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CONSUMER PREFERENCE FOR RICE CONSUMPTION IN NIGERIA

[1]*J.A. ADEYEYE, [2]E.P. NAVESERO, [3]O.J. ARIYO AND [1]S.A. ADEYEYE

[1]Department of Nutrition and Dietetics. Babcock University, Ilisan, Remo.
[2]Rice Quality Laboratory. IITA, Oyo Road. P. M. B. 5320. Ibadan.
[3]Department of Plant Breeding and Seed Technology, University of Agriculture, Abeokuta, Nigeria.
***Corresponding author:** joshuaadeyeye@yahoo.com

ABSTRACT

Rice consumption is of interest to the Nigerian economy because of the huge amount of foreign exchange being spent on its importation and the consequent depletion of scarce resources on which the level of economic activities and productivity are based. This study was aimed at identifying the quality of rice preferred by Nigerians for rice food recipes and consequently efforts made to improve the quality of locally produced rice to the taste of Nigerians. A total of 23 rice varieties were acquired from experimental fields of National Cereal Research Institute (NCRI), International Institute of Tropical Agriculture (IITA) in Ibadan and Badegi Rice Breeding Centre in Bida. Consumer preference survey of boiled rice and '*Tuwo'* foods were carried out in 6 major commercial and traditional cities of Nigeria to determine the quality of rice preferred for boiled rice and '*Tuwo'* rice foods. The survey was in questionnaire format and was carried out in Bida (Niger State), Zaria (Kaduna State), Maiduguri (Borno State), Benin (Edo State), Port-Harcourt (Rivers state) and Ibadan (Oyo State). Consumers preferred parboiled over unparboiled rice and moderate to flaky rice quality over to soft and sticky rice foods. The rating by taste panelists in Bida, Zaria and Maiduguri metropolis indicated IRAT 112, FARO 15, ITA 117 and ITA 123 were most preferred for '*Tuwo'* foods, while the least-preferred varieties were ITA 132 and TOX 1768. Consumers also preferred high amylose rice for '*Tuwo*' to low amylose, sticky rice quality. Also the rating of 6 rice varieties with respect to boiled rice indicated that ITA 117, IART 112 and FARO 15 were most preferred for boiled rice, while TOX 1768 and ITA 132 were the least-preferred in Rivers, Edo, and Oyo States perhaps as a result of people's preference for flaky rice quality for most of their rice recipes. The results indicated that most Nigerians prefer rice with moderate to high flaky rice quality suggesting that in any rice improvement programme in Nigeria these characteristics should be given a premium.

KEY WORDS: Parboiled rice, '*Tuwo',* boiled rice, imported rice, flaky and soft rice foods.

INTRODUCTION

Rice belongs to the grass family *Oryzeae,* characterized by one flowered spiklets with short glumes. Rice (*Oryza Sativa*) is a cereal that is consumed as shelled milled grain (Luh, 1980). It is the principal food crop of about one half of the population of the world (Ramaih, 1953). It contributes 40 to 80 percent of the Asian diet (IRRI, 1980) and most staple food in Liberia, Sierra Leone, Guinea, Gambia and Senegal, where rice food is eaten everyday and sometimes twice a day (Komolafe, 1974). Originally rice is not a staple diet of Nigeria, it has recently gained

tremendous popularity (in Nigeria) as a fast-to-cook food (Okwuraiwe, 1974). In the past rice was a meal only for the rich (Eka, 1982). It was often eaten only during special occasions (Okwuraiwe, 1974). Rice meals are now very popular in Nigeria. Rice foods are cherished and widely consumed in the form of traditional recipes in Nigeria. The most popular traditional rice foods are widely consumed because of their nutritive values when cooked with other condiments and for their convenience.

Rice can be boiled and eaten with various types of soups such as vegetable soup or stew. The traditional methods of preparing rice meal by Hausa population are of interest because according to Simons (1971), rice and soup are usually prepared separately and then eaten together. The rice is boiled till it is soft, pounded or crushed into semi *fufu* (*Tuwo*) form and then served with soup. Nigerians preferred imported rice to locally-produced rice because of good processing and consequently improvement in cooking qualities of the imported rice (Umore, 1985). To improve the quality of locally-produced rice to the taste of Nigerians work needs to be done to determine the choice of rice quality that will match their taste. There are increasing literature on consumption pattern of local food in urban areas of Nigeria (Adeyemi, 1985; Adeyemo, l982; Ayotade, 1981; Ezuma 1986; Komolafe, 1974; Okonkwo, 1987 and Pillaiyers l981) however, there is none on boiled and '*Tuwo*' rice food covering the whole of Nigeria.

MATERIALS AND METHODS

Eight paddy rice samples from National Cereal Research Institute (NCRI) and eleven paddy rice varieties from International Institute of Tropical Agriculture (IITA) plus four additional paddy rice samples from Badegi Rice Breeding Centre were utilized for the study.

A total of 3 kg of each sample was processed by using modified parboiling method. Cleaned paddy rice sample of about 1500 g was steeped in 2L of distilled water at 80ºC for 6hr in water bath equipped with calibrated thermometer. The steeped paddy was then immersed and steamed for 18min in 2.5L of boiling distilled water using a laboratory electric steamer. The steamed paddy rice was then oven dried at 130ºC to about 16% moisture content and slowly dried to 11-13% moisture content in the shade drying (tempering) at room temperature to avoid grain kernel stress. Data were collected on physical, chemical and cooking properties of rice.

Triplicate of 200g of each rice sample of parboiled and unparboiled paddy was hulled in a laboratory Satake Husker (model: THU) operating on two rubber roller system set at 0.8mm to determine the amount of hull to the brown rice. Also the triplicate of brown rice collected for unparboiled and parboiled rice sample was further milled to determine the amount of bran to that of polished rice.

The Grainman Milling Machine (model 60-220T) a frictional type of milling machine with prescribed additional weight on the pressure cover, milled the brown rice for 2minutes each in one pass. The difference in the weight of brown rice to that of polished rice was used to calculate the percentage of brown and polished rice. A laboratory grader or disc separator (model TGR) was used to determine the percentage of whole rain (head rice) to that of the brown rice. Most of the broken rice was discarded. One third of whole polished rice (parboiled and unparboiled) rice collected was grounded into

flour in UDY cyclone (model: 33G) mill using a 60 mesh size screen.

Alkali digestibility an index of gelatinization temperature (gel. T) was carried out on the milled rice of unparboiled and parboiled samples following the procedure of Little *et. al.* (1958). Six kernels of whole milled rice were arranged in triplicate so that the kernels did not touch each other, they were then introduced into plastic boxes (4.6 x 4.6 x 1) cm^3 containing 10ml of 1.7% KOH. The boxes were covered and incubated for 23hr at 30ºC. Evaluations were done visually to determine the extent of disintegration of the endosperm. Rice with low gelatinization temperature (gel. T) disintegrated completely, while rice with intermediate gel.T showed partial disintegration and rice with high gel.T remained unaffected in the alkali. Percentage amylose content in rice flour was evaluated using Technico Auto-analyzer (model: TNII). The accuracy of this method was verified using the 300-N Micro-sample spectrophotometer determining in triplicates the percentage amylose content of rice flour following the methods of William et. al.(1958). The percentage starch content of rice flour for unparboiled and parboiled sample was determined using the phenol-sulphuric acid methods of Duboise *et. al.* (1956).

Rice Consumer Preference Survey

A total of six screened milled rice varieties differing in amylose contents were selected for the sensory evaluation of '*Tuwo*' and boiled rice recipes. These rice varieties included: ITA 123 (28.52 amylose), FARO 15 (28.0 amylose), ITA 117 (22.21 amylose), IRAT 112 (22.0 amylose), ITA 132 (11.72 amylose) and TOX 1768 (11.0 amylose) contents. Two kilograms of each varieties of unparboiled and parboiled rice were milled and used for boiled rice sensory evaluation. Also, one kilogram of unparboiled and parboiled rice were milled and used in preparation of '*Tuwo'*. The sensory evaluation of '*Tuwo'* was carried out in Bida (Niger State), Zaria (Kaduna State) and Maiduguri (Borno State), where it forms a staple food of the Hausas, while sensory evaluation of boiled rice was conducted in Portharcourt (Rivers State), Benin City (Bendel State) and Ibadan (Oyo State). The score card sheets for performance and acceptability rating were provided to participants for assessment.

Cooking Methods

About three grams of each sample of milled rice was cooked in a 6 automatic electric cookers (Toshiba type). Before cooking, each sample was thoroughly washed in about 360ml of tap clean water. The wash water was decanted and replaced with 400ml of water into the pot containing washed rice sample. The electric cooker was switched on from the main and left for 15minutes when the audible switch-off sound was hard. The rice was tested by pressing a grain of cooked rice between fingers and further cooked to doneness. '*Tuwo'* was made by crushing cooked rice with a wooden pestle into semi-*fufu* form. The cooked boiled rice and *'Tuwo'* were served warm in serving plates to each participant at the evaluation room. A cup of water was provided to each participant to rinse the mouth after each sample was evaluated following the procedure of Lamond (1982).

Statistical Analysis

Analysis of variance was used to test the data and the difference among the means was compared using Duncan Multiple Range test (Duncan, 1955).

RESULTS AND DISCUSSION

Rice qualities preference by Nigerian consumers is presented in Table 1. Under processing, parboiled rice is most preferred, followed by white polished rice, while fresh from farm gate is the least preferred rice with means of: (71.5, 24.0 and 4.0) respectively. Under shape of rice, long and slender rice is most preferred with a mean of (47.3), followed by medium size and short and fat rice with means of: (3.0 and 20.0) respectively. However, some Nigerians consumers who do not care about shape of rice are in the minority with a mean of (2.30). For forms of rice, whole grain rice with a mean of (78.5) is most preferred to ground rice with a mean of (21.5). For colour preference, white rice colour is most preferred with a mean of (60.8), followed by cream white rice colour with a mean of (23.8), while slightly brownish rice colour with a mean of (15.3) is the least preferred. Under origin of rice, imported rice with a mean of (57.5) is the most preferred over the local rice varieties with a mean of (42.8). Under preference between imported rice brands, Uncle Ben's is the most preferred with a mean of (50.5), followed by followed by consumers who cannot distinguish among the imported rice brands with a mean of (3.0), while Carolina and Thailand rice brands with means of (11.4 and 8.2) respectively are the least preferred brands. Finally, the most important quality looked for in rice, stone free is the most preferred with a mean of (52.8), followed by taste/aroma with a mean of (24.8), while less broken rice and uniform in shape with means of: (12.3 and 7.3) respectively are the least preferred.

Parboiled rice is known to offer some advantages that may attract consumer's attention especially when such rice is properly parboiled. For instance, parboiling salvages the damaged grains and eliminates cracks, it increases head yield and is known to prevent loss of nutrients. Parboiling process inactivates and denatures the enzymes responsible for browning and deterioration of rice kernel. It is also known to improve storage property of processed rice so as to extend its shelf life. Parboiling also produces extremely hard grains that offer resistance to insect and mold attacks. The milling yield is higher and quality improved because the cracks in the rice kernels have been anneald (Ali and Ojha, 1976). The processes of steeping and hot steam treatment activate the starch granules to gelatinized and expand filling up the surrounding air spaces by removing chalkiness and imparting an amber colour characteristics to rice kernel. During parboiling, water soluble vitamins and mineral salts are spread round the grain. This resulted in the riboflavin and thiamine content being four times higher in the parboiled than the unparboild rice varieties (Kennedy *et. al.,* 1975). Majority of the people preferred long and slender rice to other forms followed by the medium size rice perhaps as a result of the quality of rice Nigerians are accustomed to see in most imported rice varieties. Varieties of rice with long and slender grains usually had uniform parboiling quality when compared to rice with medium to short sizes. The processes of steeping and heating are quicker and easier for long slender grains as water and heat uniformly penetrate and rapidly reach the middle of the endosperm (Luh, 1980), as compared to fat and short rice varieties with uneven cooking quality. There is a higher economic value attached to quality rice because most commercial rice produced and marketed are usually long and slender rice grains. The unequal size and shape rice kernel associated with fat and short medium size usually results in poor quality with unsatisfactory milling product. Over 70% of

Table 1: Rice quality preference by Nigeria consumers

Characteristics	Rice Qualities	X	LSD (0.05)
	Parboiled Rice	71.5a	5.07
Processings	White Polished Rice	24.0b	
	Fresh from farm	4.0c	
	Short and Fat Rice	20.0c	7.63
Shapes	Medium Size Rice	30.3b	
	Long and Slender Rice	47.3a	
	Does not matter	2.3a	
	Ground Rice	21.5b	7.78
Forms of Rice	Whole grain Rice	78.5a	
Colour Preference of	White colour	60.8a	9.06
cooked R ice	Creamy White	23.8b	
	Slightly Brownish	15.3b	
Preference	Imported Rice (Totality)	57.2a	0.84
	Slightly (Totality)	42.8b	
Preference between im-	Uncle Ben's	50,5c	18.30
ported rice…	Caroline	11.4c	
	Thailand	8.2c	
	No Preference	30.0b	
Most important qualities	Stone free	52.8a	6.25
looked for in rice	Less broken rice	12.3c	
	Taste/aroma	24.8b	
	Uniform in shape	7.3c	

rice consumers in Nigeria preferred white, whole grain rice to ground rice.

The general appearance of rice grain is an index of its acceptance and its purchasing value. The whole grain rice of virtuous and translucent kernels is increasingly in demand in rice industry because they offer excellent uniform processing well as good storage properties. Grains with chalky appearances are usually weak and break up more easily during milling operations because starch granules in the chalky area of the kernels are less densely packed than in virtuous translucent grain rice. Most people preferred imported rice to local rice and this may be related to their preferences for long and slender rice grains. The mean population of those who consume local rice was not different from the mean population of those who consumed imported rice. Perhaps this may be due to some local varieties having acceptable eating quality as those of the imported brands. There is also the possibility that long and slender rice grains are being grown locally thereby replacing the imported brand. Among the brands of imported rice, Uncle Ben's rice was the most preferred over Carolina and Thailand brands. This may partly be due to the popularity coupled with longer period of existence of Uncle Ben's rice in the Nigerian markets than other brands.

Parameters of preference between *Tuwo* and boiled rice recipes are presented in Table 2. Under eating qualities for boiled rice food, in-between soft/hard rice is most preferred with a mean of (61.3), followed by soft and tender quality with mean of (33.7), while hard rice with a mean of (4.8) is the least-preferred. Fluffy rice quality with a mean of

(71.7) is the most-preferred over sticky rice with a mean of (28.3). Boiled rice food with salt and water medium is most- preferred with a mean of (51.8) followed by *Tuwo* form of whole grain rice food with a mean of (32.3) while boiled rice, drained and steamed rice with a mean of (16.3) is the least preferred. Under the eating quality of *Tuwo r*ice food, in-between soft/hard rice is most preferred with a mean of (25.5), followed by soft *Tuwo* food with a mean of (21.0), while a hard *Tuwo* rice food with a mean of (2.0) is the least preferred. Warm *Tuwo r*ice food with a mean of (38.8) is the most preferred over a hot *Tuwo* and cold *Tuwo* rice foods with the means of (7.3 and 2.2), respectively.

Generally, consumers vary greatly in their preference for cooked rice. While some prefer cooked rice to be fluffy, dry and moderately hard, others desire moist and sticky rice. The cooking and eating quality of milled rice are influenced by the ratio of amylose and amylopectin fractions of starch content (Sanjiva, *et. al.,* 1952). A non-waxy/ non-glutinous rice variety usually has high amylose content. Such rice shows high volume expansion with high degree of flakiness when cooked. They also cook dry, hard and separate upon cooling. On the contrary, a waxy (glutinous) rice variety has more of amylopectin starch fraction. Such rice do not expand appreciatively in volume and when cooked it is glossy and sticky. Over 60% of rice consumers preferred in-between soft and hard quality rice suggesting that Nigerian populace prefer quality of rice with intermediate amylose rice starch content that cooks moist, tender and does not become too hard upon cooling. This choice of rice shows moderate volume expansion with intermediate degree of flakiness without clumping of rice grains. Preference for in-between soft and hard rice may be related to the mode of cooking and eating patter of consumers of rice foods. Less than 5% of the consumers like very hard flaky rice. Most consumers preferred moderately flaky rice than sticky rice quality, while boiled rice with salt and water was preferred to drain and steam rice. Also, *Tuwo* with intermediate texture between soft and hard rice is most-preferred while hard *Tuwo* is least preferred.

Table 2: Parameters of performance between Tuwo and Boiled rice recipes

Boiled Food	Eating Qualities	X	LSD (0.05)
Boiled Rice	Hard rice	4.8b	38.20
	Soft and Tender	33.7ab	
	In-between Soft/Hard	61.3a	
	Sticky rice	28.3b	2.75
	Fluffy rice	71.7a	
	Boiled, drain, stem	16.3b	27.58
	Tuwo form (from whole grain rice)		
	Boiled with salt and water	32.3ab	
		51.8a	
Tuwo Rice	Hard Tuwo	2.0b	10.00
	Soft Tuwo	21.0a	
	In-between soft/Hard	25.5a	
	Hot Tuwo Food	7.3b	10.00
	Warm Tuwo Food	38.8a	
	Cold Tuwo Food	2.2b	

The correlation matrix between those who preferred *Tuwo* and boiled rice foods are presented in Table 3. WBR is positively correlated significantly with HTB, while TF and WTF are positively correlated with FBR. The fluffy boiled rice (FBR) is negatively correlated with: ST and HTB. STB is negatively correlated with TF (-0.97), BF (-0.97), IBSH (-0.97), ST (-0.98), HTF (-0.82) and WTF (-0.97). TF also shows a perfect correlation with BF, SHT, IBSH and WTF with correlation matrix of: (1.0, 1.0, 1.0 and 1.0), respectively, while TF is highly correlated with HTF showing a correlation matrix of (0.82). BF indicates a perfect negative correlation with IBSH (-1.0) and ST (-1.0) as well as showing a highly negative correlation with HTF (-0.82), whereas, it indicates a perfect correlation with WTF (1.0). IBSHT has a perfect correlation with WTF having a correlation matrix of (1.0). Finally, ST is positively correlated with HTF (0.83) and equally shows a perfect correlation with WTF having a correlation matrix of (1.0).

There was a negative correlation between those who preferred hot boiled rice (HTBR) and those who preferred warm boiled rice (WR) suggesting that those who liked warm boiled rice did not like hot rice foods. There was a positive correlation between those who like fluffy boiled rice (FBR) and those who preferred *Tuwo* food, thus suggesting that those who liked *Tuwo* food preferred the fluffy boiled rice (FBR) to soft *Tuwo* (ST) and hot *Tuwo* food (HTF) indicating that consumers generally did not like soft hot *Tuwo* food. There was a negative correlation between the sticky boiled rice (STBR) and *Tuwo* food (TF) suggesting that most consumers did not like sticky *Tuwo* food, and the negative correlation between sticky boiled rice (STBR), hot *Tuwo* food (HTF) and warm forms. Also, the negative correlation between *Tuwo* food (TF) and boiled rice food (BR) suggested that those who liked *Tuwo* food would prefer their *Tuwo* food prepared from ground rice. The positive correlation between *Tuwo* food (TF) stiffly hard *Tuwo* (SHT) and in-between soft and hard *Tuwo* (IBSH) suggested that consumers did not like soft *Tuwo* food generally. There was a positive correlation between in-between soft and hard *Tuwo* food (IBSH) and warm *Tuwo* food (WTF) indicating that people who preferred to eat *Tuwo* of intermediate texture prefer it warmed.

The mean relative preference score for *Tuwo* rice food is presented in Table 4. IART 112, FARO 15, ITA 117, and ITA 123 rice varieties had average preference scores of: (18.5, 171, 167, and 168), while ITA 132 and TOX 1768 had preference scores of 113 and 105 respectively. The relative rating of genotype by taste panelists Bida (Niger State), Zaria (Kaduna State) and Maiduguri metropolis, (Borno State) indicated that IRAT 112, FARO 15, ITA 117 and ITA 123 were the most-preferred for *Tuwo* preparations.

This is probably due to their high amylose contents which ranged from intermediate (20 -25%) to high (26-30%) a characteristic which made them suitable for *Tuwo* preparations. The least preferred varieties: ITA 132 and TOX 1768 had amylase contents of 11.75 and 11.0 percent respectively. This suggests that amylase content of rice is a major characteristic for its suitability for Tuwo preparations. The average rating of the six rice varieties were not different in the three locations of Zaria, Bida, and Maiduguri. This suggests the universal requirement of intermediate to high amylase content of rice for *Tuwo* preparation as Bida and Maiduguri represented two widely separated *Tuwo* consum-

ing areas in Nigeria.

The mean relative preference for boiled rice preparation is presented in Table 5. ITA 117, IRAT 112, FARO 15 and ITA 123 were the most preferred over TOX 1768 and ITA 132 for boiled rice preparations. ITA 117 with relative average score of (189) was the most preferred rice variety followed by IRAT 112, FARO 15 and ITA 123 with relative average scores of: (174, 169.3, 152.7) respectively. However, TOX 1768 and ITA 132 with relative average scores of 119.6 and 116.6 were the least preferred for boiled rice foods in Rivers, Edo, and Oyo states where boiled rice forms a stable rice diet of the populace. Again, there appeared to be a relationship between the amylose contents of 28.0 while the least preferred varieties had low amylose content of 11.6. It may be that farmers generally preferred flaky to very flaky rice for most of the food preparation.

Table 3: Correlation matrix of preference between boiled rice and Tuwo food

	HBR	SBR	*BBR	HTBR	WBR	CBR	FBR	STBR	TF	BF	SHT	IBSHT	ST
SBR	-.021												
IBBR	-0.01	-0.44											
HTBR	0.62	-0.15	0.26										
W BR	0.52	0.31	0.12	0.85*									
CBR	0.37	0.49	-0.44	0.47	0.23								
FBR	0.43	0.27	-0.34	-0.74	0.54	-0.21							
STBR	0.43	-0.27	0.34	0.74	-0.38	-0.24	0.42						
TF	0.42	0.80	-0.15	-0.71	0.62	-0.36	0.97**	-0.97**					
BF	0.40	-0.76	0.14	0.69	-0.75	0.38	0.40	-0.97**	1.00**				
SHT	0.57	0.33	-0.24	0.02	-0.05	-0.11	-0.38	0.38	1.00**	-0.43			
IBSH	0.50	0.22	-0.01	-0.73	0.62	-0.35	-0.26	-0.97**	1.00**	-1.00**	0.31		
ST	0.39	0.12	0.57	-0.69	0.51	-0.32	-0.98**	-0.98**	0.42	-1.00**	0.44	0.61	
HTF	0.00	0.45	-0.45	-0.54	0.47	0.28	-0.82*	-0.82*	8.82**	-0.82*	0.79	0.74	0.83*
WTF	0.43	0.04	-0.12	-0.71	0.60	-0.33	0.97**	-0.97**	1.00	1.00*	0.34	1.00**	1.00**
CTF	0.34	-0.44	0.16	-0.50	0.48	-0.33	-0.69	-0.69	0.79	-0.79	0.13	0.83	0.77

*,**, Significant at 5% and 1% levels respectively

HBR = Hard Boiled rice
SBR = Soft Boiled rice
IBBR = In-Between Soft/Hard
HTBR = Hot Boiled Rice
WBR = Warm Boiled Rice
CBR = Cold Boiled Rice
FBR = Fluffy Boiled Rice
STBR = Sticky Boiled Rice
TF = Tuwo Food
BF = Boiled Rice Food
SHT = Stiffly Hard Tuwo
IBSHT = In Between Soft/Hard Tuwo
ST = Soft Tuwo Food
HTF = Hot Tuwo Food
WTF = Warm Tuwo Food
CTF = Cold Tuwo Food

Table 4: The Relative Preference of Six Rice Varieties for "Tuwo" Rice

Variables	Relative preference as indicated by average scores
IRAT 112	185a.
FARO 15	171a.
ITA 117	167a.
ITA 123	167a
ITA 132	113b.
TOX 1768	105b

Means not followed by the same letters are significantly different from each other by Duncan's Multiple Range Test at 0.05 level of probability

Table 5: The Relative Preference of Six Rice Varieties for Boiled Rice Food

Variables	Relative preference as indicated by average scores
ITA 117	189.3a
IRAT 112	174.6ab.
FARO 15	169.3ab
ITA 123	152.7b
TOX 1768	119.6c
ITA 132	116.6c

Means not followed by the same letters are significantly different from each other by Duncan's Multiple Range Test at 0.05 level of probability

However, the particularly high amylose rice varieties preferred most varied from location to location probably due to ease of availability. For example, in Rivers State, ITA 117 was the most preferred, while in Edo State ITA 117 and IRAT 112 were the most preferred varieties. In Oyo State, ITA 117 was also the most preferred variety as a result of people's preference for flaky rice for most of their rice recipes.

CONCLUSION

Rice preference studies indicated that most Nigerians prefer imported rice which has mainly long and slender grains because of its ease of preparing rice recipes, cleanliness and acceptable odour as opposed to some local rice varieties which contain dirt, grits and sometimes foul odour. To improve the consumer acceptance of Nigerian rice, emphasis should be placed on good processing methods. The results also concluded that most Nigerians prefer rice with moderate to high amylose rice. This suggests that in any rice improvement programme in Nigeria such characteristics should be given a priority.

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DETERMINANT OF AQUACULTURE TECHNOLOGIES ADOPTION AMONG FISH-FARMERS IN OBAFEMI – OWODE LOCAL GOVERNMENT AREA OF OGUN STATE, NIGERIA

***[1]O.J. OLAOYE AND [2]A. OLORUNTOBA**

[1]Agricultural Media Resources and Extension Centre,
[2]Department of Agricultural Extension and Rural Development,
University of Agriculture, Abeokuta, P.M.B 2240, Abeokuta, Ogun State, Nigeria
***Corresponding author:** olaoyejacob@yahoo.co.nz

ABSTRACT

The study was conducted to assess the determinant of aquaculture technologies adoption among fish-farmers in Obafemi – Owode local government area of Ogun State, Nigeria. Primary data were obtained from 224 fish farmers with an interview-schedule guide and field observation using simple random sampling and snow-balling sampling techniques during 2008 culture period. The study revealed that majority of the respondents were male (78.6%) within active age group of 41-50 years (47.0%), had primary education (51.0%), with household size of 7-8 persons (35.7%), farming as primary occupation (71.4%), fish farming experience of 3-4 years (40.0%) and belonged to fish farmers organization (51.4%). The major constraints in aquaculture were lack of access to appropriate land (31.4%), non-availability of micro-credits (97.1%), lateness in the supply of technological packages (75%), lack of infrastructural facilities (75%) and spatial factors to extension services and inputs (67.1%). The result of chi-square analysis showed that only sex (0.672, $p<0.01$) and extension agents (0.060; $p<0.01$) had significant association between socio-economic information variables and aquaculture technologies adoption. Based on the findings of this study, the following were therefore recommended: In an enterprise where a large proportion of the fish farmers were literate, adoption of disseminated improved innovation by extension agents will be embraced, high proximity to extension and communication services as well as aquaculture inputs will be enhanced if farmers formed themselves into cooperative societies, provision of rural infrastructures, as well as credit facilities should be provided by government. Participatory development of technologies between researchers and farmers are essential factors for adoption of new fish farming technologies.

Key Words: Aquaculture Technologies, Adoption, Fish-Farmers, Nigeria.

INTRODUCTION

Nigeria is blessed with inland water, brackish water and marine water fisheries resources. On the basis of her resources, fisheries can be broadly classified into: Artisanal fisheries (85%), Industrial fisheries (14%), and culture fisheries (1%) (FDF, 2005). Nigerians are high fish consumers and offer the largest market for fish and fisheries products in Africa. Out of a total annual demand of 1.5million tonnes (2005 projection), only about 511,000 tonnes are produced locally and supplemented with about 700,000 tonnes of imports worth about N50 billion (FDF, 2005). There is a shortfall of over 500,000 tonnes.

An alternative is how to substitute fish imports with domestic production in order to create jobs, reduce poverty in the rural areas where 70% of the population lives and to reduce the balance of payment deficits (FDF, 2005). Global total production of fish, crustaceans and molluscs has continued to increase and reached 142 million tonnes in 2008. While capture production has stayed around 90 million tonnes level since 2001, aquaculture production has continued to show strong growth, increasing at an average annual growth rate of 6.2 percent from 38.9 million tonnes in 2003 to 52.5 million tonnes in 2008. The value of aquaculture production was estimated at USD 98.4 billion in 2008 (FAO, 2008; 2011).

Aquaculture continues to be the fastest growing animal food - producing sector and outpace population growth (FAO, 2011) and it will play an increasingly important role in meeting the demand for fish. In 2006, China contributed 67 percent of the world's supply of cultured aquatic animals and 72 percent of its supply of aquatic plants.

World aquaculture has grown dramatically in the last 50 years. From a production of less than 1 million tonnes in the early 1950s, production in 2006 was reported to have risen to 51.7 million tonnes, with a value of US$78.8 billion. This means that aquaculture continues to grow more rapidly than other animal food-producing sectors. While capture fisheries production stopped growing in around mid-1980, the aquaculture sector has maintained an average annual growth rate of 8.7 percent worldwide (excluding China, 6.5 percent) since 1970. Annual growth rates in world aquaculture production between 2004 and 2006 were 6.1 percent in volume terms and 11.0 percent in value terms. If aquatic plants are included, world aquaculture production 2006 was 66.7 million tonnes and worth US$85.9 billion.

In 2006, countries in the Asia and the Pacific regions accounted for 89 percent of production by quantity and 77 percent of value. Of the world total, China is reported to produce 67 percent of the total quantity and 49 percent of the total value of aquaculture production (FAO, 2011).

ICLARM (2001), reported that aquaculture appear to be one of the last frontiers to increase contribution to food security in the developing world and it now represents the fastest growing agricultural industry in some countries, with fresh water aquaculture dominating total aquaculture production. Increased aquaculture production has been regarded by many people as an important option for dealing with the conflicting problem of over-fishing and increasing demand for fish. An increased in the supply of aquaculture product will reduce both the demand and price of capture fisheries. This could in turn reduce the investment and fishing effort in capture fisheries (Ye and Beddington, 1996).

Food and Agricultural Organization of United Nations (FAO, 2008) showed that Africa had much aquaculture potential indicating an opportunity to improve food security, nutrition and income generation among the poor. However, aquaculture is generally practiced on a small scale in Africa usually as simple, low input, fresh water pond culture, considering its size and demand for fish products, the continent produces very little only about 0.5% of the world aquaculture output and about 80% of this is produced by

just two countries viz: Nigeria (Tilapia, carp and catfish) and Egypt (Tilapia, carp and mullet) (Sverdrup-Jensen, 2000, FAO, 2011).

Fish farming is a feasible activity for small scale farmers to generate extra income and to add highly nutritious food to the daily diet. Fish farming can be combined with crop, animal husbandry and irrigation practices which can lead to a better utilization of local resources. However, to adopt fish farming as a new innovation, such household would have to relocate their time, labour and other resources to integrate fish farming with their traditional activities (Assiah *et al*., 1996; FAO, 2008).

Problem Statement

In spite of all the benefits associated with aquaculture, the level of adoption of aquaculture technology among house hold appears to be very low due to low contribution made by aquaculture, this amount to 0.55 metric tonnes supply locally which still remains 1.1 metric tonnes to meet up with 1.5 metric tonnes of projected national fish demand of 2005 estimates. It could be scaled up to meet the projected shortfall from natural fisheries, through the development and adoption of improved technologies which plays a critical role in improving the productivity and welfare of limited resource farmers in low-income countries (Sall *et al.* 2000). The role of extension is to facilitate the adoption of new agricultural technologies or to influence its rate of diffusion and adoption of innovation by farmers. According to Feder *et al*. (1995) and Odhiambo, (1998), adoption as a process could be influenced by a number of notable factors which include socio-economic, extension contact, provision of infrastructures and institutional factors. The questions to be asked are; whether the fish farmers perceived the improved fisheries technologies as more productive and acceptable for adoption and what are the factors influencing adoption of fisheries technologies. This study is expected to fill this gap and to provide information for possible further interventions in the promotion of aquaculture.

The paper therefore, focus on determinants of aquaculture technologies adoption among households in Obafemi- Owode area of Ogun State. It was hypothesized that socio-economic, cultural and information factors of fish farmers could lead to significant adoption of improved fisheries technologies.

Theoretical Perspectives

The development and adoption of improved technologies play a critical and essential role in improving the productivity and welfare of limited resource farmers in Low Income Countries (Sall *et al.,* 2000). Kroma, (2003) has observed that, there is a wide gap between agricultural technologies produced in research institutions, and the adoption of such technologies by small-scale farmers and rural households in sub-Saharan Africa. However, considerable research had been directed to the adoption of innovations in agriculture since Griliches (1959) pioneering work on the adoption of hybrid maize in the United States of America.

Several socio-economic factors have contributed to the adoption of new agricultural technologies. For example, Daramola (1998) stated that household, farm size, farm income, and human capital are factors influencing the adoption of improved maize varieties in Oyo State. Adoption of new practices involves time dimension in which several steps including awareness, information seeking, decision process, trial, evaluation

and adoption come into play (Sall *et al.*, 2000). Farmers may be desirous of adopting new practices but may be constrained by inadequate information about that particular innovation, caused by the inability of the extension agents to reach the farmers. Tiamiyu *et al.* (2001) stated that the determinants of adoption of soybean cultivation in Niger State were farm size, farming experience and literacy level of the adopters. Onyenweaku and Mbuba, (1991) found out that the determinants of the adoption of the seed-yam minisett multiplication technique by farmers in Anambra State of Nigeria were: profitability, lack of awareness of the technique, labour availability, frequency of attendance at meetings and extension contact, farmer's age, education, farming experience, tenancy status, membership of cooperative societies and credits.

Another factor that tends to make farmers stick to old practices may be economic, in the sense that the average cost of agricultural innovation and the risks involved may be beyond the reach of most of the farmers. Farmers who can bear the risk need constant visits and assurance by extension officers. Where there are no good roads or adequate logistic arrangements provided, the number of times an extension personnel visits a farmer may be very minimal. Related to good roads is the distance that separates the farmer from the source of information. Where the source is far, it is likely to lead to low level of adoption (Osuji, 1983).

Where farmers are provided with credit facilities (either in cash, kind or both) and farmers with dependable income, their rate of adoption is expected to be high. The ratio of extension agents to farmers is very vital for effective contact and enhances adoption.

The study was conducted in the extension villages during the 2008 culture period and was restricted to all registered fish farmers under the Ogun State Agricultural Development Programme (OGADEP). Primary data were obtained from two hundred and twenty four (224) fish farmers with interview schedule guide and field observation, which were selected using simple random sampling and snow-balling sampling techniques. The study attempts to determine factors that impede effective adoption of improved aquaculture technologies.

RESEARCH METHODS

Study Area and Sample

Obafemi Owode is one of the twenty Local Government Areas of Ogun State, Nigeria. Its headquarters are in the town of Owode at 6^0 57'N, 3^0 30'E. It is predominantly a rural settlement of about 104,787.07 hectares of land, has an area of 1,410 km^2 (544.4 sq. miles) with a population of 228,851 people at the 2006 census (Wikipedia, 2010). The local government is bound in the East by Ikenne Local Government, in the West partly by Abeokuta South Local Government and Ifo Local Government, in the south by Ifo Local Government. Obafemi Owode Local Government belongs to Ikenne Agricultural Extension Zone of Ogun State Agricultural Development Programme (OGADEP) (Fig. 1). It has two extension blocks namely Shomeke and Obafemi. The blocks were randomly and purposively selected and they consist of eight (Iro, Mokoloki, Ofada, Mowe-Ibafo, Owode, Ajura, Kobape and Oba) and six (Adigbe, Kajola, Ayerose, Ajebo, Obafemi and Ogunmakin) extension circles respectively. Snow-balling sampling was used to select fish farmers from the towns and villages within the circles during the 2008 growing season. A total of two hundred and ten (210) returned the interview guides and

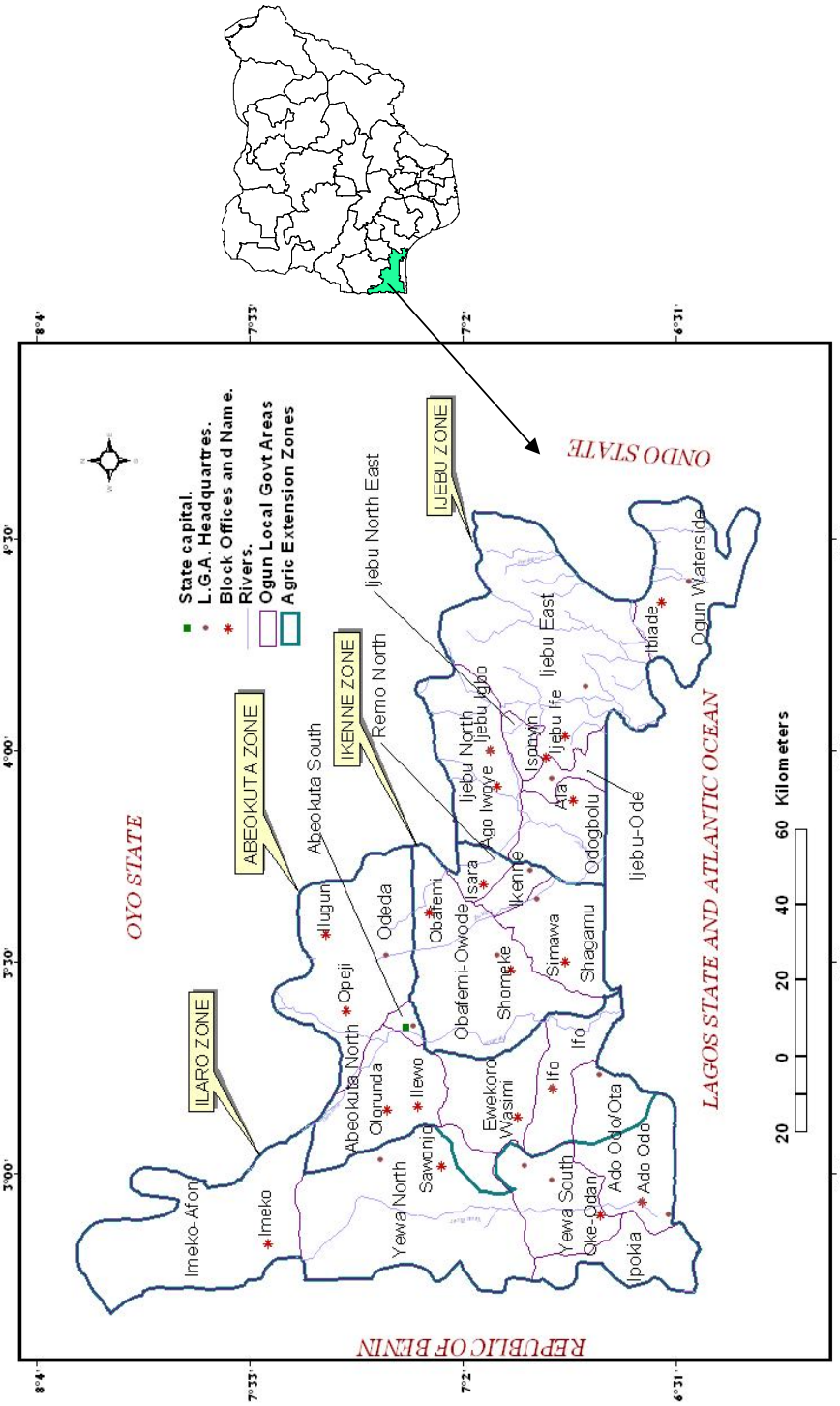

Figure 1: Ogun State ADP Zones and Blocks

the response rate of 93.8% was finally used for the study.

The data collected from the fish farmers include those on their socio-economic characteristics. These variables were based on personal characteristics that were shown in literatures to be related to adoption such as age, sex, marital status, business experience, level of education, access to appropriate land and training acquired. Part B of the instrument elicited information in factors affecting fish farming technology adoption. The farmers were asked to indicate their response on the degree of the severity of the problems encountered in the aquaculture technology adoption.

Instrument for Data Collection and Analysis

Quantitative data were collected with structured interview guide on sampled household by four trained enumerators under close supervision of the researchers. The contents of the interview guides were usually translated to the local dialect of the respondents (Yoruba) for those not literate and otherwise responses were recorded in English Language. The instruments were field tested for face and content validity by panel of experts in fisheries management, and agricultural extension and rural sociology. Minor corrections and restructuring o the instrument were made based on the recommendations of the panel of experts and reliability using the test-retest method. A reliability coefficient (r) of 0.75 obtained was considered a good and reliable measure as instrument for the data collection. Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) version 12.0 for sample statistics and logistic regression. The probability was set *a priori* at 5% level.

RESULTS AND DISCUSSION

Sample Statistics

Key summary of statistics from the survey are presented in Table 1. Of the entire fish farming households interviewed, the age distribution of the respondents showed that many (47%) of the fish farmers fall between the age group of 41-50 years, indicating that the majority of the respondents were within economically active age distribution who constitute good and potential labour force for the fisheries enterprise (FAO, 1997), while minority (4.3%) of the respondents were above 60 years of age. This age bracket is a productive age which portends better future to fish production adoption. Majority (78.6%) of the fish farmers were male, while few (21.4%) were female. This implies that more males are involved in small-scale fish farming which is in line with the culture of the people in the area where men engage in aquaculture more than women and that women are mostly involved in processing and other post-harvest activities (Raufu *et al.,* 2009). This was contrary to Worby (2001), who reported that females were often motivated than male to adopt new technologies that provide nutritional benefits such as fish culture. Majority (90.0%) of the farmers were married, while (a few of them) 1.4% were widowed. This shows that most of the small-scale fish farmers are settled family men and women with responsibilities. These responsibilities would likely make them willing to seek innovations so as to increase their income earning capacity and improve their standard of living (Raufu *et al.,* 2009). Close examination of the variables related to household level showed that many (35.7%) of the farmers had between 7-8 persons living under the same roof, while few (1.4%) of the respondents had less than two persons.

Fifty one percent of the fish farmers had at

Table 1: Distribution of fish farmers by socio-economic characteristics

Variables	Frequency	Percentage
Age in Years		
25-30	9	4.3
31-40	57	27.1
41-50	99	47.1
51-60	36	17.1
Above 61 years	9	4.3
Sex		
Male	165	78.6
Female	45	21.4
Marital Status		
Single	6	2.9
Married	189	90.0
Divorced	12	5.7
Widow	3	1.4
Household Size		
Less than 2	3	1.4
3-4	33	15.7
5-6	57	27.1
7-8	75	35.7
9-10	24	11.4
Above 11	18	8.6
Level of Education (Years.		
No Formal Education	6	2.9
Elementary Education	117	51
Secondary Education	48	22.9
Tertiary Education	39	19
Secondary Occupation		
Farming	150	71.4
Teaching	18	8.6
Civil Servant	21	10.0
Tailoring	3	1.4
Carpentry	6	2.9
Trading	6	2.9
Banking	6	2.9
Years of Experience		
Less than 2	57	27.1
3-4	84	40.0
5-6	45	21.4
7-8	15	7.1
9-10	9	4.3
Fish Farming Training		
Yes	162	77.1
No	48	22.9
Fish Farmer Organization		
Yes	102	48.6
No	108	51.4
Access to Appropriate land		
Yes	183	87.1
No	27	12.9

least primary education which was regarded as an adequate level of education for an individual to read, write and understand agricultural instructions including extension services, management and technology adoption constraints. According to Osuji (1983), lack of access to education, failure of extension to visit farmers and lack of financial assistant are institutional factors hindering the adoption of innovations by farmers. Also, Ekoja (2004) conducted a study on 500 Nigerian farmers in five ecological zones and found that significant differences existed among farmers in the adoption of innovations on account of educational qualifications, farm size and mean perception of their access to information. Majority (71.4%) of the fish farmers interviewed claimed that farming was their primary occupation, which was in line with empirical evidence that majority of the rural dwellers engaged in agricultural production. Fifty percent of the respondents were observed to have fish farming experience of between 3-4 years, while few (4.3%) of them had 9-10 years' experience. This implies that the farmers in the study area had experience in fish farming but there was indication that the technologies were very new in the last 7 -10 years. Also 51.4% of the fish farmers belonged to fish farmers' organization.

Factors affecting Fish Farming Technology Adoption

In Nigeria, many researchers including Osuji (1983), Onyenweaku and Mbada, (1991) and Tiamiyu *et al.* (2001) have investigated factors related to the adoption of improved farm practices. Table 2 shows various factors that affect aquaculture technologies' adoption in Obafemi Owode, and these were rated according to their degree of severity. Most of the fish farmers (68.6%) claimed that access to appropriate land was not a problem, while few (31.4%) of the respondents said it was a serious problem. Majority (93.3%) of the fish farmers said that old age was not a problem, while 2.9% claimed that it was a serious problem. This was in agreement with the largest age distribution (47.1%) in Table 1. Majority of the respondents (77.2%) considered non-availability of micro-credits for the purchase of inputs as a serious problem. This implies that getting credits for aquaculture business was difficult making farmers to join cooperative society.

More than half of the fish farmers (55.7%) indicated that fisheries technologies were not adaptable to fish farming system. In adequate follow up of extension advice (60%) after the establishment of field trials and distance of the extension workers' office (67.1%) to the farm locations was not a serious problem hindering adoption of fisheries technologies. This implies that the farmers were early adopter of improved technology and this was expected to have negatively affected the frequency of extension contacts. Majority (80%) of the respondents claimed that lateness in the supply of technological packages and lacks of infrastructural facilities (76%) were serious factors affecting the adoption of aquaculture technologies.

Relationship between socio-economic, information variables and aquaculture technologies' adoption

The findings in Table 3 show that all the socio-economic variables were not significant except the sex of the respondents that was significantly ($p<0.01$) related to aquaculture technologies adoption. The significance of sex to aquaculture technologies adoption was also supported by findings of Okorie (2001) which indicated that in Nigeria, men utilized the acquired training in the art of

farming and hunting.

Only extension agents in all sources of information was significant ($P<0.01$) to aquaculture technologies adoption. This finding points to the dependence of fish farmers on extension agents for information on fisheries technologies and is in agreement with the work of Obinne and Anyanwu (1991) who reported that if farmers' use of extension agents as communication source was increased they would adopt more of improved crop technologies.

Table 2: Distribution of fish farmers by factors affecting aquaculture technology adoption

Problem Encountered	Severity					
	Serious		Not a problem		Don't know	
	Freq	%	Freq	%	Freq	%
Lack of appropriate land	66	31.5	144	68.6	0	0.0
Old Age	6	2.9	198	94.3	6	2.9
Insufficient Labour	51	24.3	156	74.3	3	1.4
Micro-Credit not available for input purchase	162	77.2	48	22.9	0	0.0
Technologies not adaptable to fish farming system	81	38.6	117	55.7	12	5.7
Difficulties in recalling main features of technologies.	66	31.5	105	50.0	39	18.6
Inadequate follow up extension advice after the trials establishment	48	22.8	126	60.0	36	17.1
Distance of extension staff office to the farm location	12	5.8	141	67.1	57	27.1
Lateness in supply of technological packages	168	80.0	42	20.0	0	0.0
Diseases and Predators	66	31.4	93	44.3	51	24.3
Infrastructure Facilities	159	75.7	51	24.3	0	0.0
Government Policy	30	14.3	78	37.1	90	429

Table 3: Chi-square analysis between socio-economic, information and aquaculture technologies adoption

Variables	X2	Df	Asymp.Sig.(2sided)	Decision
Length of residence	4.133	4	0.351	NS
Age	6.628	4	0.157	NS
Sex	0.068	1	0.672*	S
Marital Status	5.019	3	0.170	NS
Household size	1.555	5	0.907	NS
Education Level	0.014	3	0.791	NS
Primary Occupation	9.545	7	0.216	NS
Experience	4.546	4	0.337	NS
Extension Agents	7.624	1	0.060*	S
Radio Broadcast	0.575	1	0.448	NS
Television Broadcast	0.128	1	0.720	NS
Newspaper	2.154	1	0.142	NS
Friends and Relation	0.151	1	0.698	NS
Village Crier	0.095	1	0.758	NS

CONCLUSIONS AND RECOMMENDATION

The conclusions that could be drawn from both the descriptive and inferential statistics are as follows:

- The majorities (95.6%) of fish farmers were male and their age range was within the economic active range which favoured the adoption of aquaculture technologies.
- Most (90.0%) of the fish farmers were married and it also revealed that they have experience in fish farming.
- The study revealed the undermining role played by capital which poses very serious threat to adoption of aquaculture technologies.
- Majority (71.4%) of the farmers that engaged in fish farming did so either for profit-making or to augment income from other sources.
- Most (77.1%) of the fish farmers obtained information on aquaculture practices through the extension agents, training and mass media but the extension personnel needed to be provided with mobility for improved services delivery.
- The spatial factors (distance) to aquaculture inputs and communication services hindered the continuous adoption of aquaculture technologies.

Based on the findings of this study the followings were therefore recommended. In an enterprise where a large proportion of the fish farmers were literate, adoption of disseminated improved innovation by extension agents will be embraced, high proximity to extension and communication services as well as aquaculture inputs will be enhanced if farmers formed themselves into cooperative societies to access micro-credit and their collective input purchased will be easier provision of rural infrastructures, as well as credit facilities should be provided by government.

Participatory development of technologies between researchers and farmers are essential factors for the adoption of new fish farming technologies.

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PRODUCTIVITY DISPERSION AND SOURCES OF TECHNICAL INEFFICIENCY IN SMALLHOLDER TIMBER MILLS IN OGUN STATE, NIGERIA

M.U. AGBONLAHOR

Department of Agricultural Economics and Farm Management,
University of Agriculture, Abeokuta, Nigeria
E-mail: agbonlahormu@unaab.edu.ng

ABSTRACT

The concept of technical efficiency is critical to measuring the firm performance, determining the degree of innovative technology adoption, overall production efficiency and sustainability of livelihood options. Our research evaluates technical efficiencies in the sawmilling sector. Specifically, the main objective of the study was to assess technical efficiency dispersion and determine the significant, firm-specific, factors that cause technical inefficiencies in sawmilling operations. Maximum-likelihood methods are applied in the estimation of the parameters of the model. In the study, panel (3 years) data from 68 sawmills was used in the empirical analysis. The primary decision-maker in the sawmill has an average age of 53years with a mean of 17years of experience in sawmill management. The average operational age of the sawmill is 13years. There were considerable wide variations, at the firm level, in technical efficiencies recorded over the periods. The estimated average technical efficiency of the sampled sawmills for the three years (2007-2009) is 61.9%. The result revealed that the initial efficiency gained in 2007 was not sustained as efficiency dropped in 2009 to 57.9%. The firm specific variables that influence technical efficiencies are owner's status as timber contractor, ownership of timber trucks, years of experience and age of the manager. The study recommends that technical and management training/workshop should be organized by relevant government agencies to regularly update operators' knowledge. Import policies should be targeted to encourage acquisition and use of modern sawmilling machines and equipment. Also, public power supply to the sawmill clusters should be improved to reduce the high processing cost associated with the use of diesel powered electricity generation sets.

Key words: Technical Efficiency, Forest, Timber, Sawmills

INTRODUCTION

Sustainable Forest Management (SFM) requires the balancing of economic, environmental, and social objectives in forest products and services exploitation. The linkage between SFM and timber economics lies in the desire to achieve a sustainable flow of economic goods (timber) from forests and to maintain healthy forests capable of providing benefits into the future (Bowles et al 1998; Barham *et al.,* 1999 and Wunder 2001). Timber is by far the highest-valued forest product in most forests. In 2008, the export of industrial roundwood, sawnwood and wood-based panels from developing countries accounted for US$13.1 billion (FAOSTAT, 2010). Under SFM, timber production requires economic efficiency in se-

lecting inputs to produce the most valuable output. The concept of technical efficiency has been used in measuring the performance of a firm, determining the degree of innovative technology adoption as well as the overall production efficiency.

Nigeria has a total forest area of 13,517 ha which represents about 15% of the total land area. Of this, less than 12% is protected and the estimated rate of loss is 2.3% per annum (http://www.fao.org/countryprofiles/index.asp?subj=5&iso3=NGA). This portends a great challenge to conservation efforts and the sustainable exploitation of the asset. The inextricable nexus that exit between forest and sustainable livelihood in coping with poverty and food insecurity has been extensively researched; stressing both the direct and indirect benefits (Wallace and Newman, 1986; Vincent 1995; FAO 2001; Iversen *et al.,* 2006; Nelson 2006). Most of the studies on SFM have focused on the forest (upstream) level measures (planting, stand management and field harvesting), the importance of efficiency of utilization of products and products processing (downstream) has not been adequately addressed (Deacon, 1994; Iversen *et al.,* 2006; Barham *et al.,* 1999; Gerwin *et al.,* 1996; Place and Otsuka 1998; Wunder 2001; Bowles *et al.,* 1998). Against the backdrop of recent evidences that has linked products processing to sustainable forest use, it is therefore imperative to quantitatively analyze the efficiency of timber processing. As highlighted above, timber is the most economically important product of the forest. The saw mill is therefore, a critical industry whose performance not only has dire implications for present livelihood but also for the future generation. The study therefore, attempts to bridge the gap in knowledge by assessing the efficiency dispersion and causes of technical inefficiencies in sawmilling in Nigeria. Forest industry (sawmill) has the potential to improve economic performance and increase state and household revenues. The realization of these opportunities, however, depends critically on the efficiency of utilization and exploitation of products.

Specifically, the study objectives are to:

- determine the efficiency distribution of the sawmills in the state and,
- determine the firm's specific factors that limits technical efficiency in the industry

The study Area and timber harvesting regulations

The study was carried out in Ogun State, Nigeria. A Forest resource, especially timber, is the most important economic product. The state is home to some of Nigeria's largest forest reserves (J4, Omo and Olokomeji). It is referred to as the Gateway State due to its strategic location to Lagos State, the economic hub of the country. The estimated human population is 3.73 million, occupying a land area of 16,400 squared kilometers (NBS, 2008). It is largely agrarian in nature with a large rural population who depend on subsistence agriculture and forests resources as major source of livelihood.

There were about 350 registered sawmills in the state in 2008 operating mainly as smallholder, family industry (Ogun State Ministry of Forestry, 2009). The forest compartment for timber harvesting is allotted to registered timber contractors by the State Government. The Ogun Property Hammer (OGPH) identification seal represents the official permit to harvest timber from the State's forest. The property hammer cost N150,000 and N250,000 for individual and corporate permits respectively. The timber contractors pay

a deposit of N250,000 as the prepaid cost of timber harvest from 10ha of forest land for a duration of 3 months. Forest-guards monitor the quality and quantity of timber harvested by individual contractors. There are other checks and gauges involving a combination of personnel and activities of Ranger and occasional spot checks on sawmills, put in place by the Ministry of Forestry to discourage sharp practices of illegal felling, over harvesting (including felling of under-girth trees) and encroachments. Penalties for illegal logging includes outright confiscation of vehicle and equipment, lockup of mills and subsequent payment of a fine of N100,000. Most sawmills are strategically located, in clusters, at the periphery of urban settlements. To operate in the state, sawmills are registered with the Ministry of Forestry. A preliminary payment of N150,000 for installation certificate is made followed by a yearly renewal fee of N20,000. Toll milling is the most common timber processing operations as most of the timber contractors do not own sawmills. Sawmilling activities is highly erratic; depending, mainly, on season, location of mill and general business condition.

The Technical Efficiency Model

Productivity has been studied by economists and policy makers for a long time. This is because in the long run, only productivity growth is considered as an engine for economic growth. Technical efficiency is just one component of overall economic efficiency. However, in order to be economically efficient, a firm must first be technically efficient. Profit maximization requires a firm to produce the maximum output given the level of inputs employed (i.e. be technically efficient), use the right mix of inputs in the light of the relative price of each input (*i.e.*, be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) (Kumbhaker and Lovell, 2000). Technological change and efficiency improvement are important sources of productivity growth in any economy.

The concept of technical efficiency is based on input and output relationships. Technical inefficiency arises when actual or observed output from a given input mix is less than the maximum possible. Allocative inefficiency arises, when the input mix is not consistent with cost minimization criteria (Coelli, 1996; Wang and Schmidt 2002). In the case of sawmills, allocative inefficiency occurs when millers do not equalize marginal returns with true factor prices. Relative productive efficiency of firms within an industry is continually shocked by economic events as well as the process of adopting technical innovations. The diffusion of new and more efficient methods is, often, a slow, drawn-out affair (Place and Otsuka, 1998). The analysis of technical efficiency involves the assessment of the degree to which production technologies are being utilized.

Traditionally, technical efficiency has been measured as the ratio of observed output to maximum feasible output. Stochastic frontier models have been widely used to assess this issue (Wang and Schmidt, 2002; Alvarez and Crespi, 2003 and Alene *et al.,* 2006). In analyzing producers' technical inefficiencies, there is a need to carefully integrate the stochastic component of production into the stochastic frontier models in order to derive reliable information on input allocation decisions. Holmes *et al.* (2000) observed that, the common stochastic specification used in the economic literatures to estimate production functions can be too restrictive. This is because; traditional approximations do not