



The Impact of Adoption of Modified Drum-Oven Technology On Income of Fish Processors in Niger State, Nigeria

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ABSTRACT

Nigeria is faced with the task of meeting the protein demands of its ever-increasing human population aimed at promoting healthy living and sustainable economic growth. Fish has been acknowledged as an important source of animal protein in the country. Hence, adoption of the modified drum-oven will enhance better supply of processed fish to the markets. The study examined the factors influencing adoption and the impact of adoption of modified drum-oven technology (MDOT) on fish processors' income and level of living. Data for the study were collected using questionnaire administered to 320 fish processors in 8 Local Government Areas (LGAs) of Niger State, Nigeria. Descriptive statistics and Propensity Score Matching (PSM) were used to achieve the aims of the study. The mean income of fish processors that adopted MDOT, (₦382, 813.00) is higher than that of non-adopters (₦201, 723.40). The Logit regression model on factors influencing adoption of MDOT by fish processors revealed that age ($P<0.05$), sex ($P<0.01$), income ($P<0.01$), processed output ($P<0.01$), compatibility ($P<0.05$), complexity ($P<0.05$) and affordability ($P<0.05$) were statistically significant at different level of probability. The significant and positive coefficients imply that a unit increase in these variables will lead a corresponding increase in the adoption of the MDOT and vice versa. The impact of MDOT on fish processors' revealed that the average output per unit of inputs of the MDOT processors was 1.008 kg. The Z-test showed that the calculated z-value (2.67) implies that there is significant difference between the income of MDOT and traditional technology respondents. The study revealed that adoption of MDOT has a positive impact on fish processors income and level of living in the study area. Extension delivery service should be funded properly by government so as to enable their services to reach a significant number of fish processors towards increase adoption of more improved technologies by interested individuals/fish processors.

Keywords: Fish, impact, modified drum oven technology (MDOT).

INTRODUCTION

Nigeria is faced with the task of meeting the protein demands of its ever-increasing human population aimed at promoting healthy living and sustainable economic growth, full and productive employment and decent work for all as enshrined in Sustainable Development Goals, SDGs 3, 8 and 16 (Oladimeji *et al.*, 2019). Fish has been acknowledged as an important source of animal protein, contributing significantly to the survival and well-being of a large number of the people in the country. Besides, it is a cheap source of animal protein with no religious taboo or any known cultural limitation affecting its consumption unlike

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pork. It contributes to the animal protein supplies of many communities in Nigeria especially in the coastal and riverine areas. It is one of the most delicate of all staple protein commodities especially in the tropical climate regions of the world (Abolagba and Nuntah, 2011).

Although both artisanal fisheries and aquaculture production has increased over the years, however, fish if not consumed within a day of harvest spoils and becomes unfit for human consumption, except it is properly handled (processed). The demand-supply gap will be bridge if the fish harvested are properly processed through MDOT. Over 80% of fish harvested in Nigeria is preserved by various methods of curing to prolong the shelf life of the fish. Fish processing is the processes associated with fish and fish products between the time in which fish are caught or harvested and the time in which the final product is delivered to the consumer (George *et al.*, 2014). The principal processing methods in Nigeria are smoking, drying, salting, fermentation, roasting, boiling and frying or any combination of these processes.

The processing and preservation of fish are of utmost importance since fish is highly susceptible to deterioration immediately after harvest leading to economic losses. Efficient preservation of fish is important when top quality, maximum yield and highest possible profits are to be achieved (Davies and Davies, 2009). It is pertinent to note that total protein consumption in Nigeria is low and below the UN / FAO'S estimated minimum of 75 gm. of daily per capita intake (Oladimeji *et al.*, 2019). Inadequate fish handling, processing techniques and storage facilities contribute significantly to the low supply of fish to rural and urban dwellers that form three quarters of the population in developing countries (Ayuba and Omeji, 2006).

According to Davies and Davies (2009) the development of appropriate fishing machinery and techniques that employed effective production, handling, harvesting, processing and storage, cannot be over-emphasized especially in the age when aquaculture development is fast gathering momentum in Nigeria. Al-Jufaili and Opara (2006) reported high incidence of fish losses as a major impediment to the realization of government goal towards increasing the contribution of the sector to the overall national economy. The use of appropriate technology which is a radical approach to step up production and processing technique, has become subordinate to social need, and is of paramount importance. Appropriate processing of fish enables maximal use of raw material and production of value-added products which is obviously the basis of fish processing profitability. Therefore, improved fish processing technologies must be adopted in Nigeria to reduce post- harvest losses and quality of fish and fishery products. The existing information on fish processing technologies in the country reflects low level of adoption of improved fish processing technologies in the country seeing that this is a serious problem in reducing poverty and achieving food security in the country (Abolagba and Nuntah, 2011). There is no doubt that fish processing would play a unique role in promoting industrial development through employment generation, value-added processing and training of skilled manpower.

The MDOT is a modification of the simple drum oven which is a traditional method of fish processing. The MDO fish processing technology has advantages like fuel efficiency compared with the traditional technology, produces good quality fish that command high price and is acceptable to consumers. It is less labour intensive and it is easy and cheaper to construct unlike other improved smoked kilns. Fish processing using this technology does not entail great capital expenditure and it is adopted by most small scale fish processors in Niger

State, Nigeria. The MDO was pioneered by National Institute for Freshwater Fisheries Research (NIFFR) and Nigerian Institute for Oceanographic and Marine Research (NIOMR) in the 1980s and was targeted at small-scale fish processors. It is an adaptation of traditional mud kiln, the firing chamber, the smoking racks and the chimney to ensure efficient smoking of fish (Bolorunduro, 2004) which has upgraded the traditional fish processing technologies and enhanced the supply of processed fish to the markets.

In spite of the efforts by government and the research institutes, the production, processing and ancillary activities in the fisheries sector are still being carried out using the rudimentary methods. According to FAO (2010) the fisheries sector is not operating in a sustainable and efficient manner. The adoption of improved fishery technologies is very low and this has caused valuable losses to the fishery sector (Oladimeji *et al.*, 2016). The MDOT is a fuel efficient fish processing technology, less labour intensive, cheaper and very simple to construct and portable which can be carried on fishing boats. The impact of MDOT on fish processing were achieved using the propensity score matching (PSM) model. The method of PSM allows this matching problem to be reduced to a single dimension of the propensity score.

Hence, an effort to provide empirical evidence on the impact of adoption of modified drum oven fish processing technology on income and level of living of fish processors in Niger State is an imperative research. The study examined factors influencing adoption and the impact of adoption of modified drum oven fish processing technology on fish processors income and level of living.

The hypotheses: H₀: adoption of modified drum oven fish processing technology has no significant impact on income and levels of living of the processors were tested.

H₁: adoption of modified drum oven fish processing technology has significant impact on income and levels of living of the processors were tested.

METHODOLOGY

Study Area

The study was conducted in Niger State, located in North –Central, Nigeria. Niger State covers a total of 76,000 square km land area, which is about 9 % of Nigerian total land area. The State is located between Latitudes 8⁰ 20' N and 11⁰ 30' N and Longitude 3⁰ 30' E and 7⁰ 20' E. The annual rainfall varies from about 1,600 mm in the south to 1,200 mm in the north (National Population Commission, NPC, 2006). The state is endowed with the River Niger and its tributaries which makes it suitable for fishing activities (Oladimeji *et al.*, 2019). Using 3.2 % growth rate of NPC (2006), the State has a projected population of 5,777,714 people in 2019. The state has abundant fishing potentials which predominant in 8 Local Government Areas (LGAs) out of 25 LGAs namely: Shororo, Borgu, Gbako, Mokwa, Lavun, Edati, kacha and Agaie (Niger State Agricultural and Mechanization Development Authority, NAMDA, 2015). The commonly processed fish in the State are *Heterotis niloticus* (*bargi*), *Oreocromis niloticus* (tilapia), *Clarias gariepinus* (Catfish), and *Lates niloticus* (*Giwan ruwa*).

The data were collected from May to October 2015 and the questionnaire captured the socio-economic characteristics, income and assets of the respondents.

Sampling Procedure

A multi-stage sampling procedure was adopted for this study. All the three ADP zones comprising A, B, and C were used for this survey and the target population was fish processors who use either modified drum oven or traditional methods of fish processing technologies. Most of the fishing and fish processing activities are concentrated in zone A of the State as such many of the respondents were selected from zone A. The first stage involved the purposive selection of all the 8 LGAs where fishing and fish processing activities are predominantly practiced. The second stage involved the purposive selection of two villages from each of the chosen LGAs based on the dominance of fish processing activities making a total of 16 villages. The third stage was the random selection of 20 respondents each from list of processors compiled through village heads with the assistance of ADP staff. A total of 320 fish processors were selected (Table 1). The 4th stage involved the segregation of the processors into two groups of adopters of MDOT (164) and non-adopters who used traditional fish processing technology (156).

Table 1: Distribution of Sample Frame and Sample Size

LGAs	Village	Zone	Sample size	Adopters	Non Adopters
Agaie	Baro	A	40	20	20
	Loguma				
Borgu	Wawa	C	40	21	19
	Fakwa				
Edati	Rokota	A	40	20	20
	Ganzhe				
Gbako	Edoshige	A	40	20	20
	Ndagbachi				
Kacha	Kacha village	A	40	20	20
	Kakapungi				
Lavun	Chanchaga	A	40	20	20
	Jimadoko				
Mokwa	Rabba	A	40	23	17
	Bitagi				
Shiroro	Gwada	B	40	20	20
	Zumba				
Total	16		320	164	156

Source: Reconnaissance Survey, 2014.

Analytical Tools

Descriptive statistics, Logit regression and Propensity Score Matching (PSM) models were used to analyse the objectives of the study. Descriptive statistics used include frequency, percentage, mean, minimum and maximum. Logit regression analysis was used to determine the socio-economic and institutional factors influencing adoption of MDOT.

The equation form of the model is specified as:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10} + b_{11}X_{11} + b_{12}X_{12} + b_{13}X_{13} + b_{14}X_{14} + \mu \dots\dots\dots (1)$$

(Equation 1 adopted from Oladimeji *et al.*, 2017)

Where: Y = technology adopted by respondents (1 = adopted, 0 = non-adopted); X₁= age of the respondent (years); X₂ = gender (male = 1, female = 0); X₃ = marital status (Single, married, divorce, widow); X₄ = fish processing experience (years); X₅ = education of the respondents (years); X₆ = household size (number); X₇ = membership of cooperatives (years of membership); X₈ = extension contact (yes = 1, no = 0); X₉ = access to credit (naira); X₁₀ = processing output of fish (kg); X₁₁ = complexity of technologies (simple = 0, complex = 1, very complex = 2); X₁₂ = affordability (cheap = 0, moderate = 1, expensive = 2); X₁₃ = compatibility (not compatible = 0, compatible = 1, very compatible = 2); X₁₄ = income (Naira) and μ = error term.

PSM was used to determine the impact of adoption of MDOT on fish processors’ income and standard of living. Propensity Score Matching (PSM) technique is used for impact assessment of intervention in agricultural production. It is carried out by making a comparison between treated group (MDOT) and control group (traditional technology). The assessment is done on average incomes of fish processors from both groups. Matching the outcomes for the treatment and control groups to estimate casual treatment effects has become a popular approach (Heckman and Hotz, (1989). Hence the estimation of mean effect of adoption as treatment requires making a match of mean output if they had not treated by adopting improved modified oven technology (control group).

The impact of MDOT on fish processors’ output was achieved through Propensity Score Matching (PSM). The analytical tool concurrently tackled the problem of selection bias and particularly non-compliance or problem of endogeneity. NN also uses the propensity score of individuals alike in the treated and control group to construct the counterfactual outcome with its major advantage of having lower variance which is achieved because more information is used.

In this case to estimate the impact on average income of individual i, the match for observed household income would be:

$$Y_1 = Y_{0i} + D(Y_{1i} - Y_{0i}) \dots \dots \dots (2)$$

Y₁ is the outcomes of adopting MDOT and Y₀ is the outcome of the same fish processor if he does not adopt the technology. So the D = (1, 0) is a binary indicator (D = 1 if adopt MDOT, 0 otherwise). Following the procedure we attempt to identify; average treatment effects:

$$(ATE) = E (Y_1 - Y_0) \dots \dots \dots (3)$$

which denotes the difference between the average incomes of two groups

$$E(Y_1 - Y_0 / D = 1) \dots \dots \dots (4)$$

represents the average treatment effects on the treated (adopters) that estimate the average income difference for the income which MDOT respondents has earned and the income he would earn if had not adopt MDOT.

$$E(Y_1 - Y_0 | D = 0) \dots \dots \dots (5)$$

denotes the average treatment effects (ATE) on the non-treated (non-adopters) which measures the income difference between the potential income that a traditional technology did not earn (D = 0) and the real income that he had earned Y₀.

(PSM equations 2-5 adopted from Idi *et al.*, 2019)

Z-statistics was used to test the hypotheses which state that adoption of MDOT has no significant impact on income and levels of living of the processors. It is a useful technique for comparing mean values of two sets of numbers. The formula is given by:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \quad (6)$$

(Adopted from Oladimejiet *al.*, 2016a)

Where: \bar{X}_1 = Mean income and level of living of the adopters of MDOT (₦); \bar{X}_2 = Mean income and level of living of the non-adopters of MDOT (₦), σ_1^2 = variance of the adopters, σ_2^2 = variance of the non-adopters, n_1 and n_2 = sample size of adopters and non-adopters fish processors, respectively.

RESULTS AND DISCUSSION

Distribution of the Annual Income of Adopters and Non-Adopters of MDOT

The frequency distribution of the annual income of adopters and non-adopters of MDOT in Niger State is shown in Table 2. The result showed that 26 % and 16 % of the adopters and non-adopters respectively fall within the highest annual income range of above ₦599, 000. On the other hand, 34 % and 47 % of the adopters of MDOT and non-adopters respectively are within the lowest annual income range of ₦ 100, 000 - ₦ 199, 000. The mean annual income of fish processors that adopted MDOT (₦382, 813.00) is higher than the mean annual income of non-adopters (₦201, 723.40) which implies that the adopters of MDOT realized higher income than the non-adopters in the study area. The implication is that adoption of new technology may provide an attractive opportunity for making better economic gains in terms of income generation, increase standard of living and ensuring food security. This result is in conformity with the findings by Oladimeji *et al.* (2016) that found the mean net margin of adopters higher than non-adopters of fishery production technology in Kwara state, Nigeria.

Table 2: Descriptive statistics of the annual income of MDOT and TFPT in Niger State

Variable (₦)	MDOT		Traditional	
	F	%	F	%
100,000 -199,000	34	20.7	47.00	30.1
200,000 -299,000	33	20.2	37.00	23.7
300,000 - 399,000	29	17.7	22.00	14.1
400,000 - 499,000	18	10.9	20.00	12.8
500,000 – 599,000	24	14.6	14.00	9.0
> 599,000	26	15.9	16.00	10.3.
Total	164	100.0	156	100.0
Minimum	181,500.00		142,150.00	
Maximum	1,621,715.00		1,315,201.00	
Mean	382,813.00		201,723.40	
Standard deviation	12,310.04		31,310.00	

Source: Field survey, 2015.

Factors Influencing Adoption of Modified Drum Oven Fish Processing Technology

The result of the Logit regression model on factors influencing adoption of MDOT by fish processors is shown in Table 2. The result revealed that age ($P<0.05$), sex ($P<0.01$), income ($P<0.01$), processed output ($P<0.01$), compatibility ($P<0.05$), complexity ($P<0.05$) and affordability ($P<0.05$) were statistically significant at different level of probability. All the coefficients of significant variables were positive and in line with *a priori* expectation except access to credit (-0.769) and complexity (-4.081) that were negative. The significant and positive coefficients imply that a unit increase in these variables will lead a corresponding increase in the adoption of the MDOT. However, as negative coefficients of access to credit and complexity increases by one unit, adoption decreases by the corresponding coefficients. The finding of this study agrees with the Oladimeji *et al.* (2017) some socio-economic variables as determinants of adoption of improved apicultural practices among bee farmers in Nigeria respectively.

Table 3: Factors influencing the adoption of MDOT

Variables	Coefficients	SE	t-value
Intercept	-2.756***	1.090	-2.53
Age	0.047**	0.022	2.14
Sex	3.448***	0.837	4.12
Marital Status	0.470	0.326	1.44
Level of education	0.856	0.563	-1.52
Household size	0.003	0.035	-0.09
Extension contact	0.120	0.337	0.36
Income	2.256***	0.195	11.57
Processing experience	0.048*	0.026	1.84
cooperative	0.041	0.061	0.67
Access to credit	-0.769	0.831	-0.93
Processed output	2.385***	0.183	13.03
Compatibility	0.412**	0.174	2.37
Complexity	-4.081***	0.566	-7.22
Affordability	1.827***	0.520	3.51
R-square	58.762***		

Source: Field survey, 2015, **, *** denote statistically significant at 5 and 1 % respectively

Following from above, the null hypothesis which stated that adoption of modified drum oven fish processing technology has no significant impact on fish processors' income was rejected and the alternative accepted.

Impact of MDOT on the Income of Fish Processors in Niger State

The impact of MDOT on fish processors' output was achieved through Propensity Score Matching (PSM). The analytical tool concurrently tackled the problem of selection bias and particularly non-compliance or problem of endogeneity. For propensity score, nearest neighbor (NN) matching algorithm was used to match the socio-economic characteristics between adopters and non-adopters of MDOT based on the t-value, Rubin B and Rubin R in Table 4. NN also uses the propensity score of individuals alike in the treated and control group to construct the counterfactual outcome with its major advantage of having lower variance which is achieved because more information is used.

Propensity scores were obtained through Logit regression model and fish processors who adopt MDOT were matched on the basis of the proximity of their scores of using MDOT in the counterfactual using individual socio-economic characteristics to form matched pairs of similar individual characteristics. All other fish processors whose scores for involvement in adopting MDOT were not matched for the MDOT were dropped from the analysis.

Table 4: Comparison between NN, R and K algorithms

Algorithms by matching	T-value	Rubin's B	Rubin's R
Nearest neighbor (NN)	1.98*	1.09	0.87
Radius (R)	1.78*	1.02	0.74
Kernel (K)	1.38	0.98	0.64
PSM Diagnostic statistics			
Observation	320		
Mean	0.206		
Standard deviation	0.086		
Minimum	0.0009		
Maximum	1.0000		

* denote statistically Significant at 10 %

The results of the impact of MDOT on productivity of fish processors are presented in Table 5. The result revealed that the average output per unit of inputs of the MDOT processors was 1.008 kg. This implies increasing return to scale, a unit increase in their inputs will lead to 1.008 units increase in the fish processed. Therefore, the average impact estimation shows that adopting MDOT had a significant and positive impact on productivity of the fish processors. The Treatment Effect on the Treated (ATT) also had a positive impact and increases productivity of the MDOT adopters by 1.805. This implies that MDOT technology positively impacted on the fish processors' productivity. The positive impact of MDOT on fish processors' income and productivity is similar to the findings of Idi *et al.* (2019) on micro-credit utilization and its impact on famers' maize output and household food security in Kaduna state, Nigeria that microcredit impact on maize output and was statistically significant at 5% level of probability.

Table 5: Impact of MDOT on fish processors' level of living

Estimation by	Sample	Treated	Control	β	SE	T-value
Output-input ratio	Unmatched	1.008	0.529	1.905	0.705	2.70
	ATT	1.036	0.574	1.805	0.795	2.27
MDOT versus				1.008	0.313	3.22
Traditional				0.529	0.156	3.39
Observed diff.				0.479	0.140	3.42

Note: treated = adopters and control = non-adopters, Note: *** P<0.01 and **<0.05 level of probability.

Z-test

The result of the t-test as presented in Table 6 shows that the calculated Z-value (2.504) is statistically significant at 1% probability level. This implies that there is significant difference between the income of respondents who adopted MDOT and non-adopters. This is further supported by higher mean income value of ₦252,156.25 of MDOT compared to traditional technology (₦106,753.6). This finding is in consonance with Robert and Noma-Fame (2012) who found out that average income of adopters of fish processing technologies in Ghana (GHC 8,204.50) is higher than the income of non-adopters (GHC 3,134.00).

Similarly, the result of the z-statistic ($z = 9.45$) in Table 7 clearly shows that there is a statistical significant difference between the level of living of the fish processors that adopted MDOT and non-adopters. This imply that MDOT had an impact on the income of the fish processors that adopted fish processing technologies which contributed in enhancing the income of the fish processors in the study area.

Table 6: Comparison between the income of MDOT and traditional fish processing technologies in Niger State

Variable	MDOT	Traditional Technology
Mean	252156.25	148416.10
Known variance	12778.07	10675.6
Observation	164	156
Hypothesized mean difference	0.00	
Z	2.504***	

*** $P < 0.01$ and ** $P < 0.05$

Table 7: Result of statistical comparison between the level living (assets) of adopters and non-adopters of MDOT in Niger state, Nigeria

Variables	MDOT	Traditional Technology
Mean value of assets owned	3469441.46	3016 632.72
Standard deviation	20082686	16692227.71
Observations	164	156
Mean income Differential	103740.14	
Z calculated	9.45***	
Z critical two-tail	1.96	

CONCLUSION

The study revealed that the mean annual income of fish processors that adopted MDOT was higher than the mean annual income of non-adopters. The study established that age, sex, income, processed output, compatibility, complexity and affordability were statistically significant at different level of probability. The study also concluded that adoption of

modified drum oven fish processing technology has significant impact on fish processors income and level of living.

Based on the findings of this study the following recommendations were made.

(i) Credit facilities when made available and accessible to the fish processors by the Government should be tailored towards acquiring fish processing technology. This could be achieved through enforcement (Central Bank of Nigeria) of agricultural credit delivery by commercial banks and micro finance institution to fish processors. These also can be achieved through aggressive mass media sensitization on credit accessibility for interested individuals or groups.

(ii) Cooperative organization becomes imperative in order to encourage fish processors who source credit from either agricultural or non-agricultural source so as to help alleviate their financial problems. These can be achieved through proper sensitization of fish processors by NGOs and other development agencies on group formation and development.

(iii) Extension delivery service should be funded properly by government so as to enable their services to reach a significant number of fish processors which will increase adoption of more improved technologies by interested individuals/fish processors.

(iv) Relevant research institutes such as Nigerian Institute for Fish Research (NIFFR) and Nigerian Institute for Oceanographic and Marine Research (NIOMR) should design more improved fish processing technologies that are accessible, user friendly, affordable and also relevant to the fish processors.

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