RESEARCH ARTICLE

Economic Analysis of Palm Fruit Processing Among Rural Farmers in Ezeagu Local Government Area of Enugu State, Nigeria

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Abstract

The study focused on the economic analysis of palm fruit processing among rural farmers in Ezeagu Local Government Area of Enugu State, Nigeria. Specifically, it described the socio-economic characteristics of palm oil processors, identified processing methods, estimated costs and returns, determined factors influencing output, and examined constraints. A multi-stage stratified random sampling technique was used to select 60 respondents. Data were collected with structured questionnaires and analyzed using descriptive statistics (frequency, percentage, mean, and gross margin model) and inferential tools such as regression and Z-test models. Results showed that 35% of producers used mechanized technologies while 65% used traditional methods. The benefit–cost ratio was 1.30 for traditional processing and 11.8 for modern methods. Regression results indicated that age (-0.773*), education (1.149*), household size (0.068***), farming experience (0.089***), income (0.113***), and access to credit (0.228***) significantly influenced palm oil processing. Major constraints were lack of electricity (100%), non-availability of palm fruit (93.3%), lack of government support (93.3%), inadequate credit (86.7%), and insufficient land (85%). The Z-test revealed a significant income difference between modern and traditional methods. The study concludes that modern processing is more profitable and recommends stronger extension services to enhance farmers' adoption.**

Keywords: palm oil, palm oil processing, economic analysis, rural farmers.

1 Introduction

Palm oil, a kind of edible vegetable oil, which is derived from the pulp of the fresh palm fruit in its various forms, has become the leading vegetable oil produced globally, accounting for one quarter of global consumption and nearly 60% of international trade in vegetable oils [1]. The increase in consumption is due to its multiple uses in both food industry and non-food sectors. It also has many competitive

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advantages over other competing oils, such as having low cost of production, high yield, and being free from trans-fatty acids. Oil palm commercially cultivated on about 12 million hectares of land in the humid tropics. Major producers are Malaysia and Indonesia (85% of global output). Other smaller but significant producers include Nigeria, Colombia, Costa Rica, Ecuador, Honduras, Cote d'Ivoire, Nigeria, Cameroon, Papua New Guinea, and Thailand [2].

Palm oil, in its various forms, has become the leading vegetable oil produced globally accounting for one quarter of global consumption and nearly 60% of international trade in vegetable oils [3]. In 2007/2008, the world consumption of palm oil reached almost 40 million tonnes and in 2050, it is forecast to reach 93.256 million tonnes, depending on the edible oil substitute demand. In recent decades, the domestic consumption of palm oil in West Africa has also increased more rapidly than its production [4]. After centuries as the leading producing and exporting region, West Africa has now become a net importer of palm oil [5]. Nigeria has a long history of palm oil production. It was its primary export in late part of the 19th century and the early part of the 20th century [6].

According to Tiku et al. [7] (2020), the palm oil industry in Nigeria since independence has been geared towards meeting domestic demand and thus reducing import bills, (i.e. it has largely been an import substitution industry). The growth in oil palm cultivation from the 1970s was in response to the increase in domestic demand as a result of growth in population, urbanization and industrialization. The structure of the palm oil industry in Nigeria has been shaped by the presence of two different markets: home consumption and industrial use in domestic manufacturing [8]. As a result, Nigeria's industry has two sub-sectors which are largely separated. The industrial use sub-sector consists of medium and large scale oil palm plantations and mills. Processing mills under large scale sub-sector process more than 10 tonnes fresh fruit bunches (FFB) per hour while installations that process between three and eight tonnes FFB per hour are termed medium scale [20]. Large sub-sector is characterized by more efficient technology, economies of scale, higher productivity on farms (in terms of yields of oil palm bunches) and in mills (in terms of quantity of oil extracted). It also produces better quality of crude palm oil and further refined palm oil products, which are sold to companies for use in manufacturing. The small scale sub-sector, however, consists of household processors who process manually and private smallholder oil palm cultivators, who largely sell their fruit bunches to small scale mechanized mills (Processing units handling up to 2 tonnes of fresh fruit bunches (FFB) per hour) [20]. The small scale sub-sector is characterized by low-yielding oil palm variety, low productivity of farm and mill, and low quality crude palm oil which is sold in the village or at small town markets [19].

Basically, there are two methods of processing palm oil, the traditional and the industrial. Within these two major methods, there are widespread variations [9]. They all apply physical means in processing to obtain crude oil. Chemicals are used if they have to go through the refining, bleaching and deodorizing (RBD) stages. Lai et al. [10] has detailed the various stages of processing fats and oils, which generally applies to palm oil as well. These processes may alter significantly the quality of the palm oil; each may be determined by the quality indices which are basically chemical or physical in nature. For example RBD reduces the level of carotenes in palm oil. The study will, therefore, be of immense help to the country as a whole and the palm oil industry in particular.

The local method is a very laborious process. The palm bunches are quartered and left overnight for easy separation of nuts from the spikelets [11]. The fruits are boiled for 1.0 to 1.5 hours, pounded in a mortar or macerated with feet in a canoe-like container. Water is added and well-shovelled up. All nuts are carefully removed out by hand. The fibres are well-shaken over in the sludge until oily foam floats to the surface of the sludge. The foams continue to collect in a container until the operation is completed. This is later boiled in pot for about 30-40 minutes. The clean edible oil then collects on the surface leaving the dirty oil at the bottom of the pot. Onu et al. [17], observed that delay in the processing of fruits can lead to increase in free fatty acid (FFA) content of palm oil and this causes a drop in quality.

The modern method uses such simple machines as presses to more sophisticated palm oil mill in processing fresh fruit bunch (FFB) into palm oil and other products [12]. Palm oil mill consists of a series of operations designed to separate the harvested bunch into distinctive fractions – stalk, fruit, fibre, oil, sludge, nut, and kernel and so on. These operations are: sterilization, stripping, digestion, crude oil extraction clarification, kernel extraction. The increased demand for palm oil resulting from an increase in population and income growth, relative to the low productivity of

the oil palm sector have mounted pressure on Nigeria to increase oil processing to meet up with market demands. Thus, Nigeria first goal is to meet the domestic demand and then if possible seeks to become competitive in export markets. In recent times, its production has drastically downsized.

Evidence from [4] revealed that this situation has been brought about by a number of socio economic and political factors along with the technological knowhow in the industry. Principal among the factors responsible for this decline is the inefficiency that exists in the production system for palm oil processing. Such inefficiencies arise from high cost of labour, lack of linking roads for transportation, electricity, water, inadequate credit facility.

According to Chew et al. [13], processing method affects the quality and quantity of palm oil produced. There is still a confusion about the method of palm oil processing that will be viable that is efficient and effective. Many studies have concluded that modern method of palm oil processing is more efficient and effective in producing both quality and quantitative palm oil [14], still others have opposed such view as Okoronkwo et al. [15] says that the traditional method of processing produces quality palm oil than the modern method in a study that analyzed the farmers perception of the advantage of the various processing techniques. Moreso, the cost and return of the two processing techniques have been in debate as some studies claim that traditional method of processing is cost effective, while some studies say that the modern method although not cost effective but rake in more returns than the traditional method. Based on this confusion, this study is set to do an economic analysis of palm oil processing among rural farmers in the study area.

The broad objective of this study was economic analysis of palm oil processing among rural farmers in Ezeagu Local Government Area of Enugu State, Nigeria. Specifically, the study

1. identified the various methods of palm oil processing;
2. estimated the cost and returns of palm oil processing;
3. determined the factors influencing the output of the palm oil processed;
4. identified the constraints to palm oil processing in the study area.

This null hypothesis was tested in the study:

H01: There is no significant difference between the income from traditional and modern oil processing methods in the study area.

2 Related Work

Ezeagu is a Local Government Area of Enugu State, Nigeria. Its headquarters is in the town of Aguobu-Owa [16]. The average temperature in this city is cooler to mild (60 degrees Fahrenheit) in its cooler months and gets warmer to hot in its warmer months (upper 80 degrees Fahrenheit) and very good for outdoor activities with family and friends or just for personal leisure. There are 28 communities in Ezeagu namely; Amasiodo-Oghe, Amankwo-Oghe, Akama-Oghe, Oyofo-Oghe, Opkogho, Olo, Iwollo-Oghe, Neke-Oghe, Obinofia, Ndiagu, Umana, Ndiuno, Obinofia Ndiuno, Obeleagu-Umana, Umumba Ndiuno, Umana Ndiagu, Aguobu, Umumba, Umana-Agba, Imezi Owa, Mgbagbuowa, Ezema-Ogulogu, Ibite-OloObinofia Ndiagu, Ogwofia Imezi-Owa. Ezeagu being mainly agrarian with expanding population shows evidence of out-migration of the youths from the rural sector in search of white-collar jobs and trading. The state produces many food crops and cash crops like cocoa, oil palm, cashew, rubber etc [18]. The population of the study consisted of all oil palm processors in Ezeagu L.G.A of Enugu State, Nigeria.

A multi-stage stratified random sampling technique was adopted in selecting 60 respondents for the study [21]. The first stage involved random select of 12 autonomous communities. The communities selected includes Akama-Oghe, Oyofo-Oghe, Opkogho, Iwollo-Oghe, Neke-Oghe, Obinofia, Ndiagu, Umana, Ndiuno, Obinofia Ndiuno, Obeleagu-Umana, Aguobu and Umumba. In the second stage, 1 village was randomly selected from the 12 communities already selected. This made a total of 12 villages. In the third and final stage, five (5) oil palm processors were purposively selected which gave a total of 60 respondents. The essence of the purposive selection was to ensure that rural farmers whose major occupation is palm oil processing were selected to avoid bias and uninformed responses [22].

The study made use of primary data through the use of questionnaire. Secondary sources of information were gotten via internet, books, bulletins, periodical, past related research work, magazines, journals and academic proceedings

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Objectives (1) and (4) were analyzed using statistical tools such as frequency, percentage and mean while objective (2) was analyzed using gross margin analysis while objective (3) was analyzed using Ordinary Least Square regression analysis. The hypothesis of the study was tested using Z-test analysis.

3 Methodology

4 Arithmetic mean

The formula to compute the mean count used in this study is specified below. The mean ($\bar{x}$) is computed by multiplying the frequency (f) of the responses under each category by the assigned value and dividing the sum ($\sum$) of the product by (N) number of respondents to the particular indicator as shown:

$$\bar{x} = \frac{\sum fx}{N}$$

Where $\sum$ = Summation, F = Frequency, X = Assigned scores to response category, N = Number of respondents, $\bar{x}$ = Arithmetic mean.

4.1 Gross Margin Model

This is stated as follows:

$$GM = TR - TVC = \sum(P_i Q_i - P_{x_i} X_i)$$

where GM = Gross Margin, P_i = Unit price of output, Q_i = Quantity of each output, P_{x_i} = Unit price of variable input, X_i = Input (Variable), $\sum$ = Summation.

The net returns (NR) and benefit-cost ratio (BCR) are expressed as:

$$NR = GM - TFC \qquad \text{(II)}$$

$$BCR = \frac{TR}{TC}$$

Where TR = Total Revenue (₦), TVC = Total Variable Cost (₦), NR = Net Returns (₦), TFC = Total Fixed Cost (₦), BCR = Benefit-Cost Ratio.

4.2 Regression Model

Objective iv: was tested using the Ordinary Least Squares (OLS) regression model.

The four functional forms of OLS in explicit form are specified as follows:

Linear function

$$Y = \beta + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + e_i$$

Exponential function

$$\ln Y = \beta + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n + e_i$$

Semi-log function

$$Y = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \cdots + \beta_n \ln x_n + e_i$$

Cobb–Douglas function

$$\ln Y = \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \cdots + \beta_n \ln x_n + e_i$$

The implicit model is expressed as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}) + e_i$$

where Y = Palm oil output (litres), X_1 = Age (years), X_2 = Sex (male = 1, female = 0), X_3 = Household size (numbers), X_4 = Farm income (naira), X_5 = Marital status (married = 1, otherwise = 0), X_6 = Farming experience (years), X_7 = Education (years), X_8 = Credit (naira), X_9 = Extension contact (number of times), X_{10} = Membership to cooperative society (yes = 1, no = 0), e_i = Error term.

4.3 Hypothesis 1

Hypothesis 1: which stated that there is no significant difference in the income from modern and traditional processing methods in the study area was tested using Z-test analysis. The model is specified as follows:

$$Z = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

5 Results and Discussion

5.1 Technologies used by the processors

Table 1. Distribution of respondents based on the technologies used in processing palm fruit.

Palm fruit processing technologies	Frequency	Percentage
Mechanized technologies	21	35.0
Traditional	39	65.0
Total	60	100.0

Source: *Field survey, 2023*

The findings on technologies used by the processors presented in Table 1 above shows that 35% of the processors were using mechanized technologies while

65% of the processors were using traditional methods of processing. This implies that traditional method of processing was the main method of processing used by oil palm producers in the area. The reason for the predominant use of traditional method of processing may be attributed to lack of finance to purchase the modern methods of processing, lack technical knowhow on the use of the modern method, age, economic factors predominant in the area (rural) etc. Liu et al. [23], in his study concluded that farmers in rural areas where less likely to adopt modern methods of farming because of the aforementioned factors.

5.2 Average cost and returns of palm fruit processing

Table 2. Average Cost and Returns estimate of Palm fruit processing in the study area.

Traditional method	**Item value/month**
Returns	
Total Revenue (TR)	193,500.00
Fixed cost	
Cost of processing equipment	103,200.00
Depreciated cost	10,320.00
Variable cost	
Labour cost	12,540.00
Transport cost	17,500.00
Storage cost	3,200.00
Other costs	2,210.00
Total Variable cost (TVC)	**138,650.00**
Total Cost	**148,970.00**
Gross Margin (TR – TVC)	**54,850.00**
Profitability (Pr = TR/TC × 100)	**1.30**
Modern method	
Total Revenue	1,330,924.6
Depreciation on Fixed Cost	51,229.2
Variable Cost (TC)	
Labour/man-day	13,077.8
Threshing cost	5,233.8
Par boiling cost	4,079.3
Cost of water in litre	17,513
Cost of firewood	2,313.0
Extraction	441.2
Clarification	17,262.2
Transportation cost	2,058.3
Total variable cost (TVC)	**61,978.6**
Total Cost (TC = TFC + TVC)	**113,207.8**
Gross Margin (TR – TVC)	**1,268,946**
BCR (TR/TC)	**11.8**

Source: *Field Survey, 2023*

From the cost analysis as presented in Table 2, returns per Naira invested in palm oil production were evaluated by dividing their net revenue by the total cost. For traditional method, the total variable cost was computed by taking a sum of the following costs: labour cost, transport cost, storage cost and other cost. The total fixed cost included cost of processing equipment and depreciated cost. For modern method, the total variable cost includes cost of labour/man-day, threshing cost, par boiling cost, cost of water, firewood, extraction, clarification and transportation.

From the result, the total variable cost stood at N138,650.00 and N 61,978.60 for traditional and modern methods respectively, the total cost stood at N 148,970.00 and N 113,207.80 for traditional and modern methods respectively. The total revenue were 193,500.00 and 1,330,924.60 for traditional and modern methods of processing respectively, while the gross margin were at 54,850.00 and 1,268,946.00 for the traditional and modern method of processing respectively. The profitability for traditional method of processing was 1.30, which implies that for every N1.00 invested in palm oil production using traditional methods will yield N0.30 in revenue in the area. The profitability for the modern method of processing shows a B/C ratio of 11.8, which implies that for every N1.00 invested in palm oil production using the modern method will yield N10.8 in revenue in the area.

The gross margin analysis above shows that the modern method of palm oil processing in the area is more profitable than the traditional method, which is line with what was expected. Modern method of processing palm oil required less expenses to run than requires less than the traditional method and is more efficient which explains why the profitability of the modern method was way higher than the traditional method of processing. When modern method of processing are used, the only major expenses will be the cost of purchasing the equipment ab initio after which the cost of processing drastically reduces because apart from harvesting the fruits, the modern technique takes care of every other step. And in the end produces more oil per kilogram of palm than the traditional method.

5.3 Factors influencing palm processing

Table 3 shows the factors affecting palm oil processing in the study area. From the table, double log has been chosen as the lead equation. The choice was based on the high value of R2(0.765), which is in conformity with a priori expectations in respect of the signs of the estimated coefficients of the explanatory variables in the model. The R2 of 0.765 implies that 76.5% of the total variations in palm processing method (Y) were accounted for by the dependent variables (Xt).

Table 3. Regression result of the factors influencing palm fruit processing in the study area.

Variables	Parameter	Linear	Exponential	Semi-Log	+ Double Log
(Constant)	*B0*	-2338.142 (-0.032)	8.980 (9.566)***	103387.027 (4.714)***	11.173 (4.507)***
Sex	*X1*	39594.605 (0.651)	0.659 (0.473)	29725.679 (1.363)	.637 (0.588)
Age	*X2*	-194.886 (-0.255)	0.007 (0.681)	-37351.323 (-0.972)	-.773 (-1.779)*
Marital status	*X3*	-26405.1 (-3.097)***	-0.303 (-2.794)**	-28338.511 (1.236)	-0.417 (1.361)
Educations	*X4*	3244.229 (1.805)*	0.064 (2.501)**	-34888.386 (1.151)	1.149 (3.355)***
Household size	*X5*	-302.356 (-0.122)	0.005 (0.172)	1376.132 (0.106)	.068 (3.461)***
Farming experience	*X6*	1950.902 (1.983)**	0.010 (0.832)	14972.501 (4.160)***	.089 (3.767)***
Monthly income	*X8*	0.422 (2.071)	1.823E-6 (0.705)	474.305 (2.037)**	.113 (5.768)***
Access to credit	*X9*	-0.057 (-0.637)	1.967E-6 (1.740)*	4482.591 (4.112)***	.288 (2.60)**
R-Square		0.685	0.655	0.616	0.765
R Adjusted		0.618	0.609	0.597	0.733
F – ratio		14.710***	11.711***	12.27***	16.144***

Source: *Field Survey, 2023*
Key: * *Significance at 10%*, ** *Significance at 5%*, *** *Significance at 1%*, + = *Lead Equation. The values in brackets are the t-values.*

The results shows that sex is positively related to the method of processing used by the farmers, with a coefficient of 0.637 which implies that a 1 unit increase in sex will bring about a 63.7% increase in farmers choice of processing method, however sex has a significant effect on the choice of processing method used by farmers.

The coefficient of education was statistically significant at 1% meaning that any unit increase in education will bring about 1.149 units increase in choice of processing method, this means that an increase in education will lead to possible adoption of modern processing method by farmers.

Household size can have 6.8% effect on processing technique used by farmers, when the family has larger household which portends more hands to do the work, then the use of traditional method may be likely, but smaller household may lead to the use of modern method. Farming experience when increased by 1 unit can cause an 8.9% change in choice of processing, monthly income had a positive relationship with processing technique as any unit increase in monthly income will increase choice of processing technique by 11.3% which implies that the higher the income, the higher the chances of choosing modern methods of processing. Access to credit also showed a positive relationship processing technique used, increase access to credit will lead to 28.8% increase in the opportunity to use modern method of processing. The findings is in tandem with the works of Olagunju [24] and that of Amusa et al. [25], who all found the above characteristics to be positively related to processing technique used.

On the other hand, age was negatively related to processing method as an increase in age will lead to a 73.3% decrease in the choice of modern method, while marital status when it tends to 1 (married) leads to 41.7% decrease in choice of modern technique for processing. This result implies that increased age reduces the ability of farmer to use more sophisticated techniques such as modern method of processing and such they continue with what they have been using all their lives which support the proverb that "old monkeys don't learn new tricks". Also when they are married, they tend to choose traditional method because of large household number, thereby reducing their choice of the modern method.

The f-ratio of 16.144 shows that the explanatory variables put together have can have a significant effect on the dependent variable at 1% level of significance.

5.4 Constraints to palm fruit processing

Table 4. Distribution of respondents according to their perceived constraints to palm oil in the study.

Constraints	Frequency	Percentages
Modern method		
Non availability of palm fruits	56	93.3
Inadequate land	51	85.0
Non availability of labour	41	68.3
Lack of credit facilities	52	86.7
Lack of government support	56	93.3
High cost of modern processing facilities	42	70.0
Lack of electricity	60	100.0
Shortage of firewood	22	36.7
Scarcity of water	17	28.3
Traditional method		
Inadequate land	56	93.3
Shortage of firewood	51	85.0
High cost of labour	41	68.3
Poor access to credit	52	86.7
Poor quality of processed oil	56	93.3
Poor access to market	42	70.0
High cost of transportation	60	100.0

Source: *Field Survey, 2023*
Key: * *Multiple responses recorded*

The result shown in Table 4 that for the modern method of processing, 100% indicated lack of electricity, 93.3% of the respondents indicated non-availability of palm fruit as a problem, and lack of government support, 86.7% indicated lack of credit facilities, while 85% said inadequate land.

For the traditional method, some of the problems indicated as constraints include inadequate land and poor quality of processed oil 93.3%, shortage of firewood 85%, poor access to market 70% and high cost of labour 68.3%. the factors mentioned are not far from a priori expectations, lack of infrastructural facilities in many areas has led to farmers underutilization of modern techniques of farming and processing, lack of access to land to engage in larger farm operations has also been a serious impediment to farmers use of technology, lack of support in the forms of extension services, lack of credit are also factors that has affected farmers use of modern techniques which is in line with the findings of Nwuzor, (2020).

5.5 Hypothesis Testing

Table 5. Z-test Comparative analysis of the difference in the income from modern and traditional palm fruit processing in the study area.

Methods	Mean	Std. Deviation	Z-Calc.	Df	Z-Tab.
Modern method[a]	198,920	10,975.8			
Traditional method[b]	153,600	9,889.8			
A – B	45,320	1,086.0	6.214***	118	1.96

Key: *There is significant difference.* *** = *significant at 1%.*

The result presented in Table 5 shows the Z-test for the comparative analysis of the difference in the income from modern and traditional palm fruit processing in the study area and the result shows a Z-calc. of 6.214 which is greater the z-tab. (1.96). Therefore, the result implies that there is a significant difference in the mean income from the traditional and modern method of processing palm oil. This affirmed that oil palm processing is more profitable with modern processing method than the traditional method.

6 Conclusion and Recommendations

Based on the findings of this study, the study concludes that traditional method of processing was the major processing technique used in the study area, as a result of various factors such as age, educational qualifications, farming experience, household size, income and access to credit. The study concludes that modern method of processing is more profitable than its traditional counterpart and encourages farmers to utilize such. Based on the findings of this study, the following recommendations have been made:

- Farmers should be aided in the use of modern techniques of processing through relevant and regular extension contact because underutilization is often due to lack of experience.
- The high profitability recorded by the use of modern method underscores the need to introduce modern methods of processing in rural communities by helping farmers get the needed materials in forms of subsidy.
- The constraints to use of modern processing techniques can be curbed if government funds are properly utilized to provide the necessary social infrastructure for farmers in the rural areas.

Data Availability Statement

Data will be made available on request.

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Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval and Consent to Participate

Not applicable.

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