

Socioeconomic Analysis, Profitability, and Technical Efficiency of Groundnut Processing among Women in Katsina State, Nigeria

Hafsat Dalhat Kankiya; Sanusi Abdullahi Beli and Junaidu Musa

Department of Agricultural Economics, Federal University Dutsin-Ma, Katsina State, Nigeria.

Corresponding author: hafsatdalhatkankia5598@gmail.com

DOI: <https://doi.org/10.62154/ajasfr.2026.023.01033>

Abstract

This study examined the socioeconomic characteristics, profitability, and technical efficiency of groundnut processing among women in Katsina, Dutsin-Ma, and Funtua Local Government Areas of Katsina State, Nigeria, and identified the constraints they face. A two-stage sampling technique, preceded by a reconnaissance and listing survey, was used to select 138 women groundnut processors. Primary data were analysed using descriptive statistics, the net farm income model, the Cobb-Douglas stochastic frontier production function, and a four-point Likert-type scale. Results showed that the mean age of respondents was 39.7 years, 52.9% were married, and 39.1% had no formal education. The total cost of processing per cycle was ₦88,307.73, while gross revenue was ₦304,827.16, giving a net return of ₦216,519.43, a benefit-cost ratio of 3.45, and a rate of return of 245.19%. The mean technical efficiency was 0.71 (range: 0.34–0.94), with education, experience, training, credit, extension contact, and processing technology identified as significant determinants of efficiency. Inadequate processing equipment (mean = 3.19) was the most severe constraint. The study concluded that groundnut processing is highly profitable, although processors are not operating at their full production frontier, and recommended improved access to processing equipment, credit, training, extension services, and women-based cooperative societies to enhance efficiency and profitability.

Keywords: Groundnut Processing, Technical Efficiency, Stochastic Frontier, Profitability, Women, Katsina State.

Introduction

Agriculture plays a critical role in Nigeria's economy, accounting for about 25% of gross domestic product and employing more than 70% of the rural population, particularly in northern states such as Katsina (World Bank, 2022). Groundnut (*Arachis hypogaea* L.) is one of the most important crops grown in the region for both domestic consumption and export, and its value chain extends beyond the farm gate into shelling, roasting, oil extraction, and cake (kulikuli) production, activities that generate substantial rural employment and income (Ibrahim et al., 2023). These processing activities, rather than primary cultivation alone, are central to rural livelihoods because it is at this stage that raw groundnut is transformed into higher-value products, and this transformation is undertaken almost entirely by women, who take on the labour-intensive tasks of shelling, roasting, and oil extraction (Kayode et al., 2024). Despite this central role, groundnut

processing among women in Katsina State remains largely small-scale, manual, and technologically underdeveloped, so that much of the potential value addition is not captured by the women who carry out the processing (Haruna et al., 2006). Women also continue to face barriers in access to land, capital, credit, and modern processing technologies that constrain their productivity and bargaining power (Muhammad et al., 2025).

Although a growing body of research has examined groundnut production and general gender constraints in agriculture, comparatively little empirical attention has been paid to the technical efficiency of the processing segment of the groundnut value chain, particularly among women (Chakuri et al., 2022). Existing studies have often focused on production-side efficiency or on general resource-access constraints, leaving a gap in understanding of how socioeconomic, institutional, and technological factors jointly shape processing efficiency and profitability (Muhammad et al., 2025; Sabo et al., 2025). This gap limits the ability of policymakers and development agencies to design targeted interventions capable of improving processing efficiency, incomes, and food security among women in the sub-sector.

This study therefore examined the socioeconomic analysis of groundnut processing among women in Katsina State, Nigeria, with specific reference to Katsina, Dutsin-Ma, and Funtua Local Government Areas. The specific objectives were to: (i) describe the socioeconomic characteristics of women involved in groundnut processing; (ii) determine the cost and returns structure of groundnut processing; (iii) determine the technical efficiency of groundnut processing; (iv) analyse the socioeconomic, institutional, and technological factors influencing technical efficiency; and (v) identify the constraints faced by women involved in groundnut processing. The findings are expected to provide an empirical basis for interventions capable of enhancing the efficiency, profitability, and livelihoods of women engaged in groundnut processing in Katsina State and comparable contexts across Nigeria.

Literature Review

Processing Economics and Profitability in Agro-Processing

Several studies have documented the profitability of groundnut-based enterprises in Nigeria, providing a basis for comparison with the present study. Iliyasu et al. (2008) reported positive net returns and a favourable benefit-cost ratio for groundnut processing, although at a level lower than that found in the present study. Akintunde et al. (2025) similarly found groundnut marketing to be profitable in northern Taraba State, though with gross margins that varied by local government area, and identified inadequate storage and processing facilities as the main constraint on profitability. A comparable cost pattern, dominated by the raw material itself, was reported by Haruna et al. (2006) for groundnut processing in Bauchi State. Dawa et al. (2024), working among women processors in Kebbi State, similarly linked profitability and the adoption of improved processing technology to training, extension contact, and access to credit. Taken together, this body of work establishes that groundnut-based enterprises are consistently profitable across different

locations in Nigeria, while also showing that the magnitude of profitability varies with local input costs, product mix, and market access.

Technical Efficiency in Agro-Processing

A parallel strand of literature has applied the stochastic frontier framework to measure technical and allocative efficiency in groundnut-based production and processing. Ibrahim et al. (2010) evaluated groundnut processing efficiency among women in North Central Nigeria and found processors operating below the production frontier, a finding broadly echoed by Katanga et al. (2025) in their analysis of small-scale groundnut oil and cake processing in Jigawa State. Zakari et al. (2014) applied a similar stochastic frontier approach to oil palm processing technologies in Cross River State and found that technical efficiency differed markedly between traditional and improved processing methods, underscoring the role of processing technology as a determinant of efficiency in agro-processing more broadly. Sabo et al. (2025), using a stochastic cost frontier for groundnut-based cropping systems in Taraba State, similarly found age, household size, educational level, extension visit, and farming experience to be the dominant sources of inefficiency, with efficiency levels that varied considerably across cropping systems. Collectively, these studies confirm that technical inefficiency is a persistent feature of small-scale groundnut enterprises in Nigeria, but that its scale and drivers vary by commodity, technology, and location.

Institutional and Socioeconomic Determinants of Processing Efficiency

A further set of studies has examined the socioeconomic, institutional, and technological factors that shape processing efficiency and profitability. Shuaibu et al. (2018) found that socioeconomic factors such as education and processing experience significantly influenced the profitability of groundnut processing among women in Kano State, while Dawa et al. (2024) identified training, extension contact, and access to credit as key drivers of the adoption of improved groundnut-processing technology among rural women in Kebbi State. Chakuri et al. (2022) and Sabo et al. (2025) similarly linked technical and allocative efficiency in groundnut production to farmer education, experience, and access to extension services. More broadly, Muhammad et al. (2025) found that access to farm inputs, extension information, and credit significantly affected farmers' credit accessibility in Katsina State, documenting the kind of institutional and resource-access constraints that plausibly extend to the processing segment addressed in this study.

Overall, the reviewed literature confirms that groundnut and related agro-processing enterprises are generally profitable, that technical inefficiency is a common and measurable feature of small-scale processing, and that education, training, credit, extension contact, and processing technology are recurrent determinants of efficiency. However, few of these studies jointly examine profitability, technical efficiency, and its determinants within a single analytical framework specifically for groundnut processing among women, and none does so for Katsina State. This gap, already identified in the Introduction, is the specific gap that the present study addresses.

Methodology

Theoretical/Conceptual Framework

This study adopts the stochastic frontier production framework as its conceptual basis. Unlike deterministic frontier approaches, the stochastic frontier model separates deviations of observed output from the theoretical maximum (frontier) output into two components: a symmetric random error capturing factors outside the processor's control (e.g., measurement error, weather-related input variation), and a one-sided technical inefficiency term reflecting the processor's own shortfall in converting inputs into output. This framework is the appropriate lens for examining processing efficiency among the women in this study because it allows technical inefficiency to be estimated directly and simultaneously linked, through the inefficiency model, to the socioeconomic and institutional factors that plausibly explain it, following Coelli et al. (2005) and Battese and Coelli (1995), as detailed in Section 4.5.

Study Area

The study was carried out in Katsina State, Nigeria, with a focus on Katsina, Dutsin-Ma, and Funtua Local Government Areas (LGAs). Katsina State is located in the North-West geopolitical zone of Nigeria and covers a land area of about 24,192 km², with a population of over 8 million people based on the 2006 national census (National Population Commission [NPC], 2006; Katsina State Ministry of Land and Physical Planning, 2022). The state lies within the Sudan Savanna ecological zone and is predominantly agrarian, with groundnut as one of its major crops. The three LGAs were purposively selected on account of their high levels of groundnut production, active processing activity, and strong participation of women in processing.

Sampling Procedure and Sample Size

A two-stage sampling technique was employed. In the first stage, the three study LGAs were purposively selected on account of their high concentration of groundnut-processing activity. This was followed by a reconnaissance and listing survey — a frame-construction procedure rather than a sampling technique in itself — undertaken with the assistance of women processors to identify processing communities and compile a sampling frame of 157 identifiable women groundnut processors across the three LGAs. In the second stage, simple random sampling (balloting without replacement) was used to select 138 respondents from this frame, with the sample size determined using the Yamane (1967) formula at a 3% margin of error.

Data Collection

Primary data were collected from the 138 respondents using structured questionnaires administered over a period of three weeks. The questionnaire captured the socioeconomic characteristics of processors, input-output quantities and costs for the cost-and-returns and stochastic frontier analyses, and the constraints faced by processors.

The questionnaire, including the constraint-severity (Likert-type) items, was pretested with a small group of groundnut processors outside the three selected LGAs, and was revised for clarity on this basis.

Analytical Techniques

Data were analysed using descriptive statistics (frequency counts, percentages, and means), the net farm income model, the Cobb-Douglas stochastic frontier production function, and a four-point Likert-type scale.

Cost and returns were determined using the net farm income (NFI) model:

$$NFI = TR - TC, \text{ where } TR = (Q_c \times P_c) + (Q_o \times P_o) + (Q_r \times P_r), \text{ and } TC = TVC + TFC \quad (1)$$

where NFI is net farm income; TR is total revenue from groundnut cake, oil, and roasted groundnut; Q_c , Q_o , and Q_r are the respective quantities sold at prices P_c , P_o , and P_r ; and TC is total cost, comprising total variable cost (TVC) and total fixed cost (TFC).

Technical efficiency and its determinants were jointly estimated using the stochastic frontier production model of Coelli, Rao, O'Donnell, and Battese (2005), specified as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + V_i - \mu_i \quad (2)$$

where Y_i is the value of groundnut processed (₦); X_1 – X_{10} are, respectively, raw groundnut (kg), labour (mandays), firewood (bundles), fuel (litres), water (litres), salt (grams), depreciation on equipment (₦), packaging materials (₦), transportation (₦), and equipment value (₦); V_i is the symmetric random error; and μ_i is the non-negative technical inefficiency effect.

Following Battese and Coelli (1995), the inefficiency effects were modelled as:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \dots + \delta_8 Z_8 \quad (3)$$

where Z_1 – Z_8 represent age (years), educational level (years of formal education), household size, years of processing experience, training (1 = yes, 0 = otherwise), amount of credit accessed (₦), number of extension visits, and processing technology used (1 = modern/semi-modern, 0 = traditional), respectively. The variance parameters $\sigma^2 = \sigma^2_v + \sigma^2_u$ and $\gamma = \sigma^2_u / \sigma^2$ were estimated following Jondrow et al. (1982), where γ must lie between 0 and 1. Maximum likelihood estimates of equations (2) and (3) were obtained simultaneously using the FRONTIER version 4.1 program (Coelli, 1994).

The constraints faced by women processors were assessed using a four-point Likert-type scale (very severe = 4, severe = 3, mild = 2, not severe = 1) rather than a classical Likert (1932) summated attitude scale, since each constraint item's mean severity score was interpreted independently; a mean score of ≥ 2.50 was used to classify a constraint as serious.

Ethical approval was obtained from the Research Ethics Committee of Federal University Dutsin-Ma prior to the commencement of the study. All respondents were adequately informed about the purpose and procedures of the study, the voluntary nature of their participation, and their right to withdraw at any time. Informed consent was obtained from each respondent before data collection. Confidentiality and anonymity of respondents were maintained in the questionnaire design.

Results

Socioeconomic Characteristics of Respondents

The socioeconomic characteristics of the 138 respondents are summarised in Table 1. The mean age of respondents was 39.7 years (range: 17–66), with the largest proportion (31.2%) falling within the 26–35-year bracket. Most respondents (52.9%) were married, while formal education was generally low: 39.1% had no formal education and only 5.8% had tertiary education (not shown). The mean household size was 6.4 persons, and the mean processing experience was 11.0 years.

Groundnut processing was the main occupation of 90.6% of respondents. Institutional and technological indicators, however, revealed considerable gaps: only 10.1% belonged to a cooperative society, only 48.6% had access to credit, only 10.1% received extension visits in the preceding year, and only 29.0% had attended any processing-related training. Nearly half (48.6%) still relied on traditional processing technology, 46.4% used semi-modern technology, and only 5.0% used modern technology.

Table 1: Socioeconomic Characteristics of Women Groundnut Processors

Variable	Frequency (n=138)	Percentage (%)	Mean (Range)
Age (years)			39.7 (17–66)
26–35	43	31.2	
36–45	31	22.5	
46–55	30	21.7	
Marital status: Married	73	52.9	
Education: No formal education	54	39.1	
Secondary	50	36.2	
Household size (persons)			6.4 (1–12)
Processing experience (years)			11.0 (2–30)
Main occupation: Groundnut processing	125	90.6	
Cooperative membership: Yes	14	10.1	
Access to credit: Yes	67	48.6	
Extension contact: Yes	14	10.1	
Training attended: Yes	40	29.0	
Processing technology:	67	48.6	
Traditional			
Semi-modern	64	46.4	
Modern	7	5.0	

Source: Field survey data, 2026.

Cost and Returns of Groundnut Processing

Table 2 shows that raw groundnut was the dominant cost item, accounting for 81.2% of total cost (₦71,657.34). Labour ranked second (5.7%), while energy inputs jointly accounted for a small share of total cost. Total variable cost was ₦85,753.86 (97.1% of total cost), while fixed cost, mainly depreciation, contributed only 2.9% (₦2,553.87).

Gross revenue of ₦304,827.16 was generated from three product streams: groundnut cake (kulikuli, 57.3%), groundnut oil (34.2%), and roasted groundnut (8.5%). The resulting net return was ₦216,519.43, with a benefit-cost ratio of 3.45 and a rate of return of 245.19%, implying that for every ₦1 invested, processors earned ₦2.45 in profit.

Table 2: Cost and Returns of Groundnut Processing per Processing Cycle

Item	Amount (₦)	% of Total Cost	% of Revenue
Raw groundnut	71,657.34	81.2	23.5
Labour	5,060.80	5.7	1.7
Firewood	2,344.88	2.7	0.8
Fuel (kerosene)	1,695.60	1.9	0.6
Other variable costs (water, salt, packaging, transport, etc.)	4,995.24	5.7	1.6
Total Variable Cost (TVC)	85,753.86	97.1	28.1
Total Fixed Cost (depreciation)	2,553.87	2.9	0.8
Total Cost (TC)	88,307.73	100.0	29.0
Groundnut cake (kulikuli)	174,760.00	—	57.3
Groundnut oil	104,250.52	—	34.2
Roasted groundnut	25,816.64	—	8.5
Gross Revenue (TR)	304,827.16	—	100.0
Net Return (TR – TC)	216,519.43	—	—
Benefit–Cost Ratio (TR/TC)	3.45	—	—
Rate of Return (%)	245.19	—	—

Source: Field survey data, 2026.

Stochastic Frontier Production Function and Technical Efficiency

The maximum likelihood estimates of the stochastic frontier production function and the inefficiency model, obtained simultaneously, are presented in Table 3. The constant term ($\beta_0 = 3.842$) was positive and significant at 1%, confirming the validity of the model specification, while the log-likelihood value (-58.43) and LR test statistic (21.36 , $df = 9$) indicated an adequate model fit and justified rejection of the null hypothesis of no inefficiency effects.

Among the input variables, raw groundnut ($\beta_1 = 0.612$) was the most important determinant of output, positive and significant at 1%, implying that a 1% increase in raw groundnut processed raised output by approximately 0.61%. Labour ($\beta_2 = 0.184$) was also positive and significant at 1%, while firewood ($\beta_3 = 0.071$), depreciation ($\beta_7 = 0.097$), and equipment value ($\beta_{10} = 0.108$) were positive and significant at 5%. The sum of input elasticities ($RTS = 1.197$) indicated increasing returns to scale. The gamma value ($\gamma = 0.812$, $p < 0.01$) showed that about 81.2% of output variation was attributable to technical inefficiency rather than random shocks.

Technical efficiency scores ranged from 0.34 to 0.94, with a mean of 0.71 and a standard deviation of 0.14, implying that processors, on average, achieved only 71% of potential

frontier output and could raise output by about 29% through better resource use without additional inputs.

In the inefficiency model, educational level ($\delta_2 = -0.078$, $p < 0.01$), years of experience ($\delta_4 = -0.014$, $p < 0.01$), training ($\delta_5 = -0.186$, $p < 0.05$), credit amount ($\delta_6 = -0.118$, $p < 0.05$), extension visits ($\delta_7 = -0.071$, $p < 0.05$), and processing technology ($\delta_8 = -0.143$, $p < 0.01$) were all negative and statistically significant, indicating that processors with more education, longer experience, and greater access to training, credit, extension services, and improved technology had significantly lower technical inefficiency. Age ($\delta_1 = 0.0042$, $p < 0.10$) had a weakly positive effect on inefficiency, while household size (δ_3) was not significant.

Table 3: Maximum Likelihood Estimates of the Stochastic Frontier Production Function and Inefficiency Model of Groundnut Processing

Variable	Param.	Coefficient	Std. Error	t-value
Constant	β_0	3.842	0.694	5.54***
Raw groundnut	β_1	0.612	0.082	7.46***
Labour	β_2	0.184	0.061	3.02***
Firewood	β_3	0.071	0.034	2.09**
Fuel	β_4	0.018	0.012	1.50
Water	β_5	0.045	0.057	0.79
Salt	β_6	0.026	0.019	1.37
Depreciation	β_7	0.097	0.046	2.11**
Packaging	β_8	0.014	0.013	1.08
Transportation	β_9	0.022	0.018	1.22
Equipment value	β_{10}	0.108	0.041	2.63**
Inefficiency Model (Dependent Variable: Technical Inefficiency Effect)				
Constant	δ_0	0.687	0.221	3.11***
Age	δ_1	0.0042	0.0023	1.83*
Educational level	δ_2	-0.078	0.029	-2.69***
Household size	δ_3	-0.012	0.011	-1.09
Years of experience	δ_4	-0.014	0.005	-2.80***
Training	δ_5	-0.186	0.078	-2.38**
Credit amount (₦, 100,000s)	δ_6	-0.118	0.046	-2.57**
Extension visits	δ_7	-0.071	0.030	-2.37**
Processing technology	δ_8	-0.143	0.054	-2.65***
Sum of elasticities (RTS)		1.197		
Sigma-squared	σ^2	0.426	0.071	6.00***
Gamma	γ	0.812	0.094	8.64***
Log-likelihood function		-58.43		
LR test of one-sided error		21.36 (df = 9)		

Note: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Source: Field survey data, 2026.

Constraints Faced by Women Groundnut Processors

The Likert-type scale analysis (Table 4) identified nine constraints, with mean severity scores ranging from 2.33 to 3.19; eight of the nine were classified as serious (mean ≥ 2.50). Inadequate processing equipment ranked first (mean = 3.19), corroborating the frontier result that processing technology (δ_8) was a significant determinant of technical efficiency. This was followed by the high cost of raw groundnut (3.04), lack of access to credit (2.98), lack of training (2.95), price fluctuation (2.89), poor extension services (2.87), high fuel/energy cost (2.86), and poor market access (2.80). Transportation problems ranked last (mean = 2.33) and was the only constraint classified as not serious. Overall, technological, financial, and institutional constraints were the most severe challenges facing women groundnut processors in the study area.

It should be noted that the frequency counts reported in Table 4 sum to 96 respondents for Item 1 and 97 respondents for Items 2–9, rather than the full sample of 138. Of the 138 respondents surveyed, 41 either left the constraints section of the questionnaire unanswered or gave responses that were not valid (e.g., missing or illegible entries, or more than one option selected for a single item) and were therefore excluded from Table 4. One further respondent gave an invalid response to Item 1 (inadequate processing equipment) specifically, while providing valid responses to Items 2–9; this respondent was excluded from Item 1 only, giving valid response bases of 96 for Item 1 and 97 for Items 2–9. The percentages and mean severity scores reported above are calculated on these valid response bases.

Table 4: Constraints Faced by Women Groundnut Processors

Constraint	Very Severe (4)	Severe (3)	Mild (2)	Not Severe (1)	Mean	Rank	Remark
Inadequate processing equipment	41 (42.7)	38 (39.6)	11 (11.5)	6 (6.3)	3.19	1	Serious
High cost of raw groundnut	26 (26.8)	53 (54.6)	14 (14.4)	4 (4.1)	3.04	2	Serious
Lack of access to credit	33 (34.0)	41 (42.3)	11 (11.3)	12 (12.4)	2.98	3	Serious
Lack of training	35 (36.1)	35 (36.1)	14 (14.4)	13 (13.4)	2.95	4	Serious
Price fluctuation	21 (21.6)	51 (52.6)	18 (18.6)	7 (7.2)	2.89	5	Serious
Poor extension services	32 (33.0)	36 (37.1)	13 (13.4)	16 (16.5)	2.87	6	Serious
High fuel/energy cost	18 (18.6)	51 (52.6)	24 (24.7)	4 (4.1)	2.86	7	Serious
Poor market access	22 (22.7)	47 (48.5)	15 (15.5)	13 (13.4)	2.80	8	Serious

Constraint	Very Severe (4)	Severe (3)	Mild (2)	Not Severe (1)	Mean	Rank	Remark
Transportation problems	14 (14.4)	32 (33.0)	23 (23.7)	28 (28.9)	2.33	9	Not serious

Note: Figures in parentheses are percentages. $n = 96$ for Item 1; $n = 97$ for Items 2–9, reflecting exclusion of invalid or missing responses to the constraints section (see Section 5.4).

Source: Field survey data, 2026.

Discussion of Findings

Socioeconomic Characteristics in Light of Existing Literature

The dominance of respondents in the 26–35-year bracket indicates that groundnut processing in the study area is carried out mainly by women within the economically active age range, consistent with Shuaibu et al. (2018) and Katanga et al. (2025). The generally low level of formal education found among respondents agrees with Zakari et al. (2014) and Ibrahim et al. (2010), who similarly reported low educational attainment among groundnut processors elsewhere in northern Nigeria. The relatively large household size likely reflects the availability of family labour for processing, as also noted by Akintunde et al. (2025).

The low rates of cooperative membership, credit access, extension contact, and training attendance, together with continued reliance on traditional and semi-modern processing technology, point to an ongoing but incomplete technological transition, consistent with Dawa et al. (2024) and Zakari et al. (2014). This pattern aligns with Ibrahim et al. (2023), who similarly found that access to improved inputs and technology, rather than production decisions alone, remains a binding constraint for groundnut-based livelihoods in Katsina State.

Cost, Returns, and Profitability in Light of Existing Literature

The dominance of raw groundnut in total processing cost confirms it as the principal input in processing, a finding that aligns closely with Akintunde et al. (2025). The low share of fixed cost relative to variable cost is consistent with Sabo et al. (2025).

The net return, benefit-cost ratio, and rate of return obtained in this study confirm that groundnut processing is highly profitable. This result is directionally consistent with, though larger in magnitude than, Iliyasu et al. (2008) and Akintunde et al. (2025). The scale of profitability found here is also broadly consistent with Ibrahim et al. (2023), who reported that groundnut-based enterprises remain among the more remunerative livelihood activities available to rural households in Katsina State.

Technical Efficiency and its Determinants in Light of Existing Literature

The positive and significant elasticity of raw groundnut is consistent with Sabo et al. (2025), Akintunde et al. (2025), and Ibrahim et al. (2010), while the significance of firewood, depreciation, and equipment value reflects the energy- and equipment-dependent nature of processing, as also noted by Haruna et al. (2006) and Iliyasu et al. (2008). The increasing returns to scale found in this study suggest that processors are operating below their

optimal scale, broadly consistent with Ibrahim et al. (2010) but contrasting with the comparably low technical efficiency reported by Das et al. (2023) among groundnut producers in Tanzania using a stochastic meta-frontier approach.

The mean technical efficiency of 0.71 obtained in this study is broadly comparable to the 70.5% mean efficiency reported by Chakuri et al. (2022) for groundnut farmers in Ghana using a Bayesian stochastic frontier approach, suggesting that the scope for efficiency gains identified here (about 29% of potential output) is not unique to Katsina State but reflects a wider pattern across groundnut-based production and processing systems in West Africa.

The significant negative effects of education, experience, training, credit, extension contact, and processing technology on inefficiency are consistent with Ibrahim et al. (2010), Zakari et al. (2014), Shuaibu et al. (2018), Sabo et al. (2025), Katanga et al. (2025), and Dawa et al. (2024), reinforcing the view that institutional and human-capital factors, more than purely technical ones, drive efficiency gaps in small-scale agro-processing.

Constraints Faced by Women Groundnut Processors in Light of Existing Literature

The ranking of inadequate processing equipment as the most severe constraint corroborates the frontier result that processing technology (δ_8) was a significant determinant of technical efficiency, and agrees with Ibrahim et al. (2010) and Shuaibu et al. (2018). The high ranking of raw material cost, credit access, and training is consistent with Zakari et al. (2014) and Dawa et al. (2024). The relatively low severity of transportation problems in this study contrasts with Akintunde et al. (2025), who identified inadequate storage and processing infrastructure, including transport-related bottlenecks, as the principal constraint on groundnut marketing in Taraba State, suggesting that infrastructure-related constraints vary across locations and value-chain segments.

Limitations of the Study

This study is subject to some limitations that should be borne in mind when interpreting its findings. First, the data are cross-sectional, so the statistically significant relationships identified in the inefficiency model (Section 5.3) are associational rather than causal; processors with more education, experience, training, credit, extension contact, and improved processing technology were associated with significantly lower technical inefficiency, but the design does not permit strong causal claims about these relationships. Second, the sample was drawn from three purposively selected LGAs (Katsina, Dutsin-Ma, and Funtua), so the findings are most directly generalisable within these areas and should be extended to other parts of Katsina State, or to Nigeria more broadly, with caution. Third, as noted in Section 5.4, the response base for the constraints (Likert-scale) analysis in Table 4 was smaller than the full sample of 138, which should be taken into account when interpreting the ranking and severity of constraints reported.

Conclusion and Recommendations

Groundnut processing is a highly profitable enterprise for women in Katsina State, as evidenced by its substantial net return, benefit-cost ratio, and rate of return. However, processors are not operating on their production frontier, with a mean technical efficiency of only 0.71, reflecting substantial technical inefficiency linked to limited access to improved processing technology, inadequate training, weak extension services, low cooperative participation, and constrained access to formal credit. Education, processing experience, training, credit amount, extension visits, and processing technology were identified as the major significant determinants of technical efficiency, indicating that interventions targeting these institutional and human-capital factors offer the greatest scope for improving efficiency and profitability in the sub-sector.

Based on these findings, it is recommended that: government and development partners facilitate the timely and affordable supply of semi-modern and modern processing equipment (e.g., mechanical shellers, oil expellers, and grinders) to women processors; the formation and strengthening of women-based groundnut-processing cooperative societies be actively encouraged to improve access to group credit, training, bulk input purchase, and collective marketing; micro-credit schemes targeted at women processors be expanded to ease investment in inputs and equipment; functional adult literacy and basic numeracy programmes, scheduled around processing activities, be introduced to address the low educational attainment of processors; and extension services be strengthened and made more accessible to women groundnut processors to accelerate the diffusion of improved processing knowledge and technology.

Acknowledgement

All thanks and glory belong to Allah, the Beneficent and Most Merciful. The authors are grateful to the Head of Department and staff of the Department of Agricultural Economics, Federal University Dutsin-Ma, for their support throughout this study. The first author also thanks her husband, Hussaini Sani Funtua, for his love, support, and encouragement. The authors acknowledge the women groundnut processors in Katsina, Dutsin-Ma, and Funtua Local Government Areas who participated in this study.

References

- Akintunde, M. O., Zubairu, A. I., Idris, Y., Igbankwe, A. T., David, F. A., & Daniel, N. G. (2025). Economics of groundnut marketing in northern Taraba State, Nigeria. *UNIZIK Journal of Agricultural Economics and Extension*, 2(2), 206–217. <https://doi.org/10.5281/zenodo.18076411>
- Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20(2), 325–332. <https://doi.org/10.1007/BF01205442>
- Chakuri, D., Asem, F. E., & Onumah, E. E. (2022). Bayesian technical efficiency analysis of groundnut production in Ghana. *Cogent Economics & Finance*, 10(1), 2074627. <https://doi.org/10.1080/23322039.2022.2074627>
- Coelli, T. J. (1994). *A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation*. Mimeo, Department of Econometrics, University of New England, Armidale.

- Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis* (2nd ed.). Springer. <https://doi.org/10.1007/b136381>
- Das, A., Kumar, S., & Ganga Rao, N. V. P. R. (2023). Potential for increasing groundnut production in Tanzania by enhancing technical efficiency: A stochastic meta-frontier analysis. *Frontiers in Sustainable Food Systems*, 7, 1027270. <https://doi.org/10.3389/fsufs.2023.1027270>
- Dawa, A., Umar, S., & Gona, A. (2024). Factors influencing adoption of improved groundnut processing technology among rural women in Kebbi State, Nigeria. *International Journal of Research and Scientific Innovation*, 11(8), 1367–1376. <https://rsisinternational.org/journals/ijrsi/articles/factors-influencing-adoption-of-improved-groundnut-processing-technology-among-rural-women-in-kebbi-state-nigeria/>
- Haruna, U., Murtala, N., & Ahmed, H. S. (2006). Economics of groundnut processing among rural women in Katagum Local Government Area, Bauchi State, Nigeria. *Savannah Journal of Agriculture*, 1(2), 138–144.
- Ibrahim, H. Y., Saingbe, N. D., & Ibrahim, H. I. (2010). An evaluation of groundnut processing by women in a rural area of North Central Nigeria. *Journal of Agricultural Science*, 2(1), 206–212. <https://doi.org/10.5539/jas.v2n1p206>
- Ibrahim, M., Ibrahim, H. Y., & Jamiu, W. M. (2023). Impact of improved groundnut varieties adoption on income, food security and nutrition of farming households in Katsina State, Nigeria. *Agricultura Tropica et Subtropica*, 56, 92–99. <https://doi.org/10.2478/ats-2023-0011>
- Iliyasu, A., Wulet, I., & Yusuf, K. (2008). Profitability analysis of groundnut processing in Maiduguri Metropolitan Council of Borno State, Nigeria. *Nigerian Journal of Basic and Applied Sciences*, 16(2), 253–256.
- Jondrow, J., Lovell, C. A. K., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, 19(2–3), 233–238.
- Katanga, Y. N., Sanusi, S. M., Gama, E. N., Okoroafor, U. C., & Wudil, A. H. (2025). Socio-economic analysis of small-scale groundnut oil and cake processing in Birnin Kudu Agricultural Zone of Jigawa State, Nigeria. *Journal of Agricultural Science and Practice*, 10(2), 24–33.
- Katsina State Ministry of Land and Physical Planning. (2022). *Land area and administrative profile of Katsina State*. Katsina State Government.
- Kayode, A. O., Malomo, J. O., Emmanuel-Rabiu, A. O., & Yahaya, Z. O. (2024). Women participation in value addition to groundnut (*Arachis hypogaea*) in Kwara State, Nigeria. *Thomas Adewumi University Journal of Innovation, Science and Technology*, 1(1). <https://doi.org/10.5281/zenodo.14197485>
- Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, 22(140), 1–55.
- Muhammad, A., Abdulmumini, L., & Ubandoma, G. A. (2025). Factors affecting credit accessibility in the Bank of Agriculture, Katsina State in Nigeria. *FUDMA Journal of Sciences*, 9(April Special Issue), 209–215. [https://doi.org/10.33003/fjs-2025-09\(AHBSI\)-3406](https://doi.org/10.33003/fjs-2025-09(AHBSI)-3406)
- National Population Commission. (2006). *2006 population and housing census of the Federal Republic of Nigeria: Priority tables*. National Population Commission.
- Sabo, A. A., Kasari, A. D., Jellason, J., & Sunday, M. U. (2025). Allocative efficiency of groundnut (*Arachis hypogaea* L.)-based cropping systems in Taraba State, Nigeria. *UNIZIK Journal of Agricultural Economics and Extension*, 2(2), 143–156. <https://doi.org/10.5281/zenodo.20633538>
- Shuaibu, H., Akinola, M. O., Akpoko, G. J., Damisa, M. A., & Yakubu, D. H. (2018). Socio-economic factors and profitability of groundnut processing by women in Kano State, Nigeria. *Journal of Agricultural Extension*, 22(2), 1–12. <https://www.ajol.info/index.php/jae/article/view/173800>
- World Bank. (2022). *Agriculture and rural development in Nigeria*. <https://www.worldbank.org/nigeria>
- Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper and Row.

Zakari, A., Nandi, J. A., & Ahmed, B. (2014). Technical efficiency differentials in oil palm processing technologies in Cross River State, Nigeria. *The Journal of Agricultural Sciences*, 9(3), 109–117. <https://doi.org/10.4038/jas.v9i3.7424>