with international agencies (such as FAO) and State Governments, has funded research across various research institutes to invent and develop improved processing and preservation technologies.

The general objective of this research is to examine the effects of adoption of improved fish processing technologies on food security status among artisanal fish processors in Lagos State, Nigeria.

The specific objectives of this study are to:

- identify the available varieties of improved fish processing technologies among artisanal fish processors in the study area.
- estimate the level of adoption of improved fish processing technologies in the study area.
- characterize the respondents' food security status based on their level of improved fish processing technologies in the study area.
- examine the effects of adoption of improved fish processing technologies on the food security status of the respondents in the study area.
- identify the constraints militating against the adoption of improved fish processing technologies in the study area.

METHODOLOGY

The study area is Lagos State, South-west, Nigeria. The State lies approximately on longitude 2°42" and 3° 22" taste of the Greenwich Meridian and between the latitude 6° 22" and 6° 42" North of the Equator. It has an estimated population of 17,552,940 persons (LASG, 2012). It is bounded in the North and East by Ogun State and in the West and South by Republic of Benin and Atlantic Ocean respectively (Oyediran *et al.,* 2016). Although the State is primarily Yoruba speaking, it attracts people of other ethnic groups within the country and foreign neighboring countries (Adefuye, 1987). Fishing is the main industry of the indigenous population of the selected communities. The fishing villages are scattered with various forms of water bodies; lagoons, rivers, creeks and swamps. By virtue of its location in Nigeria, Lagos and the environments are veritable fishing area. Most of inhabitants of the selected communities, therefore, derive their livelihood from fishing as an income generating activity.

Two stage sampling technique were used for this research. In the first stage, four artisanal fishing communities (Badagry, Eti-Osa, Epe and Ikorodu) in Lagos State were purposively selected because of the predominant activities of artisanal fishing activities in these areas. The second stage involved the use of proportionality factor (that is, the use of a random proportionate to size sampling technique) in the selection of 128 fish processors across the selected fishing communities.

Descriptive statistics such as frequency counts, percentages and mean value were used to describe the demographic and socio-economic characteristics of the respondents, while composite score technique and cross-tabulation analysis were applied to categorize the respondents' food security status based on the levels of adoption of improved fish processing techniques. Fractional logistic regression analysis was also applied to model the effect of adoption of improved fish processing

technologies and other dynamics on the food security status of the respondents in the study area.

Fractional Regression: Model Specification

According to Villadsen and Wulff (2021), fractional model regression is an appropriate technique for modeling fractional outcomes. Papke and Wooldridge (1996) suggested imposing a functional form for the conditional mean of the fractional outcome: $E(y/X)G = G(X\beta)$, where the nonlinear function $G(.)$ ensures that predictions lie inside the unit interval (Villadsen and Wulff, 2021). Explicitly, the relationship between food security status and adoption of improved fish processing technologies and other dynamics can be expressed as:

$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 \ldots\ldots\ldots\ldots\ldots b_nX_n+\mu$ …… (4) where:

Y= Index of food security status

b_0 = intercept

b_i = regression coefficient

$X_1 \ldots\ldots\ldots X_n$ = hypothesized independent variables influencing the respondents' food security status.

μ = random error term.

RESULTS AND DISCUSSION

Personal and socioeconomic characteristics

The findings in Table 1 revealed that 38.0% of the sampled artisanal fish processors were male, while 62.0% were female. Although the study is not gender based, the result underlies the fact that female in the study area had greater access to fish processing. This research finding was further supported by the assertion of Oyediran et al. (2016) that the female dominance in fish processing contributes to their economic empowerment, poverty reduction and food security. By implication, women who participated in fish processing were motivated to adopt new technologies that offer nutritional benefits. The result also indicated that males are now getting involved in fish processing as against the earlier submissions that fish processing is the sole responsibility of women in fishing industries.

Also, the results revealed the age-group distribution of the artisanal fish processors in the study area. The findings indicated the predominance of people who fall within the active age groups of the economy. Most of the respondents fell between the ages of 36-45 years while the lowest percentage (4.1%) of the artisanal fish processors fell within less than 25 years of age. By implication, fish processing in the study area were dominated by young people, who are energetic enough to withstand the stress involved in fish processing with readiness to adopt and try out new technologies. This finding agrees with Kumar et al. (2018), but disagrees with Fapojuwo *et al.* (2018), who reported a much lesser average age of the farmers.

Similarly, the findings revealed that 61.2 percent of the respondents were married and, therefore would have greater family responsibility, 22.3 percent were single, 13.2 percent were divorced, while 3.3 percent were separated. Most married people have dependants, and thus require a steady source of income. This result implies that most of the respondents were married, though some were single, widowed and few were divorced. By implication, this result suggests that most actors were married and this is in line with the findings of Adebayo et al. (2017), who reported similar findings in their study conducted in South-West Nigeria.

In terms of household size, the findings revealed that the largest percentage of household size of the respondents were 30.6% with household size ranging from 5-10. 25.6% had 2 to 5 household size while 23.1 % had less or equal to 2 members in their household which showed that most of the respondents do not adopt family planning. The study affirms that large households tend to have free labor supply toward the adoption of an innovation rather than the smaller households. By implication, this result suggests by Danso-Abbeam et al. (2018) who reported similar findings in their study conducted in Ghana. The findings also revealed that 26.5 percent of the respondents completed their secondary school education, 21.5 percent completed primary school education, 22.3 percent attempted secondary school, 9.1 percent were exempted from primary school and 10.7 percent had no formal education while 9.9 percent had tertiary education. This result implies that most of the respondents have basic education recommended and made compulsory by Federal Government of Nigeria. With this educational attainment, the adoption of fish processing technologies could be facilitated as education plays a significant role in adoption of improved technologies.

The findings also indicated that 33.9 percent of the fish processors had between 6-10 years of fish processing experience, 4.1 percent of the respondents had between 1-5 years of fish processing experience, 15.7 percent of the respondents had between 16-20 years and more than 20 years of fish processing experience, respectively. Then, 30.6 percent of the respondents also had between 11-15 years of fish processing experience. The result implies that the respondents were well experienced in fish processing in the study area. This finding agrees with Okidim and Obe-Nwaka (2021) who reported similar findings in their study conducted in River State, Nigeria. In the same vein, the findings revealed that 33.9 percent of the income fell between N151000-N250000, 32.2 percent of the income fell between N50000-N150000, 14.9 percent of the income realized by the respondents fell between N351000-450000 and 451000 and above while 4.1 percent of the income fell N251000-N350000. This indicates that most of the respondents realized good income from fish processing. This also implies that fish farming is a

high-income generating investment. The result is in line with Aminu et al. (2017) who reported similar findings in their study conducted in Lagos State, Nigeria. Overall, the results showed that the respondents have differentiated socio-economic characteristics, and this can influence the level of adoption of improved fish processing technologies and their food security status.

Table 1: Selected personal and socio-economic features of artisanal fish processors (n=121)

Variables	Frequency	Percentage
Gender		
Male	46	38.0
Female	75	62.0
Age-group (years)		
<= 25	5	4.1
26-35	37	30.6
36-45	50	41.3
46-55	19	15.7
Above 55	10	8.3
(Mean = 46 years)		
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
Above 10	28	23.1
Educational status		
No formal education	13	10.7
Primary School exempted	11	9.1
Primary School completed	26	21.5
Secondary School Attempted	27	22.3
Secondary School completed	32	26.5
Tertiary	12	9.9
Years of experience		
<5	5	4.1
6-10	41	33.9
11-15	37	30.6
16-20	19	15.7
Above 20	19	15.7
Monthly Income		
50000-150000	41	33.9
151000-250000	39	32.2
251000-350000	5	4.1
351000-450000	18	14.9
451000 and above	18	14.9

Source: Field survey, 2023

Fish processing technologies adopted

The findings in Table 2 revealed that 57.9 percent of the respondents used Charcoal oven as a fish processing technique while 64.5 percent of the respondents used fish smoking kiln as a processing technique. 45.5 percent of the respondents use electric dryer oven as a fish processing technique, 37.2 percent of the respondents use solar dryer as a fish processing technique while 55.4 percent of the respondents use gas oven as a fish processing technique. From the results, the respondents' usage of fish processing techniques spread across the study area.

Table 2: Distribution of the respondents based on fish processing technologies

Fish processing technologies	Frequency	Percentage
Charcoal oven	70	57.9
Smoking kiln	78	64.5
Electric dryer	55	45.5
Solar dryer	45	37.2
Gas oven	67	55.4

***Multiple response**
Source: Field survey, 2023

Sources of information on improved fish processing technologies

Table 3 revealed that 58.7 percent of the respondents used extension agents as the source of information on improved fish processing practices, 56.2 percent of the respondent used market as the source of information, 60.7 percent of the respondent used Radio as the source of information on fish processing practices, 57.9 percent of the respondent used Television as the source of information on fish processing practices, 59.5 percent of the respondent used Friends as the source of information on fish processing practices, 58.7 percent of the respondent used Research as the source of information on fish processing practices,. 62.0 percent of the respondent used Self experience as the source of information on fish processing practices. 61.2 percent of the respondent used religious organization as the source of information on fish processing practices. 60.3 percent of the respondents used Organization as the source of information on approved fish processing practices, 61.2 percent of the respondent used Internet as the source of information on fish processing practices. 62.8 percent of the respondents used Newspaper as the source of information on fish processing practices.

Table 3: Distribution of the respondents based on source of information

Sources	Frequency	Percentage
Extension Agents	71	58.7
Market	68	56.2
Radio	73	60.7
Television	70	57.9
Friends	72	59.5
Research	71	58.5
Self	75	62.0
Religious	74	61.2
Cooperative	73	60.3
Internet	74	61.2
Newspaper	76	62.8

***Multiple response**
Source: Field survey, 2023

Distribution of respondents by level of adoption and food security status

Table 4 presented the level of adoption and food security status of respondents in the study area. The table revealed that majority of individuals in all levels of adoption are food secured, with 67.53% of individuals in the moderate adoption group being food secured, the highest among the three groups. While 19.48% of the respondents who are in the high level of adoption group were found to be food secured and the lowest percentage of food secured individuals was found in the low adoption group, with 12.99%. Furthermore, the result showed that majority (63.63%) of the respondents who are in the moderate level of adoption group were found to be food non-secured, also 27.27% of the respondents who are in the low level of adoption were found to be food non-secured and 9.09% of the respondent who are in the high level of adoption group were found to be food non-secured. The total result revealed that the moderate level of adoption has the highest percentage of food secured households (67.53%) and food non-secured households (63.64%). However, the result indicated that there is a correlation between the level of adoption and food security. The moderate adoption group has the highest percentage of food-secured individuals, which may indicate that certain adoption of fish processing technologies is more effective at promoting food security.

Table 4: Distribution of respondents by Level of Adoption and Food Security Status

Level of Adoption	Food Secure	Food Insecure	Total
Low	10 (12.99)	12 (27.27)	22 (18.18)
Moderate	52 (67.53)	28 (63.63)	80 (66.12)
High	15 (19.48)	4 (9.09)	19 (15.70)
Total	77 (100.00)	44 (100.00)	121 (100.00)

Source: Field Survey, 2023

Effect of adoption of improved fish processing technologies on food security status of fish processors

Table 5 presents the results of the fractional logistic regression analysis fitted to model the effects of adoption of improved fish processing technologies on food security status of the respondents in the study area. It was observed that the coefficient of adoption index was positive (a direct relationship with food security status) and it is statistically significant at 5% probability level, while the coefficient of marital status is negative (an inverse relationship with food security status), and it is also significant at 5% probability level. Meanwhile, the coefficient of access to storage facilities was positive (a direct relationship with food security status) and it is also significant at 10% probability level.

Given these results, the coefficient of adoption index was found to be significant and positive, which implies that an increase in the rate of adoption of improved fish processing technologies has the possibility of increasing food security status of the respondent by 0.5587 unit, and the association between adoption index and food security status is statistically significant. This is in line with what Obisesan and Omonona (2013) reported in their related study in Nigeria where they revealed the impact of the Root and Tuber Expansion Programme (RTEP) improved production technology on the food insecurity incidence, depth and severity of the beneficiaries. As noted in their study, the food insecurity incidence of RTEP beneficiaries reduced by 16.27%, 12.02% and 21.54% when compared with the all the population of Non-RTEP beneficiaries (ANRTEPB), Non-RTEP beneficiaries within RTEP Areas (NRTEPBW) and Non-RTEP beneficiaries outside RTEP Areas (NRTEPBO), respectively. Furthermore, the coefficient of access to storage facilities was also found to be positive and significant, indicating that having access to storage facilities is associated with a higher likelihood of respondents been food secure by 0.1085 unit. However, the coefficient of marital status was found to be negative and significant indicating that married fish processors are more likely to be food secure by 0.1014, while unmarried fish processors are less likely to be food secure. By implication, married individuals will likely have more family members to use as family labour, hence the chance of having higher productivity outcome in terms of fish processing, income generated and being food secure is high.

In conclusion, since adoption of improved fish processing techniques appears to have a significant and positive relationship with the farmers' food security status, it is safe to reject the null hypothesis and accept the alternative hypothesis that adoption of improved fish processing techniques has a significant relationship with the processors' food security status in the study area.

Table 5: Effect of Adoption of Improved Technologies on Food Security Status

Variable	Coefficient	Marginal effect	Std.Err	Z value	p>/z/
Adoption index	2.9612	0.5587	1.3946	2.12**	0.034
Age	-0.2286	-0.431	0.1649	-1.39	0.166
Gender	0.7115	0.1342	0.4433	1.60	0.109
Marital Status	-0.5376	-0.1014	0.2477	-2.17**	0.030
Education	0.2205	0.0416	0.1385	1.59	0.111
Extension access	0.3957	0.0746	0.4653	0.85	0.395
Market access	-0.4147	-0.0782	0.4358	-0.95	0.341
Information from friends	0.5209	0.0983	0.4953	1.05	0.293
Information from Cooperative	-0.0846	-0.0159	0.4717	-0.18	0.858
Access to storage	0.5751	0.1085	0.3139	1.83*	0.067
Constant	-2.760	-	1.568	-1.76*	0.079

Source: Data analysis, 2023

Constraints affecting adoption of fish processing technologies

The result in Table 6 revealed the constraints and/or challenges (minor and major) affecting the adoption of improved processing technologies in the study area. Parts of the challenges considered by the respondents are: lack of storage facilities, high cost of procurement of the

equipment used for the technology, pest infestation, apathy towards transitioning from the old methods of processing to the improved ones, poor marketing structure, compatibility issue as regards the existing practice, and poor extension service delivery. Likewise, complexity of the technology, lack of seamless access to the technologies, lack of technical skills, and perception about the appropriateness of the improved technologies were also cited as parts of the constraints militating against the adoption of improved fish processing technique in the study area. With this observation, appropriate policy actions targeted at addressing these highlighted challenges, needs to be implemented so as to boost the adoption and uptake of the improved fish processing technologies as these have been shown to be good, from health and environmental perspectives.

Table 6: Distribution of the respondents based on the constraints affecting adoption of improved processing technologies

Constraint	Major	Minor	Not a constraint
High cost of procurement of the technologies	49 (40.5)	47 (38.8)	25 (20.7)
Complexity of the technology	42 (34.7)	51 (42.1)	28 (23.1)
Compatibility with existing practice	45 (37.2)	47 (38.8)	29 (24.0)
Apathy towards improved technologies	48(39.1)	45 (37.2)	28 (23.1)
Lack of easy access to the technologies	31(25.0)	52 (43.0)	38 (31.4)
Non-availability of the technologies	40 (33.1)	45 (37.2)	36 (29.8)
Technologies are 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 facility	32 (26.4)	38 (31.4)	50 (41.3)

The values indicated in the table are frequencies, while those in parentheses are percentages
* - Multiple response
Source: Field survey, 2023

CONCLUSION

Based on the findings of the study, it was concluded that artisanal fish processors is an industry that is mostly dominated by young, energetic male individuals who have a considerable level of fish processing experience and access to education. This suggests that there is potential for the industry to continue to thrive in the future, especially if interventions are made to increase adoption rates of improved fish processing technologies. Additionally, the good income realized by most of the respondents implies that artisanal fish processing can be a viable means of livelihood for individuals in the study area. Also, the study concluded that the artisanal fish processors in the study area have access to a variety of sources of information on fish processing technologies. However, the majority of them have only a moderate level of adoption of fish processing technologies, indicating a need for targeted interventions to increase adoption rates. The study also concluded that over a third of the respondents were classified as food non-secured suggesting that there is a significant food security issue in the area, which may be due to a variety of factors such as poverty, lack of employment, poor infrastructure, or inadequate social protection programs. Addressing these issues may be necessary to improve food security and enhance the livelihoods of artisanal fish processors in the study area. Based on the findings, it was also concluded that the adoption of improved fish processing technologies and access to storage facilities were positively associated with food security among artisanal fish processors in Lagos state. Therefore, interventions that encourage the adoption of improved fish processing technologies and provide access to storage facilities are likely to improve the food security status of fish processors. It was concluded from the findings that marital status is negatively associated with food security, with unmarried fish processors being less likely to be food-secure. Therefore, policies and programs that specifically target unmarried fish processors may be necessary to improve their food security status. Furthermore, it was concluded from the study that there were several constraints that affected the adoption of Fish Processing Technologies. The most significant constraint is the perception that these technologies have no relative advantage over traditional techniques. Lack of storage facilities and pest infestation were also identified as major constraints. Poor marketing structure and extension services were also significant barriers to adoption. However, complexity and difficulty in adopting improved technologies were found to be minor constraints and inadequate capital and lack of technical skills were not significant constraints.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are suggested:

- Given that the perception that the technologies are not ideal for fish processing and have no relative advantage over traditional techniques is a significant constraint affecting adoption, it is important to increase awareness among artisanal fish processors about the benefits of improved fish processing technologies. This could be done through targeted outreach programs that provide clear and concise information on the benefits of improved fish processing technologies.
- The study found that having access to storage facilities increases the likelihood of food security status of the respondents. Therefore, it is recommended that government and non-governmental organizations should provide storage facilities for artisanal fish processors to store their processed fish, which can help reduce spoilage and increase their income.
- Poor extension services were identified as a significant constraint to the adoption of improved fish processing technologies. Therefore, it is recommended that extension services be improved through training and capacity building programs for extension agents and the provision of necessary resources to enable them to effectively disseminate information to fish processors.
- The study found that poor marketing structures were a significant constraint to the adoption of improved fish processing technologies. Therefore, it is recommended that marketing structures be strengthened to provide better access to markets for artisanal fish processors. This can be achieved through the establishment of cooperative societies or the provision of credit facilities to help processors expand their businesses and access more markets.

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