INTENSITY OF PALM FRUIT PROCESSING TECHNOLOGY-USE AMONG PALM FRUITS' PROCESSORS IN ONICHA LOCAL GOVERNMENT AREA IN EBONYI STATE, NIGERIA

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ABSTRACT
The study analyzed intensity of technology-use among palm fruits' processors in Onicha Local Government Area in Ebonyi State, Nigeria. Specifically, the study described the intensity of technologies-use in oil palm processing in the area; ascertained the determinants of method of processing used by oil palm fruit processors and examined the constraints to oil palm fruits processing in the study area. Purposive sampling procedure was employed to select 58 respondents for the study. Data were analyzed using descriptive analysis (frequency, percentage, mean) and logit analysis. Logit analysis indicated that marital status (–6.754), cost of labor (–0.002), level of education (2.303) and annual income (0.342) were the variables that determined technology-use, while variables such as credit access and quantity of oil palm fruit were not significant. The constraints encountered in technology-use were ranked as follows high cost of palm fruits (95%), inadequate processing equipment (91.37%), difficulty in obtaining credit (86.21%), high cost of palm fruits transportation (84.48%), and inadequacy in the supply of palm fruits (76.31%). It is recommended that palm fruit processors should form a co-operative society thereby procure more equipment for sustainable palm fruits' processing.

Key words: technology-use, intensity, palm fruits' processing

INTRODUCTION

Palm fruit, *Elaeis guineensis*, is a type of fruit that grows on palm trees with an oily fleshy outer layer with kernel inside. Palm fruits processing is an important economic activity in Southeast zone of Nigeria. The palm fruit is by every standard the most economically important tree crop and proceeds from it have positively influenced the socio-economic life of the rural communities and so it has potential of improving their living conditions (Apeh and Opata, 2019; Okolo *et al*., 2019). Palm fruits which are processed into palm oil have been a major source of foreign exchange to Nigeria as well as a source of revenue to major segments of the rural population of South East zone of Nigeria (Onoh and Peter-Onoh, 2012; Okolo *et al*., 2019). Most agricultural produce require processing to consumable forms. In other words, processing helps to enhance their utility toward satisfying consumers.

Processing of oil palm fruit in Nigeria has not been fully explored due to its non-mechanization. Large percentage of palm fruit juice in Nigeria market is processed from the traditional method which is not only unhygienic but is equally labourious and time consuming (Ekeoma *et al*., 2022). Palm fruit processing is the set of methods and techniques used to transform the raw palm fruits into palm oil, palm kernel oil, palm kernel cake and other by-products for human and livestock consumption or industrial uses. Palm fruit in its natural form is highly perishable, unless it undergoes processing to convert it to palm oil and other by-products. Palm fruit is the most efficient oil crop that is vital to oil commodity due to its versatility for being a practical raw material in producing a number of commercial products. Generally, food crops processing add value to the agricultural produce and helps in the durability/increase in shelf life of food crop products, as well as the availability of the product for consumption (Adiaha, 2017). The most appropriate processing technology is one that produces the highest quality of oil with the highest extraction rate and lowest cost given the available capital. Palm fruit is processed to obtain three commercial products which are palm oil, palm kernel oil and palm kernel cake. According to Owoo and Lambo-Quayefio (2018), agro-processing has the potential to increase nutritional value and also increase food security, through a reduction in food spoilage and wastage. Processed farm produce such as oil palm also enjoy greater price stability on the world market and therefore increase market opportunities for exports, contributing to income securities particularly in the rural communities where most of the processors dwell.

In the 1960s before oil became the dominant income earner for Nigeria, palm oil from the southeastern region of Nigeria was one of the tripods on which the economy of Nigeria stood. With the discovery and dependence of the Nigerian economy on crude oil, the role of agriculture as a whole and palm oil in particular dwindled (Adetola, 2015). Nigeria not only ceased exporting palm oil, but also became a net importer of palm oil even from Malaysia (Ekenta et al., 2017).

The supply of palm oil is expected to increase in order to meet the growing demand of the world population (Syarifudin and Zareen, 2021). The world population continues to grow and the rising domestic consumption of palm oil could not match the sluggish growth in production. This may be attributed to the mostly used outdated equipment during palm fruit processing. This method of palm fruit processing is arduous, time consuming and oil yield is usually low (Eric and Ikheloha, 2017). Often, about 25-75% of potential palm oil is lost during processing while 71.8-90.6% and 9-28% of palm oil end up as waste under smallholder palm oil processing in Nigeria depending on the variety of the oil palm (Eric and Ikheloha, 2017). Palm oil has always been processed by using traditional primitive rural technique of cooking the palm fruits in a pot and pounding the cooked fruits in a wooden mortar. The mash is then squeezed either by hand or any other method which will squeeze the palm oil out of the mash. Other identified constraints of palm fruits processing according to Alabi et al. (2020) were the supply of inputs, the inefficiency of processing methods, the low quality of the output, the lack of infrastructure and inefficient distribution. This downturn in the palm oil output in Nigeria's market share therefore, may be boosted by sustained use of technologies to increase its productivity among the small holder processors that account for 70% of the industry supply (WG, 2010).

Technology is the result of man's ingenuity that facilitates and simplifies his activities. Technology-use among oil palm processors in the study area refers to the adoption and utilization of various technological tools, equipment and processes in the extraction of palm fruits. Technology-use can also be defined as the application of knowledge of nature for achievement of goals. It includes the fashioning of instruments, synchronization of activities with nature and use of natural materials to achieve a goal in a more efficient way (OECD, 2017). Technology-use in oil palm processing ensures efficiency, productivity and profitability among the processors. It also promotes employment generation while contributing to enterprise development, diversification of rural economies, import substitution, among others.

In Onicha, it was observed that there were two prevalent methods of palm fruit processing. Oyeronke and Adedotun (2019), also reported on these two broad methods of palm oil processing, the traditional or manual methods normally referred to as low technology and the mechanized or modern method of processing. The difference is the equipment being employed and of course the quality of output each method produce. The modern or mechanical methods are further grouped into categories according to the intensity of the techno-logy utilized and degree of complexity of the unit operational machinery. These are the small-scale mechanical units, medium-scale mills and large industrial mills. After harvesting the fruits in the groves or plantation, the fruit bunches are moved to the mill where the fresh fruit bunches are weighted and then quartered before they are transferred to the sterilization unit where they are cooked. After sterilization, the next step is stripping and threshing to separate the fruit from the husks. The husks are then discarded and later used as fuel for firing furnaces that power the sterilizer. The separated fruits are then transferred to the digester where the cooked fruits are mashed into a pulp. The mash is transferred to the presser from where the palm oil will be squeezed out and transferred into a clarifier for sedimentation. The intensity of technology-use in oil palm processing is the extent and magnitude with which various technologies are integrated into different stages in oil palm processing, from harvesting to the production of palm oil and other palm-based products. The use of technology can impact efficiency, productivity, and quality in the palm oil industry. Intensity of technology use can be defined as the degree or extent to which the palm fruit processors employed mechanical or semi-modern technologies in the processing of palm fruits in the study area. It can further be defined as the level of the available technologies incorporated in palm fruits. FAO (2005) asserted that improved processing technologies for the extraction of palm oil were generally identified using some of the following technologies.

Bunch Reception
Fresh fruits harvested from the field as bunches or loose fruits are normally emptied into wooden boxes suitable for weighing on a scale so that quantities of fruit arriving at the processing site may be checked.

Threshing
This is the removal of fruits from bunches. Fresh fruit bunches consist of fruits embedded in spikelet growing on a main stem. It's a mechanized system whereby a rotating drum or fixed drum equipped with rotary beater bars detach the fruit from the bunch, leaving the spikelet on the stem.

Sterilization
This means sterilizing or cooking palm fruits, by using high temperature wet-heat treatment on the loose fruit, cooking normally uses hot water while

sterilization uses pressurized steam. Fruit cooking weakens the pulp structure, softening it and making it easier to detach the fibrous material from the oil during the digestion process. The high heat is enough to partially disrupt the oil-containing cells in the mesocarp and permits oil to be released more readily.

Digester

This is the process of releasing palm oil in the fruits through the rupture or breaking of cells. The digester consists of a steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of beaters and the fruit at high temperature, this helps to reduce the viscosity of the oil, pounds the fruits outer covering, and completes the whole pounding process that begins during the sterilization phase.

Extraction of the Palm Oil

There are two methods of extracting oil from the digested material. One system uses mechanical or screw presses and is called the dry method. The other called the wet method uses hot water to leach out the oil. In the dry method, the objective of the extraction is to squeeze the oil out of a mixture pressured on the digested mash.

Clarifier

This is the separation of oil from its unstrained impurities, because the fluid coming out of the press is a mixture of palm oil, water, debris, fibrous material and non-oily solids. But by clarification, the oil is purely separated from its impurities. The aim of clarification is to extract impurities from the crude oil so as to recover the maximum possible yield of pure oil. Clarification carried out for further sedimentation of the palm oil extract (Oyeronke and Adedotun, 2019).

Furthermore, the importance of oil palm to the national economy of Nigeria cannot be over emphasized. It ranges from production of food for human consumption, employment, income to farmers and nation and raw materials for industries. Oil palm is among the most productive and profitable of tropical crops for bio-fuel production. Based on this background, the study seeks to ascertain the extent palm fruits' processors had imbibed and intensified the use of different technologies in order to increase productivity to curb shortages in product supply in the recent times. Consequently, the objectives of the study were to (i) describe the intensity of technologies-use in oil palm processing in the area, (ii) ascertain the determinants of method of processing used by oil palm fruit processors, (iii) and examine the constraints to oil palm fruits processing in the study area.

MATERIALS AND METHODS

The study was carried out in Onicha Local Government Area (LGA), Ebonyi State, Nigeria. The State shares a border with Benue State to the North, Enugu State to the West, Imo and Abia States to the South and Cross River State to the East. Its capital and largest city is Abakaliki. Ebonyi State covers an area of 5,533.00 km² and lies at latitudes 5° 40′ and 6° 45′ N and at longitudes 7° 30′ and 8° 30′ E. It has a population of 2,175,501 (NPC, 2006); with current population estimate of 2,880,383 (NBS, 2017) and a growth rate of +2.74. The state has 13 LGAs namely Abakaliki, Afikpo North, Afikpo South, Ebonyi, Ezza South, Ikwo, Ishielu, Ivo, Izzi, Ohaozara and Onicha. The State is divided into three agricultural zones namely Ebonyi North, Ebonyi Central and Ebonyi South. Agriculture and agro processing are the prevalent occupations of the people in the state. These include oil palm fruits processing, rice production among other crops.

A multistage sampling technique was used for selecting 58 palm fruits processors in the study area. In stage 1, among the three agricultural zones in the state: Ebonyi North, Ebonyi Central and Ebonyi South. Ebonyi South was purposively selected for the study because of the high concentration of palm fruit processors in the zone. In stage 2, Onicha LGA was purposively selected due to the predominance of palm fruits processors in the area. Stage 3 involved random selection of four communities from the LGA selected which included; Amanator, Isu Achara, Mgbaneze, and Umuniko. In stage 4, 15 palm fruits processors were randomly selected from each of the communities which provided a sample size of 60 processors. Sample size of 58 processors were used, while two questionnaires were invalid. Primary data were collected from the palm fruit processors through the use of structured interview schedule. Data collected were analyzed using both descriptive and inferential statistics. Descriptive statistics such as mean, percentage and frequency distribution were used to analyze variables in objectives one and three. In objective three, mean value of < 50% implies minor constraints while > 50% indicate major constraints. Intensity of technology-use is the level of the available technologies incorporated in palm fruits processing and the indicator is typically measured by dividing number of participants in a single/particular technology by total number of respondents.

Similarly, the intensity of technology-use was calculated as follows:

$$I_t = \frac{T_u}{N} \; ;$$

where I_t is intensity of technology-use, T_u is number of participants in a single/particular technology, N is total number of respondents. The technologies include bunch reception, threshing, sterilization, digestion, extraction, and clarification. Decision rule: if the value of I_t for a particular technology is $\geq 50\%$, there is high intensity of technology-use; otherwise when $I_t < 50\%$ there is low intensity of technology-use in the palm fruits processing.

In order to achieve objective two, Logit regression model was employed. The binary response in this study is whether the respondents utilized solely improved technology or traditional method. Y is a random variable, it can be assumed that Z takes the value of 0 or 1, where 0 denotes traditional method and 1 denotes improved technology-use. X_1………. X_n are the characteristics to be related to the occurrence of this outcome, and the logistic model specifies that the conditional probability of event that Y is 1 gives the values of X_1………. X_n as:

$$L_1 = \ln (P_1/1 - P_1) = Z = \alpha + \beta_1 X_1 \ \ldots\ldots\ \text{(1)};$$
$$\text{Logit prob.} (Z_i) = \alpha + \sum \beta_i X_i + \mu_i.\ \ldots\ldots\ \text{(2)};$$

where P_1 is probability of use of improved technology in processing of palm fruit; $1 - P_1$ is the odd ratio of use of traditional technology in processing of palm fruit. The model is explicitly stated as:

$$Z_i = b_0 + b_1 X_1 + b_2 X_1 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + e_i \ \ldots\ \text{(3)};$$

where Z_i is method of processing used (1 if oil palm processors used mechanized method of processing, 0 if oil palm processors used traditional method of processing); b_0 is constant term; b_1-b_{10} is logit coefficients for independent variables represent determinants of method of processing; X_1 is sex (male is 1; female is 0); X_2 is age (years); X_3 is household size (number); X_4 is marital status (single is 1; others is 0); X_5 is cost of labour (naira); X_6 is quantity of oil palm fruits (kg); X_7 is access to credit (naira); X_8 is level of education (years); X_9 is membership of processors' cooperative (member is 1; non-member is 0); X_{10} is years of processing experience (years); e_i is error term.

RESULTS AND DISCUSSION
Intensity of Technologies-Use in the Study Area
Table 1 indicates that the technologies: threshing, sterilization, digestion, extraction and clarification were highly utilized in the study area. This suggests that the majority of the processors are moving away from traditional method of palm fruits' processing following high intensity of technologies used ranging from 0.62-1.00. The processors attested to the fact that these technologies help to reduce drudgery associated with the traditional methods i.e., pounding of the palm fruit with pestle and mortar or the stress of mashing with feet in a wooden trough. Adaigho and Nwadiolu (2017) reported that the perception of farmers on the level of use of technologies such as sterilizer, digester, and mechanical press was high in Delta State. This is consistent with the findings of the research, indicating that the processors are embracing the use of technology for efficient palm oil extraction. Ofoka and Nwalieji (2019) also reported that majority of palm fruits processors operate semi-automated oil processing system. Amusa et al. (2017) in a related study in Abia State reported that

most of the medium- and large-scale processors use mainly the digester screw which is very efficient in the extraction of palm produce. On the other hand, technology-use in processing of palm fruits is adjudged to increase quality and quantity of processed products (Amusa et al., 2017).

Determinants of Technology-Use by Oil Palm Fruit Processors
Estimates for the determinants of method of processing used were obtained using the logit model at $p \leq 0.05$ (Table 2). Marital status, cost of labour, education, and annual income were the significant variables that determines technology use while variables like sex, age, household size, quantity of oil palm fruit, credit access, cooperative membership and years of processing experience were not significant. The coefficient (–6.754) of marital status was significant at p-value 0.05 and negatively related to technology-use in palm fruit processing. The odd ratio of 0.001 indicates that technology-use decreases among the married processors by 99.9% unlike the unmarried ones. This implies that married palm fruit processors were unlikely to employ modern technology compared to the unmarried processors. The implication of the result may be due to the use of family labour through traditional oil fruit extraction among the married processors in order to save cost. Obike et al. (2016) reported in a labour related work that farmers; including agro-processors should be encouraged to utilize their family labour efficiently in order to reduce cost of production and decrease in agricultural revenue. The coefficient of labour cost is –0.002 and shows that the log odd in favour of technology-use decreases as labour cost associated to use of modern technologies increases. The odd ratio of 0.998 indicates that for every one-unit increase in labour cost, the odds of employing modern technologies decreases by a factor of 0.9998 or 0.20%. This implies that palm fruit processors tend to move away from the use of modern technologies should the cost increases. It can be further explained that processors may tend to rather patronize cheaper method rather than incur more cost using modern technologies. Saheen et al. (2019) conformed to the finding that agro-processing sector is dominated by small-scale industries, labour-intensive resulting in high cost of labour and lacks capital investment.

Table 1: Distribution of the respondents according to intensity of technologies used in palm fruit processing

Processing technology	Frequency*	Intensity	(%)
Bunch reception	36	0.620	62.00
Threshing	56	0.966	96.55
Sterilization	58	1.000	100.00
Digestion	45	0.776	77.58
Extraction	48	0.828	82.76
Clarification	42	0.724	72.41

Field Survey (2019). *multiple responses

Table 2: Logit estimate of the determinants of technology-use

Variables	Coefficient	S.E.	Wald	p-value	Exp (B)
Sex	1.373	2.640	0.270	0.603	3.946
Age	0.138	0.103	1.817	0.178	1.148
Marital status	−6.754	2.486	7.380	0.007*	0.001
Household size	−2.448	1.549	2.498	0.114	0.086
Labour cost	−0.002	0.001	6.387	0.011*	0.998
Quantity of oil palm fruit	0.016	0.010	2.372	0.124	1.016
Credit	0.597	3.007	0.039	0.843	1.816
Education	2.303	0.932	6.105	0.013*	10.004
Co-operative	4.308	2.417	3.178	0.075	74.291
Experience	0.070	0.119	0.345	0.557	1.072
Annual income	0.342	0.154	4.932	0.027*	1.408
Constant	27.936	15.252	3.355	0.067	1.357

Computed from survey data (2019). $p \leq 0.05$. * - 5% level of significance, S.E. - standard error, Wald - Wald statistics, Exp (B) - odd ratio.

Educational level coefficient is 2.303 with p-value of 0.013 indicating statistical significance at 0.005 level. The odd ratio (10.004) indicates that for every one-unit advancement on the educational level of the processors, the odds of embracing the use of modern technology increases by 0.004. Relatively high literacy level is an asset as the oil palm processors would be exposed to many information sources, embrace innovations and adopt the use of technologies to aid and increase their productivity. In a related study by Khoza et al. (2018), factors such as educational level including other factors such as land tenure, agro-processing training and information had a positive influence on agro-processing participation. Annual income coefficient 0.342 with p-value 0.0027 is significant at 0.05 level. The odds (1.408) indicates that for every one-unit increase in annual income of the processors, the odds in favour of using a modern technology increases by 1.408 or 40.8%. Bortamuly and Goswami (2015) conforms with the result that annual income of the industry owners plays a crucial role in the use of modern technology.

Constraints of Palm Fruit Processors
Percentage scores above 50 were considered as the constraints encountered by the processors. Results in Table 3 show that high cost of palm fruits (95%), inadequate processing equipment (91.37%), difficulty in obtaining credit (86.21%), high cost of palm fruits' transportation (84.48%), inadequate/seasonality of palm fruits (79.31%) were the dominant constraints faced by oil palm processors in the study area. Alabi et al. (2020) established that lack of funds, poor processing facilities and transportation problems constitute the major challenges facing oil palm industry in Nigeria. Adaigho and Nwadiolu (2017) also reported lack of access to credit facilities as the major constraint faced by oil processors in their study. According to Shehu et al. (2021), it was posited that there are other challenges facing palm oil industry in Nigeria such as lack of good planting materials, poor funding, improper milling and lack of technology.

Table 3: Distribution of respondent based on constraint in oil palm processing

Variable	Frequency*	(%)
High cost of palm fruits	55	95.00
Inadequate processing equipment	53	91.37
Difficulty in obtaining credit	50	86.21
High cost of palm fruits' transportation	49	84.48
Inadequate/seasonality of palm fruits	46	79.31
Inaccessibility of feeder roads	28	48.27
Destruction of rainforest	26	44.82
Instability of government policy	24	41.37

Field Survey (2019). *multiple responses

CONCLUSION
Based on the findings, it may be concluded that the variables relating to marital status, cost of labour, level of education and annual income were the significant determinants of intensity of technology-use while variables like sex. age, household size, quantity of palm fruits, credit access, cooperative membership and years of experience of oil palm fruit processed were not significant. The study recommends that rise in processors' annual income could help them establish oil palm processing plants at various communities as a means of reducing cost of oil palm processing. This will in turn solve the problem of any relative increase in cost incurred in the processing palm fruits and inadequacy in processing equipment thereby making the venture more attractive for the youths. Establishment of a processing plant in the community will serve as incentives to the use of modern technologies among the married processors. It is recommendable that cooperator processors establish high yielding oil palm plantations to reduce dependency on palm fruits supply from the forest and make palm fruits readily available at minimal cost. Government intervention on the feeder roads will enhance the conveyance of both the oil palm and oil products.

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