Journal of Agriculture, Food and Ecology 4(1) (2026)23–32

Journal of Agriculture, Food and Ecology

https://dergipark.org.tr/tr/pub/jafe

e-ISSN: 3023-5871 © JAFE Volume:4, Issue: 1 (2026)

Economic Efficiency of Oil Palm Fruit Processing in Enugu and Anambra States, Nigeria

Rita Ngozika AGBOGO [a], Olugbenga Omotayo ALABI[b*], Ojuh Ezekiel HARUNA[c], Alimi Folorunso LAWAL[d], Cecilia Anthony DANBAKI[e]

[a]*Department of Agricultural Economics, Faculty of Agriculture, University of Abuja, PMB 117 Gwagwalada-Abuja, Federal Capital Territory, NIGERIA.*
[b]*Department of Agricultural Economics, Faculty of Agriculture, University of Abuja, PMB 117 Gwagwalada-Abuja, Federal Capital Territory, NIGERIA.*
[c]*Prince Abubakar Audu University, Anyigba, Kogi State, NIGERIA.*
[d]*Department of Agricultural Economics and Extension Services, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai, Niger State, NIGERIA.*
[e]*Federal College of Forestry Mechanization, Afaka, Kaduna State, NIGERIA*
[*]*Corresponding Author E Mail: omotayoalabi@yahoo.com*

Geliş Tarihi/Received	Kabul Tarihi/Accepted	Yayın Tarihi/Published
10.02.2026	15.05.2026	25.05.2026

DOI: https://doi.org/10.5281/zenodo.20265618

Citation: Agbogo, R.N., Alabi, O.O., Haruna, O.E., Lawal, A.F., Danbaki, C.A. (2026). Economic Efficiency of Oil Palm Fruit Processing in Enugu and Anambra States, Nigeria. Journal of Agriculture, Food and Ecology, 4(1): 23-32.

Abstract

This research investigated economic efficiency of oil palm processing in Enugu and Anambra States, Nigeria. A multi-stage sampling technique was used to select 152 low-technology and 312 high-technology oil palm fruits processors. Primary data were used based on a well-structured questionnaire. The data were analyzed using descriptive statistics, stochastic frontier model and Probit Regression model. The results show that the years of experience, household size, years of education, age of processors, income of the processors, and access to credit facilities were the significant factors influencing the economic efficiency of low-technology and high-technology of oil palm fruit processors. The Pseudo R square value is 0.2441 and 0.1790 for low-technology and high-technology. This suggests that the model is well fitted for the two groups, however the model is well fitted of predicting the behaviour or choices within the low-technology group than the high-technology group. The average economic efficiency value obtained by the oil palm processors using low-technology was 63.8% while that of processors using high-technology was 93.6%. This implies that, on average, an individual processor using low-technology to process oil palm was able to obtain an economic efficiency of about 63.8% leaving an inefficiency gap of 36.2% that need to be filled using the existing low-technology. The processors using high-technology were able to obtain 93.6% level of economic efficiency on average basis with an inefficiency gap of 6.4% that needed to be filled using the existing available high- technology to reach the maximum level of economic efficiency in the study area. The study recommended that government should establish specialized technology upgrade credit window at low interest that will assist oil palm fruit processors transit from manual mortar and pestle methods to mechanized digesters and hydraulic presses. Modern machines can recover up to 75% of available oil, compared to only 25% - 35% with low-technology methods.

Key words: High-Technology, Low-Technology, Oil Palm Fruit, Probit Regression Model, Southeast Nigeria

1. Introduction

Oil palm (*Elaeis guineensis*) is one of the important palm trees that produces oil, which is utilized throughout the World and can be used in various ways both for food and non-food purposes. One of the major products of oil palm fruits processing is palm oil followed by palm kernels, which can be consumed or used as raw materials in industries. According to Udoh and Essien (2015), palm oil which is extracted from the fibrous layers of fresh oil palm fruits had become the largest and most essential vegetable oil produced in recent years globally. Adeniyi et al. (2014) stated that palm oil is used across the globe not limited to any geographical location and is rich in Vitamin A. Nigeria is ranked fifth among the world largest producers of palm oil but there is still shortage in palm oil production to meet the country's huge local demand. In the year 2022, the country's palm oil production was estimated at 1,300,000 metric tons (MT), while the national demand was about 2,500,000 MT per annum (CBN, 2022). However, the gap between domestic production and local demand in Nigeria as at 2022 was about 1.2 million MT with its negative implications to manufacturing industries and local consumers. Sequel to an effort to address the demand and supply gap of palm oil in Nigeria, government came up with different programmes to support the production of oil palm and enhance the yield, yet the country is spending millions of Dollars importing palm oil (Federal Ministry of Agriculture and Rural Development FMARD, 2021).

Nwalieji and Ojike (2018) reported that oil palm fruits processing techniques can be classified into four groups depending on the degree of complexity of the machinery involved. These are: the traditional methods, small-scale mechanical units, medium-scale mills and large industrial mills. Nevertheless, majority of the small-scale processors (about 80%) in developing countries still employ traditional methods of processing, which is characterized by a low level extraction efficiency of palm oil (Muzari et al., 2012, Ogunmola et al., 2019).

Oil palm fruit processing in the country is faced with many challenges irrespective of all the efforts performed by the government and private sector towards improving the processing techniques over the years (Abdul-Qadir et al., 2016).

According to Adaigho and Nwadiolu, (2018), in 1960's, Nigeria was the leading producer of palm oil in the world and the advent of crude oil exploration, and the civil war drastically reduced the production of palm oil in the country. Most smallholder oil palm fruits processors are still faced with inefficiency in their processing activities which may lead to unsustainable palm oil production, (Onyiuke, 2021).

Economic efficiency refers to the highest level of performance that uses the least amount of inputs to achieve the optimal level of output. Sanusi et al. (2022) stated that the economic significance of oil palm to our country Nigeria is food production for human consumption, source of foreign exchange earnings, supply of raw materials to industries and source of employment to the citizens. Therefore, the overall economic importance of oil palm to the Nigerian economy cannot be overemphasized. However, economic efficiency of traditional and improved oil palm fruits processing technologies can help to reduce the cost of processing, increase the level of output and maintain reasonable prices for oil palm fruits products.

Economic efficiency is the capacity of a firm to allocate scarce resources to their most valuable uses and waste are minimized. Hopkins et al. (2016) opined that an agricultural firm achieves economic efficiency when the marginal value of the inputs is equal to their respective unit costs. When the marginal value is higher, the firm can make higher profits by producing more, thereby becoming more efficient. If the marginal value is lower, the firm may decrease its production to increase its profits.

Economic efficiency in the context of oil palm fruit processing is a concept that represents the ability of a processor to maximize high-quality output while minimizing the total cost of inputs. It is formally defined as the product of technical efficiency, the capacity to achieve the maximum possible extraction of crude palm oil (CPO) from a given quantity of fresh fruit bunches (FFB) using available technology and allocative efficiency, which reflects the processor's skill in using inputs (labor, water, fuel, and fruit) in proportions that minimize costs based on prevailing market prices. In the Nigerian context, this often involves a trade-off between traditional labor-intensive methods and mechanized pressing; a process is truly economically efficient only when it operates on the stochastic frontier, meaning no more oil can be extracted without increasing costs, and no costs can be lowered without sacrificing oil quality or volume. Factors such as the oil extraction rate (OER) and the reduction of "free fatty acids" (FFA) are critical metrics, as they determine the final market value and industrial utility of the oil produced.

Phitthayaphinant and Satsue (2013) carried out research on assessing economic efficiency of oil palm production in Aoluek district, Krabi province, Thailand. The study described the socio-economic characteristics of oil palm producers and assessed the economic efficiency of oil palm production as well as investigated factors affecting economic efficiency of oil palm production in Aoluek district, Krabi province. Data were obtained from 150 oil palm producers which were selected using a simple random sampling technique. Multiple regression analysis and stochastic frontier analysis were employed during data analysis. The results revealed that most of the sampled oil palm producers were late middle-aged male with an average land holding size for oil palm plantation. The main factors that positively affected economic efficiency of oil palm production were farming experience, extension services, sources of seed and oil palm production methods while grouping for bargaining power formation significantly affected economic efficiency negatively.

Nwandu et al. (2021) carried out research on economic analysis of palm oil processing in Ndokwa-West Local Government Area of Delta State, Nigeria. The study employed multistage sampling technique to select 120 palm oil processors randomly and data were collected with the aid of well-structured questionnaire. Descriptive statistics and profit margin were used for the data analysis. The results showed that majority of the palm oil processors were female and average household size was 5 persons. The study also reported that average daily sales of palm oil processors were ₦31, 000 mean annual income was ₦1, 000,000.00 while total cost, average revenue and average profit were N49,188,150, N78,114,417.05 and N28,929,267.05, respectively.

Processing experience, credit access and household size had statistically significant effect on palm oil output in the study area. It was recommended that credit facilities should be made available to oil palm fruits processors at low interest rate in order to increase and develop production of palm oil.

Uche et al. (2017) conducted a study on economic analysis of palm oil processing in Ikwerre and Etche Local Government Areas of Rivers State, Nigeria. The study focused on palm oil processing cottage industries and multistage random sampling technique was used to collect data. Structured questionnaires were distributed as well as personal interviews were used to source data from palm oil processors. Regression analysis and gross margin analysis were employed in the analysis of data for the study. The result showed that gross margin and mark-up of the enterprises are moderate but outputs were inelastic to the inputs such as labour and capital. In other words, this shows that returns to investment are smaller than it should be, thereby concluded that production process is technically inefficient in the study area. The study recommended that improved oil extraction technology from fresh fruits to revise elasticity of oil in terms of fresh fruits use and revenue generation.

Onoja and Ogali (2015) examined economic survey of oil palm products' processing and marketing in Kogi State, Nigeria. The study was to determine the level of profitability and major problems affecting oil palm products' processing and marketing in Kogi State of Nigeria. Primary data were used for the research and were collected by the use of questionnaire and oral interviews.

Multistage sampling technique was used to select 60 respondents which were used for this study.

Descriptive statistics and gross margin analysis were used for analysis and the result showed that majority (50%) of the farmers obtained their fresh fruit bunches from the village market. It also revealed that oil palm processing and marketing is profitable business in the study area with a gross margin of N603,320.00K (USD 4,695.10) and gross margin ratio of 2.72 from a medium enterprise. It was recommended that rural infrastructure, tax reduction as well as credit access are imperative to improve oil palm processing and marketing in the study area.

The study of Nnamani and Okereke (2022) evaluated the intensity of palm fruit processing technology-use among palm fruit processors in Onicha local government area of Ebonyi State, Nigeria. The study employed purposive sampling procedure to select 58 respondents. Data were analyzed using descriptive analysis and Logit analysis. The Logit analysis indicated that marital status (-6.754), cost of labour (-0.002), level of education (2.303), and annual income (0.342) were the variables that determined technology-use.

The research of Ejike et al. (2025) focused on the economic analysis of palm fruit processing among rural farmers in Ezeagu local government area of Enugu State, Nigeria. A multi-stage stratified random sampling technique was used to select 60 respondents. Data were analyzed using descriptive statistics, and inferential tools. The results show that 35% of producers used mechanized technologies, while 65% used traditional methods. The regression result 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.

Despite the vital role of the oil palm industry in the livelihoods of rural households in Enugu and Anambra States, a significant research gap exists regarding the comprehensive economic efficiency (technical, allocative, and profit) of modern versus traditional processing methods in the face of rising operational costs. While some studies have touched on general profitability, there is a lack of recent, data-driven analysis using stochastic frontier models to quantify the specific "efficiency gap" caused by infrastructure deficits—such as the 100% lack of electricity reported by some processors and the socio-economic factors that prevent small-scale processors from transitioning from labour-intensive traditional methods to more efficient semi-mechanized systems. Furthermore, there is insufficient evidence on how specific resource constraints and land tenure issues in these specific states directly impede the maximization of oil extraction rates (OER), leaving a critical void in evidence-based policy frameworks needed to boost regional output to meet national demand.

The knowledge and empirical analysis of economic efficiency of the two major oil palm fruit processing technologies in the country is imperative in the growth and development of oil palm sector in Nigeria.

The main aim of the research is to evaluate economic efficiency of oil palm fruit processing in Enugu and Anambra States, Nigeria. Specifically, the objectives were to (i) evaluate the factors influencing economic efficiency of low-technology and high-technology oil palm fruit processing, (ii) estimate the average economic efficiency score of low-technology and high-technology oil palm fruit processing, (iii) determine the distributions of economic efficiency scores of low-technology and high-technology oil palm fruit processors.

This study was guided by the following hypothesis stated in null-form: Ho_1: There is no significant difference between economic efficiency of low-technology and high-technology oil palm fruit processing in the study area.

2. Materials and Methods

The study was conducted in Anambra and Enugu States, Nigeria. Anambra State occupies the land area of about 4,844km^2 and 70% of which is arable land. The vegetation is a tropical rainforest and major crops cultivated in the area are oil palm, rice, citrus fruits, maize, cassava among others. Enugu state has a tropical climate with its characteristic high temperature throughout the year (Okorie et al., 2021). The population of Enugu State is estimated to be about 4,411,100 and a land area of about 7,625km^2 (NPC Projection, 2016). Economically, the state is predominantly agrarian in the rural areas with substantial proportion engaged in public services. In the urban areas, trading is the dominant occupation, reasonable proportion in public services and small percentage of the population engaged in manufacturing activities. The crops that are mainly cultivated in the area are: yam, cocoyam, cassava, oil palm, rice (Ume et al., 2021). A multi-stage sampling technique was used to select the target respondents for the study. The formula of Yamane (1967) (as shown in equation 1) was used to estimate the total sample size for both low-technology and high-technology oil palm fruits processors. A total sample size of 152 low-technology oil palm fruit processors and 312 high-technology oil palm fruit processors from sample frame of 1020 were selected from the two states. The Yamane (1967) statistical formula is stated thus:

$$n = \frac{N}{1+N(e)^2} \qquad (1)$$

Where,

n = Required Sample Size,

N = Sample Frame (Number)

e = Sampling error (0.05)

2.1. Economic Efficiency Model

Economic efficiency of a firm following Latifat et al. (2013) is a combination of technical and allocative efficiencies of that firm. On the other hand, it could be described as capacity of a firm to produce a predetermined quantity of output with minimum cost at a given level of technology. Therefore, economic efficiency is the product of technical efficiency and allocative efficiency;

$$EE = TE\ X\ AE \qquad (2)$$

Where:

EE=Economic efficiency (number)

TE =Technical efficiency (number)

AE=Allocative efficiency (number)

2.2. Factors Influencing Economic Efficiency of Low-Technology and High-Technology Oil Palm Fruit Processing

The factors influencing economic efficiency of low-technology and high-technology oil palm fruit processing, using Probit Dichotomous regression model is stated below:

$$EE = \propto_0 + \propto_1 Z_{1ij} + \propto_2 Z_{2ij} + \propto_3 Z_{3ij} + \propto_4 Z_{4ij} + \propto_5 Z_{5ij} + \propto_6 Z_{6ij} + \mu_i \qquad (3)$$

Where:
EE= Economic Efficiency (dummy: 1 = If EE > 0.5, 0 = Otherwise)
Z_{1ij} = Years of oil palm fruits processing experience (years)
Z_{2ij} = Household size (number of people in the household)
Z_{3ij} = Years of formal Education (years)
Z_{4ij} = Age of processor (years)
Z_{5ij} = Income of the processor from other business or job (Naira)
Z_{6ij} = Access to loan (dummy: 1 = yes; 0 = Otherwise)
$\propto_0$ = Constant term
$\propto_1 - \propto_6$ = Parameters estimated
μ_i = Error Term

3. Results and Discussion

3.1. Factors Influencing Economic Efficiency among Low-Technology and High-Technology Oil Palm Fruits Processors

Table 1 presented the result of the maximum likelihood estimates of the Probit regression model to determine the factors influencing economic efficiency of the oil palm processors using low and high technologies in the study area. The results show that six (6) variables were statistically significant factors influencing economic efficiency for low-technology processors, while five (5) variables were statistically significant factors influencing the economic efficiency for oil palm processors using high-technology. The Pseudo R square value is 0.2441 and 0.179 for low-technology and high-technology. This denotes that the model is well-fitted for the two technology groups. The LLF (The Likelihood Function) (-20.6513 and-79.5781) are significantly different from zero at 1% probability level. This shows that the data and the specified model is of a good fit.

Years of experience in oil palm processing influenced economic efficiency for processors using low-technology and high-technology. The magnitude of the coefficient of years of experience was positive and statistically significant at 10 percent and 1 percent probability levels, respectively. The marginal effect of the years of experience for low-technology processors was 0.0598, while the marginal effect of the years of experience for the processors using high-technology was 0.0106. This implies that a unit change or increase in the years of experience in oil palm processing, while keeping all variables constant, will result in the increase in the likelihood or probability of economic efficiency to increase by 5.9% and 1.1% for processors using low-technology and high-technology, respectively. The implication of these results is that years of experience enable processors to acquire more knowledge on oil palm processing that could enhance profit maximization, which could lead to a higher chance of being economically efficient. This conforms with the findings of Haruna et al. (2021) who discovered positive relationship between years of experience and economic efficiency in Kogi State, Nigeria. They asserted that productivity is expected to increase with years of experience as experienced processors master techniques of production. This is a fact as years of experience could make them avoid previous mistakes as they are more likely to take informed decisions in order to improve productivity and profitability that will in turn increase their economic efficiency.

Household size influenced economic efficiency negatively for oil palm processors using low- technology and positively influenced economic efficiency for processors using high-technology. The marginal effects of the processors using low-technology and high-technology were 0.0246 and 0.2860, respectively. This shows that a percentage change in household membership, keeping other variables constant will result in the decrease in the likelihood or probability of the economic efficiency of the processors using traditional technology by 2.46% and increase in economic efficiency for processors using high-technology by 28.6%. The implication of this finding is that larger households for processors using low-technology could reduce their economic efficiency because more resources could be channelled for family affairs than oil palm processing activities. This finding is in line with Okello et al. (2019) who reported that household size had negative relationship with economic efficiency level in Uganda. The finding is also in consonance with Aboaba (2020), who posited that household size decreased economic efficiency of rice farmers in Ogun State, Nigeria. In the case of oil palm processors using high-technology, household size increased economic efficiency. This could be as a result of the supply of labour by the family and the money that would have been used to pay for labour is channelled to other resources which could increase economic efficiency. This is in line with Melese et al. (2019) who opined that a larger household size guaranteed availability of family labour for farm operations to be accomplished in time in Ethiopia.

Years of formal education influenced economic efficiency of the oil palm processors using low-technology positively and was statistically significant (P<0.01), while for processors using high-technology, it was also positive and significant at 1 percent probability level. The marginal effects of the years of formal education for both processors using low-technology and high-technology were 0.0050 and 0.2317, respectively. This implies that a unit change in the number of years of formal education will result in the increase in the probability level of economic efficiency for processors under low-technology and high-technology by 0.5% and 23.2% respectively. This implies that technology adoption must be paired with education to reach maximum efficiency. Processors with more education have the capacity to adopt new technologies, perceive, interpret and know how to respond to any information regarding new method of oil palm fruits processing technologies. This is in line with findings of Gela et al. (2019) who reported a positive relationship between years of schooling and economic efficiency and asserted that educated farmers were more economically efficient than uneducated ones, as education enabled them to adopt innovation in agriculture. This finding is also consistent with the results of Abdulsalam et al. (2014) who reported that oil palm processors with considerable years of education respond readily to effective decision making in agriculture productivity and likely to lead to higher levels of economic efficiency.

Age of the processors influenced economic efficiency of low-technology oil palm processors negatively and positively for processors using high-technology and it was statistically significant at 1 percent and 5 percent probability levels, respectively. The marginal effect of the age of processors using low-technology was -0.2215 and -0.1906 for processors using high-technology. This finding implied that a unit change or increase in the age of the processors, while keeping other variables constant will result in the decrease in the likelihood of economic efficiency of oil palm processors using low-technology and high-technology by 22.2% and 19.1%, respectively. This implies that as the processors advance in age their ability to achieve maximum economic efficiency decreases while younger processors have the capacity to adopt new technologies and innovations which could enhance profit maximization. This result conforms to the findings of who Osman et al. (2018) who reported indirect and significant effect of age on economic efficiencies in Ghana and asserted that older farmers were economically less efficient than younger farmers. This could be as a result of the habit of using old and traditional practices by the older ones which does not allow them to easily adopt new practices and modern technologies. This finding contradicts the work of Aboaba (2020) who asserted that age of the farmers had positive effect on economic efficiency among rice producers.

Income of the processors influenced economic efficiency of the oil processors using low-technology positively and was statistically significant ($P<0.10$). Income makes funds available for investment in oil palm processing venture enabling the processors to purchase large quantity of oil palm fruits and the required inputs which enhance profit maximization.

Access to loan facilities influenced economic efficiency of the oil palm processors using low-technology and high-technology positively and was statistically significant ($P<0.01$), respectively. Access to loan enhances the ability of the processors to purchase equipment that led to increase in economic efficiency through profit maximization. The marginal effect of the oil palm processors using low-technology and high-technology was (0.12879) and (0.4731), respectively. The implication of this finding is that a unit change in the amount of loan accessed by the processors, while keeping other variables fixed will result in the likelihood or probability of the economic efficiency of the oil palm processors to increase by 12.9% and 47.3%, respectively. This is in consonance with Idiaye et al. (2022) who posited that access to credit could enhance economic efficiency of oil palm processors in Osun State, Nigeria.

Table 1. Maximum Likelihood Estimates of the Probit Regression of Factors Influencing Economic Efficiency of Low-Technology and High-Technology Oil Palm Fruits Processing

Variable	**Low- Technology Processors**				**High-Technology Processors**			
	Coefficient	**Std Error**	**Z-Score**	**ME**	**Coefficient**	**Std Error**	**Z-Score**	**ME**
Years of Experience	0.0859*	0.0441	1.95	.0598	0.1067***	.0332	3.23	.0106
Household Size	-0.0946***	0.0876	-10.8	.0246	0.0860***	.0095	9.05	.2860
Education	0.1324***	0.0469	2.82	.0050	0.2317***	.0399	5.81	0.2317
Age of Processors	-0.0148***	.0022	-6.77	-.2215	-0.2191**	.0992	-2.22	-.1906
Income of the Processors	1.64e-07*	9.11e-	1.80	1.64e-	1.85e-*	1.34e-	1.38	1.85e-
Access to Credit Facilities	0.12879***	.0483	2.67	.12879	0.4479***	.1049	4.27	.4731
Constant	0.4528***	.0998	4.54		.4573*	.2484	1.91	
Diagnostic Statistics								
Log Likelihood	-20.6513				-79.5781			
Pseudo R^2	0.2441				0.1790			
Prob > Chi^2	0.0380				0.8207			

Source: Computed from Field Data (2024)

3.2. Distribution of Economic Efficiency Scores among Oil Palm Processors Using Low-Technology and High-Technology

The summary description of the distribution of economic efficiency scores obtained by oil palm processors using low-technology and high-technology is presented on Table 2. The analysis revealed that 21.9% of the oil palm processors using low-technology obtained 0.-0.20 level of economic efficiency while, 1.2% of the processors using high-technology attained 0-0.2 level of economic efficiency. About 49.7% and 26.3% of the traditional and improved technology processors obtained an economic efficiency score of between 61%-80%. Approximately, 10.6% of the processors using low-technology obtained an economic efficiency scores ranging from 81-100%. Majority (60.25%) of the oil palm processors using high-technology attained an economic efficiency score of 81% to 100%. The minimum economic efficiency score obtained by low-technology and high-technology processors were 0.021 and 0.041, respectively. The maximum economic efficiency level obtained by the processors using low-technology and high-technology were 88.9% and 100% respectively. The average economic efficiency value obtained by the oil palm processors using low-technology was 63.8% while that of processors using high-technology was 93.6%. This implies that, on average, an individual processor using low-technology to process oil palm was able to obtain an economic efficiency of about 63.8% leaving an inefficiency gap of 36.2% that needs to be filled using the existing low-technology. The processors using high-technology were able to obtain 93.6% level of economic efficiency on average basis with an inefficiency gap of 6.4% that needed to be filled using the existing available improved technology to reach the maximum level of economic efficiency in the study area. This result shows that oil palm processors using high-technology were more economically efficient than the processors using low-technology in oil palm fruits processing in the study area. This result is in line with the findings of Aboaba (2020) and Biara et al. (2023), who reported similar average economic efficiency in their respective studies.

Table 2. Distribution of Economic Efficiency Scores among Low-Technology and High-Technology Processors

Economic Efficiency	Low-Technology Processors		High-Technology Processors	
Score	Frequency	Percentage	Frequency	Percentage
0-0.20	33	21.85	4	1.28
0.21-0.40	16	10.60	14	4.48
0.41-0.60	11	7.28	24	7.69
0.61-0.80	75	49.67	82	26.28
0.81-1.00	16	10.60	188	60.25
Minimum	.020963		.0413287	
Maximum	.8898571		1.000430	
Mean EE	.6378131		.9359734	

Source: Computed from Field Data (2024)

3.3. Test of Hypothesis

Table 3 presents the test of hypothesis between economic efficiency of low-technology and high-technology oil palm fruit processing in the study area. The null-hypothesis was rejected because the t-calculated value is greater than t-tabulated value.

Table 3. There is no Significant Difference Between Economic Efficiency of Low-Technology and High-Technology Oil Palm Fruits Processing in the Study Area

Variable	Economic Efficiency (Values)
Traditional Processors	0.6378
Improved Processors	0.9359
Standard Deviation (Traditional)	.0111
Standard Error (Traditional)	.0091
Standard Deviation (Improved)	.314
Standard Error (Improved)	.018
t-Calculated	198.586
t-Table Critical Value	1.96

Source: Computed from Field Survey Data (2024)

Conclusion

This research investigated the economic efficiency of oil palm fruits processing in Enugu and Anambra States, Nigeria. A multi-stage sampling technique was used to select 152 low-technology and 312 high-technology oil palm fruit processors were selected. Primary data were used based on a well-structured questionnaire. Data were analyzed using descriptive statistics, stochastic frontier model, and Probit regression model. The following conclusions were based on the null-hypothesis:

Ho_1: There is no significant difference between economic efficiency of low-technology and high-technology oil palm fruit processing in the study area.

The null hypothesis that stated there is no significant difference between economic efficiencies of low-technology and high-technology oil palm fruits processing technologies in the study area was tested using t-test of difference between means statistics. The results (Table 3) revealed that there was a significant difference between economic efficiency means of oil palm fruits processors using low-technology and high-technology at 5 percent probability level. Therefore, the null hypothesis was rejected, and the alternative hypothesis was accepted. The reason for rejecting the null hypothesis was because the estimated t-value of the economic efficiency of the processors using low-technology and high-technology processing were 198.586 which is found to be greater than the t-table critical value of 1.96. The economic efficiency means of the oil palm fruits processors using low-technology and high-technology were 0.6378 (63.7%) and 0.9359 (93.6%) respectively. This implies that there was a significant difference between the economic efficiency of oil palm fruits processors using low-technology and high-technology in the study area.

Based on the findings of this research the following recommendations were made:

(i) **Mechanization of Key Stages**-Processors should transition from manual mortar and pestle methods to mechanized digesters and hydraulic presses. Modern machines can recover up to 75% of available oil, compared to only 25% - 35% with low-technology methods.

To incentivize the transition from traditional processing to high-efficiency industrial standards, the government should establish a Specialized Technology Upgrade Credit Window specifically for small and medium-scale oil palm processors. This policy should provide low-interest, long-term financing with a "performance-linked" interest rate reduction: as processors demonstrate an increase in extraction rates from the baseline 25% to the 75% modern industrial benchmark, a portion of the loan interest is subsidized or forgiven. By de-risking the capital-intensive purchase of modern hydraulic presses and automated centrifugal systems, the credit window addresses the primary barrier to entry that keeps local producers trapped in low-yield cycles. Furthermore, the policy should mandate that equipment purchased under this window includes a technical training and maintenance contract, ensuring that the 50% increase in oil recovery is not just a theoretical capability but a sustainable operational reality that bolsters national food security and reduces reliance on palm oil imports.

(ii) **Adoption of Improved Varieties**-Mills should prioritize sourcing improved varieties, which significantly increases the oil-to-fruit ratio.

(iii)**Formation of Processing Cooperatives**- Individuals smallholder often lack the capital for high-technology mills. By forming cooperatives, they can pull resources to purchase integrated continuous digesters screw presses (DSP) and share maintenance costs.

(iv) **Waste Valorization**-Efficiency can be improved by selling or re-using by-products. Fiber and shells should be utilized as fuel for the boiling/sterilization process to reduce firewood costs, while palm kernel cake can be sold to the livestock feed industry.

(v)**Extension Services**-Deploy agricultural extension officers to train processors on modern sterilization and clarification techniques to ensure the production of oil which commands higher prices.

(vi) **Rural Road Maintenance**- Invest in farm-to-market roads to reduce the high transportation costs of fresh fruits bunches which currently eat into processors margins

(vii) **Rural Electrification**-Support the establishment of agro-processing zones with stable power, as electricity is a major bottleneck for the transition to fully automated mills.

Ethics approval:

Not applicable

Conflict of interest:

The authors declare no competing interests.

Authors' contributions:

Corresponding author: O. O. A.; conceptualization: R. N. A., O. O. A., O. E. H., A. F. L., C. A. D.; investigation: R. N. A., O. O. A., O. E. H., A. F. L., C. A. D.; data analysis: R. N. A., O. O. A., O. E. H., A. F. L., C. A. D.; writing original draft: R. N. A., O. O. A., O. E. H., A. F. L., C. A. D.; writing -review and editing: R. N. A., O. O. A., O. E. H., A. F. L., C. A. D.; supervision: R. N. A., O. O. A., O. E. H., A. F. L., C. A. D.;

Data availability statement:

All data generated or analysed during this study are included in this published article. The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

References

Abdul-Qadir, M. I., Okoruwa, V. O. and Salman, K. K. (2016). Competitiveness of oil palm production system in Nigeria: Apolicy Analysis Matrix Approach. *International Journal of Hybrid Information Technology*, 9(5), 231-250.

Aboaba, K. O. (2020). Economic efficiency of rice farming: a stochastic frontier analysis approach. *Journal of Agribusiness and Rural Development,* 4(58), 423-435. http://dx.doi.org/10.17306/J.JARD.2020.01377.

Abdulsalam, Z., Nandi, J. A. and Ahmed, B. (2014). Technical Efficiency Differentials in Oil Palm Processing Technologies in Cross River State, Nigeria. *The Journal of Agricultural Sciences,* 9(3), 109-116. http://dx.doi.org/10.4038/jas.v9i3.7424.

Adaigho, D. and Nwadiolu, R. (2018). Adoption of Recommended Palm Oil Processing Technology in Isoko North Local Government Area, Delta State, Nigeria. *Asian Journal of Agricultural Extension, Economics and Sociology*, 24(1), 1-8.

Adeniyi, O. R., Ogunsola, G.O. and Oluwusi D. (2014). Methods of palm oil production in Ogun State, Nigeria: A resource use efficiency assessment. *American International Journal of Contemporary Research*, 4(8), 173-179. https://doi.org/10.9734/AJAEES/2018/39987.

Biara, E., Mezgbu, A., Adugnaw, A. and Habtamu, M. (2023). Sources of Wheat Production Technical Inefficiency Among Smallholder Farmers in Northern Ethiopia: Beta Regression Approach, *Congent Economics and Finance*, 11, 12208895. https://doi.org/10.1080/2332039.2023.2208895.

CBN (2022). Central Bank of Nigeria (CBN)'s Proactive Intervention in Oil Palm Development written by James Emejo. This day Publication, 3rd May, 2022.

Ejike, O. S., Victor, A. E and Okorokwo, F. C. (2025). Economic Analysis of Palm Fruit Processing among Rural Farmers in Ezeagu Local Government Area of Enugu State, Nigeria. Agricultural Science and Processing, 2 (3), 133-141. http://dx.doi.org/10.62762/ASFP.2025.271322

Gela, A., Haji, J., Ketema, M. and Abate, H. (2019). Technical, allocative and economic efficiencies of small-scale sesame farmers: the case of west Gondar zone, Ethiopia. Review of Agricultural and Applied Economics, 22(2), 10-17.

Haruna, E. O. Felix, O. O., Ameh, O. E. and Gold, O. O. (2021). Gender Analysis in Economic Efficiency of Rice Farmers in Kogi State, Nigeria. International Journal of Agricultural Economics, Management and Development, 9(2), 140-153.

Hopkins, J., Reardon, T. and Crawford, E. W. (2016). Climate Change and Crop Choice in Zambia: A Mathematical Programming Approach. NJAS-Wageningen Journal of Life Sciences, 81, 19-31.

Idiaye, C. O., Owolabi, T. O. and Oluwatayo, I. B. (2022). Profit Efficiency of Palm Oil Processing in Osun State, Nigeria. European Journal of Economics, Law and Social Sciences, 6(1), 236-250.

Latifat, L.W., Ogbaji I. E. and Ocholi A. (2013). Technical and Allocative Efficiency of Palm Oil Processing in Benue State, Journal of Sustainable Development in Africa, 15(6), 153-169

Melese, T., Alemu, M., Mitiku, A. and Kedir, N. (2019). Economic Efficiency of Smallholder Farmers in Rice Production: The Case of Guraferda Woreda, Souther Nations Nationalities People's Region Ethiopia. International Journal of Agriculture Innovation and Research, 8(2), 1-17.

Muzari, W., Gatsi, W. and Muvhunzi, S. (2012). The Impacts of Technology Adoption on Smallholder Agricultural Productivity in Sub-Saharan Africa: A Review. Journal of Sustainable Development, 5(8), 69-77.

Nnamani, N. G. and Okereke, O. (2022). Intensity of Palm Fruit Processing Technology-Use among Palm Fruits Processors in Onicha Local Government Area of Enugu State, Nigeria. Agro Science Journal of Tropical Agriculture, Food, Environment and Extension, 21 (4), 63-68. https://dx.doi.org/10.4314/as.v2li4.10

Nwandu, P. I., Ike, P. C., Okenye, P. C. and Onwuaroh, A. S. (2021). Economic Analysis of Palm Oil Processing in Ndokwa-West Local Government Area of Delta State, Nigeria. Dutse Journal of Pure and Applied Sciences, 7(2), 1-9.

Nwalieji, H. U. and Ojike, H. U. (2018). Characteristics of Small Scale Palm Oil Production Enterprise in Anambra State. Journal of Agricultural Extension, 22(1), 22-34.

Ogunmola, O. O., Oyawole, F. P. and Oladele, B. O. (2019). Evaluating the Effects of Adoption of Improved Processing Technologies on Technical Efficiency of Palm Oil Processors in Ogun State, Nigeria. FUDMA Journal of Sciences, 3(4), 190-200.

Onoja, A. O and Ogali, T. U. (2015). Economic Survey of Oil Palm Products' Processing and Marketing in Kogi State, Nigeria. Consilience, (13), 336-345. https://www.jstor.org/stable/26427287

Onyiuke, J. (2021). Stakeholders' Workshop on Oil Palm for South Eastern Region of Nigeria by Federal Ministry of Agriculture and Rural Development. www.independent.ng. Retrieved on 15th July, 2022.

Phitthayaphinant, P. and Satsue, P. (2013). Assessing Economic Efficiency of Oil Palm Production in Aoluek district, Krabi province, Thailand. Journal of Agricultural Technology 9(7), 1677-1690

Sanusi M. M., Idowu S. D., Akerele D. and Olabode T. S. (2022). Economic Analysis of Palm Oil Processing in Odogbolu Local Government Area, Ogun State, Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension, 21(2), 1301-35.

Uche, C., Etowa, E. B. and Anele, P. C. (2017). Economic Analysis of Palm Oil Processing in Ikwerre and Etche Local Government Areas of Rivers State, Nigeria. Applied Tropical Agriculture, 22 (1), 5-8.

Udoh, O. S. and Essien, B. S. (2015). Palm Oil Processing and Marketing and Sustainable Livelihood in Rural Communities of Akwa Ibom State, South-South, Nigeria. Department of Sociology and Anthropology University of Uyo – Akwa Ibom State, Nigeria. Journal of Business and Management, 17(10), 43-50.

Yamane, T. (1967). Statistic: An Introduction Analysis, 2nd Edition Haper and Row, New York. Happer and Raw.