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Technical efficiency of traditional and improved oil palm fruit processing in Enugu and Anambra States, Nigeria

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Abstract

This study investigated technical efficiency of traditional and improved oil palm fruits processing in Enugu and Anambra States, Nigeria. A multi-stage sampling technique was used to select 464 oil palm fruit processors. Primary data were collected via well-structured questionnaire. The data were analyzed using descriptive statistics, and stochastic production frontier model. The result shows that the mean age, years of school attendance, and household sizes for traditional oil palm fruits processors were 40 years, 10 years, and 7, respectively. The mean age, years of school attendance, and household sizes for improved oil palm processors were 43 years, 12 years, and 7, respectively. In the technical efficiency component, the significant factors influencing the output in litres of traditional and improved oil palm fruits processed include quantity of oil palm fruits, quantity of water, quantity of firewood/fuel, capital inputs, and labour use. The age, household size, access to loan facilities were significantly from zero in influencing the technical inefficiency of traditional and improved oil palm fruits processing, while years of experience significantly influence the technical inefficiency of traditional oil palm fruits processing. The mean technical efficiency scores of traditional and improved oil palm fruits processors were 0.8270 and 0.8718, this leaves 17.3% and 12.82% for improvement. The study recommended that oil palm fruit processors organize themselves into cooperative groups or clusters to enable them to access improved processing equipment directly from manufacturers and to process for their members at low cost.

Keywords: stochastic production frontier model, technical efficiency, oil palm fruits processing, traditional, improved, seeds, Nigeria

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 as well as used as raw materials in industries, biofuel and feedstock (Woittiez et al., 2017). Palm oil is extracted from the fibrous layers of fresh oil palm fruits and has become the most essential and widely produced vegetable oil globally in recent years (Udoh &

Essien, 2015). The products of the oil palm fruits processing could be used in the manufacturing of soap, vegetable oil, margarine, candles and many other products (Agwu et al., 2017). Nwalieji & Ojike (2018) observed that oil palm serves as a source of income, food security and livelihood to the rural farmers and other stakeholders in the value chain. According to Central Bank of Nigeria, CBN (2022), Nigeria was overthrown as the world's largest palm oil producer in 1966 from its vantage position as the leading exporter of

palm oil to a net importer of the produce, depending largely on other countries to meet its domestic demand over the years. With a production of 1.3 million metric tons of palm oil Nigeria is the fifth-largest producer of palm oil in the world and the top producer in Africa.

According to Onu et al. (2022), there are two (2) major methods of oil palm fruits processing in Nigeria namely traditional and improved methods. Salius et al. (2016) detailed the various operations involved in the traditional technology, the fresh fruits bunches (FFB) are systematically cut up, heaped and left for a night or two for easy removal of fruits from spikelets. The fruits are boiled for some time, pounded in a mortar or drenched with feet in a canoe-like vessel which is made of wood or mold. Water is added, extraction and separation are done by hands, the processor collects the crude oil in a container until the operation is finished. The collected crude oil is boiled in the pot for about half an hour and the clean edible oil then settles on the surface, while the unclean oil remains at the bottom of the pot. Modern (improved) method ranges from the use of simple machines that presses oil to the use of sophisticated palm oil mills in processing fresh fruit bunches (FFB) into its products (Ogunmola et al., 2019). Oil palm processing mills have various operations designed as follows: sterilization, stripping, digestion, crude oil extraction, clarification, kernel extraction. However, small-scale processors mostly use the traditional method, while large scale processors use modern methods (Soyebo et al., 2005).

Majority of the small-scale processors (about 80%) in developing countries still employ traditional methods of processing, which is characterized by low level extraction efficiency of palm oil (Muzari et al., 2012, Ogunmola et al., 2019., Onyiuke, 2021). Currently, the gap between domestic demand and supply of palm oil in Nigeria is increasing and at about 1,250,000MT per annum (CBN, 2022).

Technical efficiency as defined by Lawal et al. (2013) and Dube et al. (2018) is the maximization of ratio of output to factor inputs, hence it measures the quantity of the physical ratio of processing output to quantity of inputs without taking into consideration the prices of the inputs and output. An efficient oil palm fruits processing technology implies that resources are combined in a way that gives maximum efficient product from available resources and this will guarantee sustainable output of oil palm fruits processing (Ogunmola et al., 2019).

Objectives of the study

The aim of the study is to evaluate the technical efficiency of traditional and improved oil palm fruits processing in Enugu and Anambra States, Nigeria. Specifically, the objectives were: (1) describe the socio-economic characteristics of traditional and improved oil palm fruits processors, (2) evaluate factors influencing the technical efficiency and inefficiency of both technology groups, (3) determine the technical efficiency scores of traditional and improved oil palm fruits processors

Hypothesis of the study

This study is guided by the following hypothesis stated in null-form: H_{01} : There is no significant difference between technical efficiency of traditional and improved oil palm fruit processors

MATERIALS AND METHODS

This study was conducted in Enugu and Anambra States, Nigeria. The two states are predominantly known for oil palm processing and they are in the southeast region of Nigeria. A multi-stage sampling technique was used to select sample size of 464 respondents which comprises of 152 traditional and 312 improved oil palm processors.

In stage one, two agricultural zones were purposively selected from each state because of the predominance of oil palm production and processing in the place. Therefore, in Enugu State, Nsukka and Awgu Agricultural Zones were selected, while in Anambra State, Onitsha and Aguata Agricultural Zones were selected. Second stage, two local government areas notable for oil palm production and processing were also purposively selected from each selected agricultural zone. In Nsukka Agricultural Zone of Enugu State, Igbo-Eze South and Udenu Local Government Areas (LGAs) were selected, while in Awgu Agricultural Zone, Oji River and Aninri LGAs were selected. In Onitsha Agricultural Zone of Anambra State, Ekwusigo and Ihiala LGAs were selected, while in Aguata Agricultural Zone, Nnewi South and Orumba North LGAs were selected.

Third stage, three (3) communities were randomly selected from each selected local government area thus: In Igbo-Eze South, Nkalagu-Obukpa, Itchi, and Ovoko Communities were selected for the study, while in Udenu LGA, Umundu Orba, Obollo Etiti, and Imilike-Uno were selected. In Oji River; Achi, Akpugoeze, and Inyi Communities were selected, while in Aninri; Nenwe, Mpu, and Oduma Communities were selected. In Ekwusigo LGA, Oraifite, Ozobulu and Ubulu Uno were selected while in Ihiala LGA, Azia, Isseke and Amorka Communities were selected. In Nnewi South LGA, Amichi, Osumenyi and Ebenator Communities were selected, while in Orumba North LGA, Okoh, Ajali and Ufuma Communities were selected making a total of twenty-four (24) communities. In the fourth stage, 70% proportionate of the number of traditional and improved oil palm fruits processors were employed. In line with this, Yamane (1967) statistical formula (as shown in equation 1) was used to estimate the total sample size for both traditional and improved oil palm fruits processors.

A total sample size of 76 traditional oil palm fruit processors (sample frame of 148) and 161 improved oil palm fruit processors from sample frame of 544 (Enugu State ADP, 2023) were selected from Enugu State. A total sample size of 76 traditional oil palm fruit processors (sample frame of 149) and 151 improved oil palm fruit processors (sample frame of 476) was selected from Anambra state (Anambra State ADP, 2023) making a total sample size of 464 oil palm fruit processors.

Primary data were used for the study and it was collected with the aid of a well-structured questionnaire. The instrument for data collection focused on such information as socio-economic characteristics of the respondents, cost of labour and type, cost of water, firewood or gas. Other costs such as cost of capital items like digesting machine, pulp pressing machine, nut cracking machine, local digesting vessel, pots, tanks, wheel barrow as well as life span of each equipment's etc. Reliability for this research was carried out by giving a group of oil palm fruits processors samples of questionnaire at different periods of time. The items in the questionnaire were included in the reliability test and it was conducted separately for traditional and improved processors. The questionnaire was pre-tested on selected oil palm processors to evaluate the appropriateness of the design, relevance, and clarity of the questions. The appropriate corrections were made on the pre-tested questionnaire in order to capture the relevant data required to achieve the objectives of the study, questions that proved vague or ambiguous, attracted additional corrections on the questionnaire to ensure its appropriateness, and reliability. The results from the instrument were found to be similar each time it was given and test-retest reliability was estimated with correlations between the scores. Internal consistency of the questionnaire was examined and the result of the reliability test gave a Cronbach's alphas of 0.948 (94.8%) in each case. The Cronbach's alpha coefficient for the variables (0.948,

94.8%), suggesting that the factors included in the research instrument had relatively high internal consistency and highly reliable for the analysis. This indicates that about 94% of the variance in the score is reliable variance. This result implies that data collected from the study area was valid and reliable. The lowest acceptable level of the reliability correlation coefficient is 0.70 (Sugiyono, 2010). Cronbach’s alpha ranges from 0 to 1. A reliability coefficient of 0.70 or higher is considered acceptable reliability (Bolarinwa, 2015). The questionnaire was validated by the team of experts, professionals in the field and appropriate reliability test was conducted.

$$\alpha = \frac{N\bar{X}}{\bar{Y}+(N-1)\bar{X}} \quad (1)$$

Where: α = Cronbach’s Alpha, N = Number of variables, \bar{Y} = Average variance, \bar{X} = Average inter-item covariance among the variables The Yamane (1967) statistical formula of estimating sample size is stated thus:

$$n = \frac{N}{1+N(e)^2} = 464 \quad (2)$$

Where: n = Required Sample Size, N = Sample Frame (Number), e = Sampling error (0.05)

Data were analyzed using descriptive statistics and stochastic frontier production model.

Stochastic production efficiency frontier model (SPEFM)

According to Alabi et al. (2022), the SPEFM is stated as follows:

$$Y_i = f(X_i, \beta_i)e^{v_i-u_i} \quad (3)$$

$$\ln Y_i = \beta_0 + \sum_{i=1}^4 \beta_i \ln X_i + \dots \beta_n \ln n + V - U_i \quad (4)$$

Technical efficiency (TE_i) was be estimated as follows:

$$TE_i = \frac{Y_i}{Y_i^*} \quad (5)$$

$$TE_{ij} = \frac{F(X_i, \beta) \exp(v_i - u_i)}{F(X_i, \beta) \exp(v_i)} \quad (6)$$

$$TE_{ij} = \exp(-u_{ij}) \quad (7)$$

where: Y_i = output of traditional and improved oil palm fruits processing (litres); Y_i^* = unobserved frontier output of traditional and improved oil palm fruits processing (litres); X_i = vectors of variable inputs; β_i = vectors of estimated parameters; V_i = random errors in rice output; U_i = error term which is due to technical inefficiency; X_1 = quantity of oil palm fruits per processing cycle (kg); X_2 = quantity of water (litres); X_3 = quantity of firewood/fuel (kg); X_4 = capacity of physical or capital asset (quantity in kg of fresh fruit bunches per pot or per machine hour); X_5 = labour use (mandays)

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 \quad (8)$$

where: Z_1 = age of processors (years); Z_2 = years of formal education (years); Z_3 = years of experience (years); Z_4 = household size (number); Z_5 = access to credit facilities (1, access; 0 = otherwise); α_0 = constant term; $\alpha_1 - \alpha_5$ = estimated parameters; U_i = error term due to tie

RESULTS AND DISCUSSION

Descriptive statistics of traditional and improved oil palm fruits processors

Table 1 shows that majority (74.3%) of the sampled oil palm fruits processors using traditional technologies were female and 25.7% were male processors, while 44.6% of the sampled oil palm fruits processors using improved technology were female and 55.4% were male. This indicated that oil palm fruits processing using traditional technology is being dominated by female processors, while most of those using improved technology were male processors. This result is in agreement with the findings of Nwalieji & Ojike (2018) who reported that 74.2% of the female participated in oil palm fruits processing in Anambra State, Nigeria and noted that women in the sampled communities were responsible for sales of oil palm produce. Also, the study revealed that 56.6% and 47.1% of the sampled oil palm fruits processors using traditional and improved technologies were married.

Table 1. Descriptive statistics of traditional and improved oil palm fruits processors

S/N	Variables	Unit of Measurement	Traditional	Improved
1	Gender	% Male	25.7	55.4
2	Marital status	% Married	56.6	47.1
3	Mean age	Years	40	43
4	Mean years of school attendance	Years	10	12
5	Mean household size	Number	7	7
6	Processing experience	Years	14	11

Source: Computed from field survey data, 2024

Factors influencing technical efficiency of the oil palm fruits processors using traditional and improved technologies

The average age of the sampled processors using traditional technology and improved technology were 40 years and 43 years, respectively. This finding shows that the oil palm fruits processors using both traditional and improved technologies were still young processors, active and energetic in their age of productivity, and they can adopt technology easily. This finding is in consonance with the findings of Ibitunde et al. (2023) who posited that majority of the oil palm processors were within the age of 26-50 years. The average years of schooling attained by the sampled processors using traditional and improved technologies were 10 years and 12 years, respectively. This implies that on average the processors attained secondary school level of formal education which could enable them to read and write, to keep records and also enable them to adopt new innovations and technologies. This is also in line with the findings of Ibitunde et al. (2023) who reported that oil palm processors in Osun State, Nigeria had at least one form of education, implying that they may have the technical know-how to apply modern processing techniques and may be ready to adopt technology or innovations that can improve their oil palm fruits processing standard that could lead them to earn higher profit. The average household size of the sampled oil palm processors using traditional and improved technology is 7 persons per household. Furthermore, the average oil palm fruits processing experience of the sampled processors using traditional technology was 14

years, while those using improved technology had 11 years’ experience in oil palm fruits processing. Experience enables processors to acquire knowledge and technical know-how on the processing processes that could make them maximize profit. This is in conformity with the findings of Oga & Oga (2022) who reported 14 years of oil palm processing experience for processors in Afikpo North Local Government Area of Ebonyi State, Nigeria.

The results of the maximum likelihood estimate of the production function frontier for oil palm processors using traditional and improved technologies are presented in Table 2. The variance parameters reveal important model diagnostics. The total variance (σ^2) of 0.3938955 and 0.145365 for traditional and improved processors were significant at 1% probability level, confirming the suitability of the stochastic frontier framework over an ordinary least squares model. These values confirm that there is a significant gap between the actual output of the traditional and improved processors with the maximum possible output (the frontier). This explains how much of the production shortfall in traditional and improved oil palm fruit processing is due to the processors’ own mistakes and the factors they cannot control. It is the sum of random noise and technical inefficiency for the traditional and improved oil palm fruit processors, random noise includes factors like bad weather, machine breakdown, sudden fruit spoilage, or measurement error, technical inefficiency include factors like poor processing techniques,

mistakes, poor resource management, lack of experience, and wastage during stripping. The lower value of sigma square for improved processors ($\sigma^2=0.145365$) indicate a much more stable production environment, improved technologies such as hydraulic press, automated digesters standardize the process leading to more predictable output and less overall variance. The Lambda of 0.737521 and 0.814431 for traditional and improved processors indicate that approximately 73.75 and 81.44 percent of total output variation was due to technical inefficiency, rather than random noise for traditional and improved processors, respectively. This suggests that technical inefficiency like human error and poor methods contributes more to the variation in oil palm output than random external shocks. This shows that traditional and improved processors could significantly increase their oil yield by improving their management or technical skills, even without changing their basic equipment. If Lambda is greater than zero, it justifies the use of the stochastic frontier model over a standard ordinary least squares regression. The improved processors have a higher Lambda (0.814) than the traditional ones (0.737), this suggests that for improved processors, a larger proportion of the total variation in output is due to failure to use the technology correctly (technical inefficiency) rather than random external factors, with the improved technology. The difference between the best processors and the average processors can be attributed to skill and management. The log-likelihood values of 92.024808 and 81.29778 for traditional and improved processors, respectively, further indicates satisfactory model fit.

The results show that the quantity of oil palm fruits influenced the total output of palm oil produced (in litres) for processors using traditional and improved technologies positively and was statistically significant ($p < 0.01$). The coefficients of the quantities of oil palm fruits for traditional and improved technologies were 0.6625 and 0.1567,

respectively. This implies that one percentage increase in the quantity of oil palm fruits processed while holding other variables constant will result in the increase in the total output of palm oil produced in litres for traditional and improved technologies by 66.3% and 15.7%, respectively. The more quantities of oil palm fruits processed the more likelihood of increase in the total output of palm oil. This is in line with the findings of Abdulsalam et al. (2014) who reported positive influence of the fresh palm oil fruits on total output of palm oil for traditional and improved technologies in Cross River State, Nigeria.

Quantity of water influenced palm oil output in litres for traditional and improved technologies positively and it was statistically significant at 1% probability level. The coefficient of the quantity of water for traditional processors was 0.2097 and 0.4938 for those using improved technology. This shows that a percentage change in the quantity of water used by the processors, keeping other variables constant, will result in the increase in the palm oil output in (litres) for processors using traditional and improved technologies by 20.9% and 49.3%, respectively. This finding is contrary to the findings of Lawal al. (2013) who indicated that the quantity of water did not significantly influence on the output of palm oil in Benue State, Nigeria.

Quantity of firewood/fuel influenced palm oil output positively for oil palm processors using traditional technology and negatively for processors using improved technology but they were statistically significant ($P < 0.01$). The elasticities of the quantities of firewood/fuel for processors using traditional and improved technologies were 0.2390 and -0.1607, respectively. This indicates that a percentage change in the quantity of firewood /fuel used by processors keeping other variables constant will result in the increase in the total output of palm oil in litres by 23.9% for the processors using traditional technology and decrease in the palm oil output by 16.1% for processors using

improved technology. This is due to higher cost of diesel fuel per litre than the firewood cost, also the diesel fuel might not be easily available. In general, diesel fuel is utilized in improved technology, while firewood is utilized in traditional technology.

Capacity of physical or capital assets influenced total output of palm oil in litres for processors using traditional technology positively and it was statistically significant at 1% probability level. It was also statistically significant at 1% probability level for processors using improved technology. The magnitude of the coefficient of capital for processors using traditional technology was 0.3065 while the coefficient of the capital input for oil processors using improved technology was 0.3349. This indicates that a percentage change in the amount of capital used in oil palm fruits processing keeping other variables fixed will result in the increase in palm oil (litres) by 30.7% for processors using traditional technology and 33.5% increase in oil output for processors using improved technology. Capital has the capacity to enable processors to purchase processing equipment required which could enable them to operate at larger scale that might make them to earn more profit. This is in line with the findings of Lawal et al. (2013) who posited that increased amount of capital resulted to increased output of palm oil in Benue State, Nigeria.

Labour inputs influenced total output of palm oil in liters for traditional and improved technologies processors positively and was statistically significant at 1% probability level. The magnitude of the coefficient of labour for processors using traditional and improved technologies were 0.8852 and 0.3694, respectively. This implies that a percentage change in the supply of labour while keeping other variables fixed will result in the increase in the total output of palm oil processed by 88.5% and 36.9% for the two categories, respectively. Labour increases as a result of expansion in operational size which will

eventually lead to increase in the total output. This result aligns with the study of Takele & Selassie (2018), who reported that the intrinsic dedication and shared commitment within family labour, contributed significantly to overall production efficiency. The finding is also in line with Obokare et al. (2024) who suggested that an increase in number of labour supply will significantly contributes to enhanced production output of oil palm output and technical efficiency level.

The technical inefficiency components revealed that 4 variables were statistically significant for the oil palm processors using traditional technology and 5 variables for processors using improved technology. The negative sign of the coefficient of the variables implies increase in the technical efficiency, while the positive sign signifies decrease in technical efficiency in oil palm fruit processing.

Age of the processors influenced technical inefficiency of the oil palm processors using traditional technology negatively and positively for processors using improved technology and it was statistically significant at 1% probability level. The coefficient of age of processors using traditional and improved technologies were -0.1888 and 0.5172, respectively. This implies that a percentage change or increase in the age of oil palm processors using traditional technology, keeping other variables constant, will result in the increase in technical efficiency by 18.8% while a percentage increase in the age of processors using improved technology, keeping other variables fixed will lead to decrease in technical efficiency by 51%. The implication of this result is that older processors using traditional technology were more efficient than the younger ones. This could be because older processors had more experience than the younger processors, while younger processors using improved technology were more efficient than older processors because the younger processors can easily adopt innovations or new technologies. The older processors with their wealth of experiences are more accustomed or

used to traditional technology and may not be easily amenable to change or adopt new technology. This is in consonance with the findings of Iwala et al. (2006) who reported positive contribution of age to technical inefficiency for processors using improved technologies. This is understandable because older farmers would not only possess lesser vigour for supervision but also very few of them believed in the imperatives of adopting new or improved technologies.

Years of formal education influenced technical inefficiency for oil palm processors using improved technology negatively and it was statistically significant ($P < 0.05$). The magnitude of the coefficient of the years of formal education was -0.0717 . This shows that a percentage increase in the number of years of schooling pursuing formal education, keeping other variables fixed will result in the decrease in technical inefficiency and increase in technical efficiency of the processors using improved technology by 7.2%. Education status plays a very important role in influencing the processors to adopt new technologies. This conforms to the finding of Ishiaku et al. (2017) who reported that educational level influenced technical efficiency of rice processors that used improved technology positively in Nasarawa State, Nigeria.

Years of experience influenced technical inefficiency for oil palm fruits processors using traditional and improved technologies negatively and was statistically significant at 10 percent and 1% probability levels, respectively. The coefficient of the years of experience in processing oil palm fruits was -0.1186 for processors using traditional technology and -0.3546 for processors using improved technology. This indicates that a percentage change or increase in the years of experience in oil palm fruits processing while keeping other variables constant, will result in the increase in technical efficiency for oil palm fruits processors using traditional and improved technologies by 11.86% and 35.46%,

respectively. Experience acquired over the years by the processors will enable them acquire some specific technical know-how in oil palm fruits processing that could enable them to achieve higher technical efficiency in utilizing their available resources to maximize profit. This is in line with the findings of Nwahia et al. (2020) who reported that farmers with more experience in agricultural productivity tended to be more technically efficient than those that has lesser farming experience.

Household size influenced technical inefficiency of oil processors using traditional technology negatively and positively for processors using improved technology and it was statistically significant at 1% probability level. The coefficients of household size were -0.0461 and 0.4911 for processors using traditional and improved technologies, respectively. This implies that a percentage change or increase in the number of persons per household, keeping other variables fixed, will result in the increase in technical efficiency for processors using traditional technology by 4.6% and decrease in technical efficiency of the processors using improved technology by 49.1%. The implication of these results is that as number of households labour for oil palm fruits processing increase, there will be a cost saving for hiring labour by processors using traditional technology. This could be because more resources could be diverted to other uses like payment of school fees for children and feeding. This result is also consistent with the finding of Okello et al. (2019) who asserted that larger number of persons in a household could lead to decrease in technical inefficiency in the sense that available resources may be diverted for solving family problems rather than farm activities.

Access to loan facilities influenced technical inefficiency negatively for processors using traditional and improved technologies and was statistically significant ($P < 0.10$) and ($P < 0.01$), respectively.

Table 2. Maximum likelihood estimates of the stochastic production frontier of oil palm fruits processors

Variable	Traditional technology			Improved technology		
	Coefficients	Std Error	Z-Score	Coefficients	Std Error	Z-Score
Palm oil output, Liters						
Quantity of oil palm fruits	.6625411***	.0754079	8.77	.1567467***	.0487545	3.22
Quantity of water	.2097449**	.0844607	2.48	.4938132***	.0589061	8.38
Quantity of firewood/fuel	.2390072***	.0675918	3.54	-.1607379***	.0449845	-3.57
Capacity of asset	.306564**	.0735038	4.17	.334952***	.0494302	-6.78
Labour use	.8852032***	.1392342	6.35	.3694654***	.0752335	4.91
Constant	.3261496	.4025453	0.81	1.432466***	.2649596	5.41
<i>Technical inefficiency model</i>						
Age of Processors	-.188842***	.0331932	-5.69	.5172212***	.0194213	2.67
Years of Formal Education	-.0003171	.0067715	-0.05	-.0717502**	.0353931	-2.03
Years of Experience	-.0118554*	.0063855	-1.86	-.3546321**	.0466923	-7.59
Household Size	-.046139***	.0123862	-3.73	.491123***	.0952371	5.16
Access to Loan Facilities	-.2885521*	.1546489	-1.87	-.041054***	.0062651	-6.55
<i>Diagnostic Statistics</i>						
Log likelihood	-92.024808			-81.29778		
Sigma square	.3938955			.145365		
Lambda	.737521			.814431		

Source: Computed from field data, 2024

Legend: ***, **, * - Significant at 1%, 5% and 10% Probability Levels

The coefficients of access to loan facilities for the oil palm fruits processors using traditional and improved technologies were -0.2886 and -0.0411, respectively. This implies that as the likelihood of processors that have access to loan facilities increases, keeping other variables fixed, will result in the increase in technical efficiency of the processors using traditional technology by 28.9% and 4.1% for the oil palm fruits processors using improved technology. This result is in line with the findings of Nwandu et al. (2021) who reported that access to credit influenced technical efficiency of palm oil production in Ndokwa-West Local Government Area of Delta State, Nigeria. When credit was readily available to the processors, their productivity increased, vice versa. The finding also agreed with Ekwere & Edem (2014) who asserted that access to credit enabled farmers to attain maximum technical efficiency if appropriately harnessed.

Distribution of technical efficiency scores among processors using traditional and improved technologies

Table 3 presents the distribution of the technical efficiency scores among the oil palm processors. The results show that 54.6% of the oil palm processors using traditional technology obtained technical efficiency ranging between 0.61-0.80 while, 29.5% of the oil processors using improved technology fell within the same range. About 16.3% of the traditional processors obtained technical efficiency from 0.81-1.00 while majority (69.5%) of the oil palm fruits processors using improved technology obtained technical efficiency from 0.81-1.00. The minimum and maximum values of technical efficiencies obtained by processors using traditional technology were 0.2414 and 0.9911 while the minimum and maximum values of technical efficiencies obtained by processors using improved technology were 0.2487 and 1.00, respectively. The mean technical

efficiency obtained by oil palm processors using traditional technology was 82.7% while the oil palm processors using improved technology obtained technical efficiency of about 87.2%. This revealed that the oil palm processors attained a commendable level of technical efficiency but there existed a gap that require to be filled to obtain maximum technical efficiency using the existing technologies by the best performing processors. This finding agrees with Obokare et al. (2024) who reported 95% average technical efficiency of oil palm processors in Delta State, Nigeria. They asserted that oil palm processors maintained a commendable high level of operational efficiency. The mean technical efficiency index also signifies the potential for an average palm oil processor using traditional and improved technologies to enhance technical efficiency by 17.3% and 12.82%, respectively. This is in line with the findings of Anyaoha and Zhang (2023) who reported that there existed a potential for

increasing the level of technical efficiency among palm oil processors. Other studies on technical efficiency by Ahmed and Melesse (2018) and Aboaba et al. (2020) also reported similar results.

Test of hypothesis

The result of test of hypothesis is presented in Table 4. The null-hypothesis which state that there is no significant difference between technical efficiencies of traditional and improved oil palm fruits processing technologies in the study area was tested using t-test difference between mean statistics (Table 4). The results show that there was a significant difference in technical efficiencies between traditional and improved oil palm fruits technologies at ($p < 0.05$) probability level. Therefore, the null hypothesis was rejected and the alternative hypothesis accepted.

Table 3. Summary statistics of the distribution of technical efficiency score among processors using traditional and improved technologies

Technical efficiency <i>Score</i>	Traditional technology processors		Improved technology processors	
	<i>Frequency</i>	<i>Percentage</i>	<i>Frequency</i>	<i>Percentage</i>
0.21-0.40	5	3.29	7	2.24
0.41-0.60	39	25.66	10	3.21
0.61-0.80	83	54.61	78	25.00
0.81-1.00	25	16.45	217	69.55
Minimum	.2414332		.2487962	
Maximum	.9911989		1.000430	
Mean TE	.8269772		.8717681	

Source: Computed from field data, 2024

Table 4. Estimated parameters for the assessment of technical efficiency

Variable	Technical efficiency (Values)
Traditional processors	0.826
Improved processors	0.872
Standard deviation (traditional)	0.135
Standard error (traditional)	0.011
Standard deviation (improved)	0.110
Standard error (improved)	0.006
<i>t</i> -calculated	3.6536
<i>t</i> -table critical value	1.96

Source: Computed from field data, 2024

The null hypothesis was rejected because the estimated t -value of the technical efficiencies for traditional and improved technologies was 3.6536 which is higher than the t -table critical value – 1.96. The mean technical efficiency for oil palm fruits processors using traditional and improved technologies were 0.826 (82.6%) and 0.872 (87.2%), respectively. This implies that there was significant difference between the mean technical efficiency for oil palm processors using traditional and improved technologies in the study area.

CONCLUSIONS

This study focused on technical efficiency of traditional and improved oil palm fruits processing in Enugu and Anambra States, Nigeria. A multi-stage sampling technique was used to select 464 traditional and improved oil palm fruits processors. The study concluded that the processors using improved technology are more technically efficient than those using traditional technology and the average technical efficiency obtained by the oil palm processors using traditional and improved technology were 82.7% and 87.2%, respectively. The research findings showed that the statistically significant factors that increased the technical efficiency of oil palm fruits processors using traditional technology were age of processors, years of processing experience, household size and access to loan, while years of formal education, years of processing experience and access to loan facilities increased technical efficiency for those using improved technology. Based on the results and findings of this study, the following recommendations were made:

(i) Breeding and research on oil palm by research institutes and universities should be encouraged to get an improved variety that can produce fruits all year round.

(ii) Processors should be linked to oil palm producers to guarantee regular supply of oil palm fruits.

(iii) Processors can organize themselves into cooperative groups or clusters to enable them access to improved processing equipment direct from manufacturers and also process for their members at low cost.

(iv) Traditional and improved oil palm fruits processors should improve on their management and technical skills to improve their technical efficiency and increase their output using the same level of technology.

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