Effect of False Bottom Rice Parboiling Technology on the Rice Quality Parameters in Awka North Local Government Area of Anambra State

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Abstract

This study examined the effect of false-bottom rice parboiling technology on rice quality parameters in Awka North Local Government Area of Anambra State, Nigeria. The study specifically identified the differences in rice quality parameters between false-bottom and conventional parboiling technologies and estimated the effect of false-bottom adoption on rice quality, proxied by observed output. Data were collected from rice processors selected through a two-stage sampling technique. The descriptive statistics, Chi-square tests, propensity score matching, and robust regression techniques the analytical techniques used to operationalized the study. The results revealed statistically significant differences in most rice quality parameters between adopters and non-adopters. Rice processed using false-bottom technology recorded higher proportions of white grains (76.7% compared to 3.3% under conventional processing), lower grain breakage, improved cleanliness, and shorter cooking time, with most quality differences significant at the 1% level of probability. The treatment effect analysis showed that adopters achieved a mean output of 33,636.57 kg, more than double the mean output of non-adopters (16,553.49 kg), with a highly significant t-value of 8.07***. The robust regression results further confirmed that adoption had a strong and positive effect on rice quality outcomes, explaining between 68% and 76% of the variation in observed quality indicators. The study concludes that false-bottom parboiling technology significantly improves rice quality and processing efficiency. We therefore recommend that VCDP and other government agencies should scale up the technology through targeted training, extension support, and accessible financing to enhance the competitiveness of locally processed rice.

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1. Introduction

The quality of rice depends mainly on the processing techniques or decisions (Obianefo *et al*., 2023) [14]. Realization of this is very important because consumers respond to what they can see and experience, such as cleanliness, grain integrity, colour, and cooking behaviour. In Nigerian rice markets, evidence showed that consumers attach price premiums to visible grain attributes like fewer broken grains, overall presentation and better uniformity. Peterson-Wilhelm *et al*. (2022) [17]; Adewale *et al*. (2024) [3] noted that rice quality, quickly translates into cash outcomes for processors and farmers. This aligned with the practical observation that money realized by rice farmers and processors is tied to the level of satisfaction customers derive from the product (Peterson-Wilhelm *et al*., 2022; Adewale *et al*., 2024; Obianefo *et al*., 2023) [17, 3, 14].

In Anambra State, and in many communities such as those in Awka North, rice processing before the expansion of value chain development programme (VCDP), rice processing largely depended on conventional parboiling practices with limited process control, which often produced avoidable defects that affect appearance and milling performance (State Programme Management Unit, FGN/IFAD VCDP, 2017) [20]; Obianefo *et al*., 2023 [14]. These quality issues matter not only for consumer acceptance, but also for competitiveness against better-finished local and imported alternatives (Peterson-Wilhelm *et al*., 2022) [17].

VCDP have now promoted improved (false bottom) parboiling technologies to address both quality and efficiency constraints in rice processing subsector. The study by Meresa *et al*. (2020) [11] noted that controlling soaking and steaming conditions can improve head rice yield, strengthen kernels, reduce chalkiness, and reduce breakage. These qualities jointly raise the proportion of marketable rice and improve cooking quality. In field practice, the false bottom parboiling approach aims to improve heat transfer and uniformity by separating paddy from direct contact with boiling water and relying more on steam (Obianefo *et al*., 2023) [14], with programme manuals emphasising standardized soaking, moisture control, and steaming routines to reduce defects and improve milling outcomes (State Programme Management Unit, FGN/IFAD VCDP, 2017) [20]. Apart from quality, some empirical evidence anchored on rice processing economics, reported that processing is generally profitable and that technology choice and adoption conditions influenced efficiency and returns (Lawal *et al*., 2025 [10]; Ndindeng *et al*., 2025 [13]). Adoption-focused evidence also showed that trained processor groups respond to improved technologies such as false bottom systems, particularly where extension and programme structures support learning and access (Salami & Adisa, 2023 [19]; Abubakar *et al*., 2023 [1]).

Furthermore, most available evidence concentrated on adoption patterns, technology gaps, and economic performance, while fewer studies isolate measurable quality outcomes under real processing conditions. In Anambra State, for example, research documents technology-gap efficiency and heterogeneity among small-scale processors, suggesting that even when beneficiaries are exposed to similar advisory services, their capabilities, constraints, and outcomes may differ in systematic ways (Obianefo *et al*., 2023) [14]. This matters for impact evaluation, because adopters and non-adopters may not be comparable at baseline, and naive comparisons can overstate or understate the true effect of the false bottom technology. Studies on false bottom adoption in Nigeria also suggest that training and group participation influence uptake, which reinforces the possibility of selection effects when evaluating outcomes (Salami & Adisa, 2022 [19]; Abubakar *et al*., 2023 [1]). To demonstrate the novelty and strengthen causal inference in Awka North, this study applied propensity score matching (PSM) to test for systematic mean differences in socioeconomic variables, enforce common support, and then estimate the effect of false bottom adoption on rice quality parameters relative to conventional parboiling. In doing so, the study provides policymakers enough evidence that can help judge whether scaling false bottom technology delivers consistent, observable improvements in rice quality, not only improvements in adoption statistics (Ndindeng *et al*., 2025 [13]; State Programme Management Unit, FGN/IFAD VCDP, 2017 [20]). Thus, the specific objective seeks to:

1. identify the differences in rice quality parameters (whiteness, brightness texture and broken rice) between false bottom and conventional rice parboiling technologies; and
2. estimate the effects of the false bottom parboiling technology on rice quality parameters proxied as observed output.

2. Literature Review

In Nigeria, consumers strongly prefer rice with uniform grains, minimal broken fractions, appealing whiteness, and desirable cooking texture. This is an indication that rice quality remains a critical determinant of market competitiveness and processors' income. Empirically, the study Muochebe, Nwajinka, and Nwatu (2021) [12] demonstrated that optimized parboiling conditions significantly improved head rice yield and reduced grain breakage in FARO-44 rice, it also improves visual quality attributes like grain colour and appearance. Earlier, Adekoyeni and Adeboye (2018) [2] noted that soaking duration and parboiling temperature affected the cooking and sensory properties of Ofada rice, this confirmed that hydrothermal processing directly influenced textures and consumers acceptability. These findings support the proposition that parboiling technology choice, rather than paddy quality alone, determines whiteness, brightness, texture, and breakage outcomes.

Another study by Itadare *et al*. (2025) [9] further showed that improved parboiling technologies such as the false-bottom system have the potential to enhance milling performance and economic returns. They reported that adoption of false-bottom parboiling technology significantly improved the economic performance of rice processors in Ekiti State, largely through reduced processing losses and improved marketable rice quality. Collaboratively, Obianefo *et al*. (2023) [14] also submitted that technology gaps among small-scale rice processors in Anambra State were largely associated with differences in processing efficiency and output quality, implying that equipment and practice heterogeneity can translate into observable quality differentials. Furthermore, VCDP programme manuals and implementation reports emphasized that false-bottom technology improves parboiling uniformity, reduces grain fissuring, and enhanced grain appearance (State Programme Management Unit, FGN/IFAD VCDP, 2017 [20]; State Programme Management Unit, FGN/IFAD VCDP, 2017 [20]). These prior studies collectively justified the expectation that false-bottom and conventional parboiling technologies will produce systematic mean differences in whiteness, brightness, texture, and broken rice fractions, which aligned with the objectives of the study.

Equally, the study by Arouna *et al*. (2023) [6] examined the adoption of the improved GEM parboiling system among women parboilers in Benin they found that adoption significantly increased income, mostly due to improved rice quality and reduced grain breakage during milling. Again, the study by Ndindeng *et al*. (2025) [13] provided a comprehensive review of parboiling and milling regimes in sub-Saharan Africa, they conclude that improved parboiling technologies enhance head rice yield, reduce breakage, and increase market value. Though, they observed that adoption remained uneven due to cost and knowledge challenges.

Globally, they study by Zhuang *et al.* (2025) [21] noted that parboiling technology significantly influenced rice microstructure content, leading to increased grain hardness and reduced stickiness. Collaboratively, another study by Salam *et al.* (2024) [18] equally found that parboiling conditions influenced grain hardness, milling yield, and visual quality parameters, confirming that hydrothermal processing modified both sensory and physical attributes of rice. These empirical evidences uncovered the mechanistic pathways through which false bottom parboiling technologies influenced rice quality to reinforce the needs to compare this improved technology with conventional technologies in Awka North.
More importantly, Alabi *et al.* (2024) [5] applied propensity score matching (PSM) to estimate the impact of Value Chain Development Programme (VCDP) participation on the net farm income in Niger State, they uncovered a significant and positive treatment effects after correcting for selection bias. Collaboratively, Ebenehi *et al.* (2024) [7] also used PSM to estimate the income effects of climate-smart agricultural practice adoption on rice farmers in Niger and Kwara State, Nigeria. They opined discovered that climate-smart adoption significantly caused income gains among adopters relative to non-adopters after the matching. The aforementioned studies is an indication that technology adopters are systematically different from non-adopters, also, PSM is an appropriate econometric tool for reducing selection bias and obtaining unbiased treatment effect estimates.

3. Materials and Methods

Area of the Study

The study was conducted in Awka North Local Government Area (LGA) of Anambra State, Nigeria. The area is located between latitude 6°30′ and 6°47′ North and longitude 7°30′ and 7°37′ East. The LGA lies within the tropical rainforest zone and experiences a humid tropical climate with clearly defined wet (April – October) and dry (November – March) seasons. These climatic conditions, combined with generally fertile soils, make the area suitable for a wide range of agricultural activities. The nine communities that made up the LGA are Amansea, Isu-Aniocha, Mgbakwu, Urum, Amanuke, Ebenebe, Ugbenu, Ugbene, and Achalla which serves as the LGA headquarters. Agriculture is the dominant economic activity in the area, the major crops cultivated in the area include cassava, rice, maize, and yam, cultivated largely for both subsistence and local market supply (Osuafor *et al.*, 2020) [16].
The fact that Awka North is an active implementation area of the Value Chain Development Programme (VCDP) informed the choice of this location. VCDP is an agricultural development initiative jointly funded by the Federal Government of Nigeria and the International Fund for Agricultural Development (IFAD), with the aim of improving the productivity, incomes, and livelihoods of smallholder farmers and agro-processors, placing particular emphasis on the rice and cassava value chains (Obianefo *et al.*, 2022) [15]. In Awka North, VCDP interventions include support for selected rice processing cooperatives through capacity-building, improved access to markets, and the introduction of modern processing technologies, notably the false-bottom rice parboiling system. These interventions make the area particularly relevant for examining agricultural value chain development and its implications for rural livelihoods.

Sampling Technique and Sample Size

This study employed survey research design and adopted a two-stage sampling technique in a manner that is both systematic and consistent with VCDP operational structure select the respondents for the study. The VCDP implements its interventions through farmer cooperatives; therefore, the cooperative-based sampling approach was identified as the most appropriate to capture programme-related practices and outcomes.
In the first stage of sampling, cooperatives were selected. According to records from the Anambra State VCDP, three rice processing cooperatives in the study area currently practice the use of false-bottom rice parboiling technique, with two located in Achalla and one in Ebenebe. These three cooperatives were purposively selected because they directly represent the target group using the improved parboiling technology under investigation. To enable meaningful comparison, an additional three VCDP-supported rice processing cooperatives that practice only conventional parboiling methods were randomly selected from the same LGA.
The second stage involved the selection of individual respondents from each cooperative. Each cooperative has an average membership strength of twenty-five (25) rice processors. From each cooperative, ten (10) rice processors were randomly selected to participate in the study. This resulted in a total sample size of sixty (60) respondents, which comprised of thirty (30) processors using the false-bottom parboiling technique and thirty (30) processors using conventional parboiling methods. The selected sample size was considered adequate to allow for comparative analysis while ensuring manageable field data collection and in-depth engagement with respondents.

Method of Data Analysis

The study made use of a combination of analytical techniques such as descriptive statistics, Chi-square analysis and propensity score matching (PSM) technique. Objective one was achieved with the descriptive statistics, while the argument was further strengthened with the support from Chi-square. While objective two was achieved with the help of PSM from R software.

Model Specification

A. Chi-square

The rice quality parameters referred to in the study include whiteness, brightness, texture, aroma, black patches, and the proportion of broken rice. These parameters were identified and categorized based on observable quality outcomes. The functional relationship in objective one for the model is expressed as:

$$RQP = f(PT)$$

Where:
RQP = rice quality parameter represents each of the identified attributes above. And PT = parboiling technology refers to the type of parboiling method used, categorized as false-bottom or conventional.

However, the Chi-square statistics is explicitly specified as:

$$x^2 = \sum\left[\frac{(O_i - E_i)^2}{E_i}\right]$$

Where:
χ^2 denotes the Chi-square test statistic, O_i = observed frequency of each rice quality category, E_i = expected frequency under the assumption of no association between rice quality and parboiling technology.
The null hypothesis assumed that there was no significant difference in rice quality parameters between rice processed using false-bottom and conventional parboiling technologies.

B. Propensity Score Matching
To estimate the effect of the false-bottom rice parboiling technology on rice quality parameters, the study applied a Propensity Score Matching (PSM) technique. The rice quality was proxied by output quality, defined in terms of observable attributes as earlier defined. Output quality was treated as a binary outcome, indicating whether the processed rice met acceptable quality standards or not.
The use of Propensity Score Matching was motivated by the non-random nature of technology adoption among rice processors. Since participation in the false-bottom parboiling technology was not randomly assigned, simple comparison between adopters and non-adopters could lead to biased estimates due to differences in observable characteristics. PSM helps to address this potential selection bias by constructing a comparable control group based on observable covariates after identifying a systemic mean difference (SMD) in the covariates. In the first stage, the propensity score, defined as the probability of adopting the false-bottom parboiling technology, was estimated using a binary logit model. The adoption equation is specified as:

$$P(Tech_i = 1|X_i) = Pr(Tech_i = 1) = \Lambda(\alpha_0 + \alpha_1 X_i)$$

Where:
$Tech_i$ is a binary variable indicating adoption of the false-bottom parboiling technology, taking the value of 1 for adopters and 0 for non-adopters. X_i is the vector of observable characteristics (age, sex, marital status, educational level, household size, processing experience, extension contacts, number of trainings attended, estimated annual income) influencing technology adoption. $\Lambda(\cdot)$ represents the logistic cumulative distribution function. α_0 and α_1 are parameters to be estimated. These observable variables in this model represents the vector of covariates selected based on theory and empirical evidence suggesting their influence on technology adoption.
In the second stage, adopters of the false-bottom parboiling technology were matched with non-adopters who had similar propensity scores. This matching process ensured that both groups were comparable in terms of observed characteristics. The effect of the technology on rice quality output was then estimated by comparing the mean outcome between matched adopters and non-adopters.
The average treatment effect on the treated (ATT) is specified as:

$$ATT = E(Y_1 - Y_0 \mid Tech = 1)$$

Where:
Y_1 = rice quality output for adopters of the false-bottom parboiling technology, Y_0 = counterfactual rice quality output that adopters would have obtained had they used the conventional parboiling method. A positive and statistically significant ATT indicates that the adoption of the false-bottom parboiling technology improves the likelihood of producing high-quality rice output compared to conventional parboiling practices.

4. Results and Discussion
4.1. Difference in Rice Quality Parameters
The results presented in Table 1 showed statistically significant differences in rice quality parameters between processors who adopted the false-bottom parboiling technology and those who relied on conventional methods. All assumptions underlying the Chi-square test were satisfied, and in instances where expected cell counts were below five, Fisher's exact test was appropriately applied. These observed differences underlined the role of improved parboiling technology in enhancing rice quality outcomes under the Value Chain Development Programme, consistent with the programme's quality-oriented objectives.
For the rice appearance: the results showed that 76.7% of rice processed using the false-bottom technology appeared white, while 10.0% appeared brown and 13.3% mixed. In contrast, only 3.3% of rice processed using conventional methods appeared white, with 23.3% brown and a dominant 73.3% classified as mixed. Fisher's exact test (2.96***) confirmed that this difference is statistically significant at the 1% level of probability. This finding suggests that the false-bottom technology produces rice with a more desirable white appearance, which is widely associated with higher consumer preference and better market prices. This result agrees with Peterson-Wilhelm *et al*. (2022) [17] and Adewale *et al*. (2024) [3], who reported that Nigerian consumers place strong value on visible grain attributes, particularly colour uniformity. The predominance of mixed and brown grains under conventional processing reflects uneven heat distribution and moisture control, a challenge also noted by Obianefo *et al*. (2023) [14] and Meresa *et al*. (2020) [11].
For rice texture among false-bottom processors, 50.0% of rice was reported to have a hard texture, 46.7% medium, and only 3.3% soft. For conventional processors, 26.7% reported hard texture, 30.0% medium, and 43.3% soft. Fisher's exact test (1.97*) showed that the difference is significant at the 5% level of probability. Medium to hard texture is generally preferred because it reflects effective gelatinisation during parboiling, producing rice that cooks evenly without becoming mushy. This finding aligned with Adekoyeni and Adeboye (2018) [2] and Muochebe *et al*. (2021) [12], who demonstrated that controlled soaking and parboiling temperatures improve rice texture and cooking quality. The higher proportion of soft-textured rice among conventional processors suggests suboptimal hydrothermal control, consistent with observations by Ndindeng *et al*. (2025) [13].
For rice aroma: the results revealed that 43.3% of false-bottom rice had a strong aroma, 40.0% mild aroma, and 16.7% no aroma. In comparison, 50.0% of rice processed conventionally had a strong aroma, 43.3% mild aroma, and only 6.7% no aroma. The Chi-square value (7.88***) showed that this difference is statistically significant at the 1% level of probability. While conventional processing produced

slightly more strongly aromatic rice, the false-bottom technology resulted in a more balanced aroma profile with fewer aroma-deficient grains. This pattern is consistent with Salam *et al*. (2024) [18], who reported that parboiling conditions influence volatile compound retention and aroma expression. The finding also suggests that excessive or uneven heating under conventional methods may intensify aroma at the expense of other quality attributes, a trade-off noted by Zhuang *et al*. (2025) [21].

Table 1: Difference in rice quality parameters

Rice quality parameters:	False-bottom		Conventional		Expected count
	Frequency	%age (%)	Frequency	%age (%)	
Rice appearance:					
White	23	76.7	1	3.3	23
Brown	3	10	7	23.3	3
Mixed	4	13.3	22	73.3	4
Fisher's exact test	2.96***				
Rice Texture:					
Hard	15	50	8	26.7	15
Medium	14	46.7	9	30	14
Soft	1	3.3	13	43.3	1
Fisher's exact test	1.97*				
Rice Aroma:					
Strong	13	43.3	15	50	13
Mild	12	40	13	43.3	12
No aroma	5	16.7	2	6.7	5
Chi-square	7.88***				
Rice cleanliness:					
Very clean	18	60	4	13.3	18
Clean	6	20	24	80	6
Dirty	6	20	2	6.7	6
Chi-square	5.00 ***				
Black parches:					
Very much	0	0	19	63.3	6
Much	6	20	10	33.3	0
Less	24	80	1	3.3	24
Fisher's exact test	1.41 NS				
Cooking/parboiling time:					
Less than 40 min.	22	73.3	3	10	22
40 - 60 min.	6	20	11	36.7	6
More than 60 min.	2	6.7	16	53.3	2
Fisher's exact test	3.80				
Brokenness:					
Much	9	30	19	63.3	9
Moderate	6	20	7	23.3	6
Less breakage	15	50	4	13.3	15
Chi-square	3.78***				

Source: Field Survey, 2025. Significant at 1% (***), 5% (**) level of probability.

For rice cleanliness: false-bottom processors reported that 60.0% of their rice was very clean, 20.0% clean, and 20.0% dirty. In contrast, conventional processors recorded only 13.3% as very clean, while 80.0% was classified as clean and 6.7% dirty. The Chi-square statistic (5.00***) indicates a highly significant difference at the 1% level of probability. These results demonstrate that the false-bottom technology substantially improves rice cleanliness by reducing husk residues, stones, and other impurities. This finding agrees with VCDP implementation reports, which emphasize improved hygiene and reduced contamination as key benefits of false-bottom systems (State Programme Management Unit, FGN/IFAD VCDP, 2017 [20]; State Programme Management Unit, FGN/IFAD VCDP, 2022 [20]).

For black patches: none of the rice processed using the false-bottom technology was reported to have very much blackening, while 20.0% had much and 80.0% had less. In contrast, 63.3% of conventionally processed rice had very much black patches, 33.3% had much, and only 3.3% had less. Although Fisher's exact test (1.41, not significant) did not show statistical significance. Black patches are commonly associated with poor heat regulation and charring during parboiling. This observation supports the findings of Meresa *et al*. (2020) [11] and Obianefo *et al*. (2023) [14], who linked uncontrolled heating during conventional parboiling to grain scorching and surface defects.

For cooking and parboiling time: 73.3% of rice parboiled with false bottom cooked in less than 40 minutes, 20.0% within 40 to 60 minutes, and only 6.7% required more than 60 minutes. In contrast, only 10.0% of conventionally processed rice cooked in less than 40 minutes, while 36.7% cooked within 40 to 60 minutes and 53.3% required more than 60 minutes. Fisher's exact test (3.80***) confirmed that this difference is significant at the 1% level of probability. The shorter cooking time associated with false-bottom rice reflects improved gelatinization and moisture uniformity, which enhances consumer convenience. This finding is consistent with Ndindeng *et al*. (2025) [13], who reported that improved parboiling technologies reduce cooking time and improve household acceptability.

For brokenness: the results further revealed that 50.0% of false-bottom rice experienced less breakage, 20.0% moderate breakage, and 30.0% much breakage. In contrast, 63.3% of conventionally processed rice had much breakage, 23.3% moderate breakage, and only 13.3% less breakage. The Chi-square value (3.78***) implied that this difference is statistically significant at the 1% level of probability. Lower levels of broken grains among false-bottom processors suggests stronger grain integrity and improved milling performance. This finding strongly agrees with Muochebe *et al*. (2021) [12], Itadare *et al*. (2025) [9], and Ndindeng *et al*. (2025) [13], all of whom reported reduced breakage and higher head rice yield under improved parboiling systems.

4.2. Effect of False-bottom Adoption on Rice Quality

The result of the propensity score matching (PSM) used to investigate the effect of false-bottom adoption on rice quality is presented in Tables 2 to 4. The analysis identifies the socioeconomic factors that significantly influenced adoption (Table 2), examines how adoption impacted rice output as a proxy for quality (Table 3), and assesses the robustness of this effect through regression analysis (Table 6).

The logistic regression results uncovered several socio-economic factors significantly influencing the likelihood of adopting the false-bottom parboiling technology. Overall, the model diagnostics indicate satisfactory fit, with the Akaike Information Criterion and deviance statistics confirming the robustness of the estimated model (AIC = 57.485; Null deviance = 83.178). These results collectively demonstrate that key socio-economic factors, particularly sex, extension contact, training exposure, and income, play a decisive role in influencing the adoption of false-bottom parboiling technology. By extension, these factors indirectly shape rice quality outcomes, reinforcing the importance of targeted training, inclusive extension services, and financial support mechanisms in scaling improved rice processing technologies.

Sex had a positive and statistically significant effect on adoption (Estimate = 2.513, z = 2.33**, $p < 0.05$) at the 5% level of probability, implying that male processors were more likely to adopt the false-bottom technology than their female counterparts. The finding aligned with previous studies which reported that men tend to dominate technology adoption in rice processing due to greater access to resources, equipment ownership, and decision-making authority within cooperatives (Salami & Adisa, 2022 [19]; Abubakar *et al*., 2023 [1]). Similar gender-based adoption patterns were also observed by Ndindeng *et al*. (2025) [13], who noted that women processors often face financial and institutional constraints that limit uptake of improved parboiling technologies.

Extension contacts exhibited a strong positive and statistically significant effect on adoption (Estimate = 0.814, z = 2.83**, $p < 0.01$). This implied that an increase in the frequency of extension visits significantly raised the probability of adopting the false-bottom technology. Regular interaction with extension agents exposes processors to improved parboiling practices, reinforces correct operational procedures, and builds confidence in using new technologies. This finding agrees with Salami & Adisa (2023) [19], who emphasized that extension support plays a critical role in facilitating technology uptake among rice processors. Obianefo *et al*. (2023) [14] similarly reported that processors with frequent extension contact demonstrated better adherence to recommended practices and achieved superior rice quality outcomes.

The number of training sessions attended also had a positive and significant effect on adoption (Estimate = 0.336, z = 2.04**, $p < 0.05$). This finding suggests that participation in training programmes substantially increased the likelihood of adopting the false-bottom parboiling technology. Training enhances technical competence and reduces uncertainty associated with operating improved facilities. This result supports earlier evidence that capacity-building initiatives are central to the adoption of improved rice processing technologies (Meresa *et al*., 2020 [11]; Itadare *et al*., 2025 [9]). It also aligned with VCDP implementation reports, which stress that structured training is necessary for achieving sustained improvements in processing quality (State Programme Management Unit, FGN/IFAD VCDP, 2017 [20]; State Programme Management Unit, FGN/IFAD VCDP, 2022 [20]).

Annual income was found to be statistically significant (Estimate = 0.001, z = 2.15**, $p < 0.05$), this implied that higher-income households were more likely to adopt the false-bottom technology. This finding suggests that financial capacity remains an important determinant of adoption, particularly given the relatively capital-intensive nature of improved parboiling facilities. Processors with higher income levels are better positioned to meet upfront costs and complementary investments such as improved packaging and branding. This result is consistent with findings by Lawal *et al*., 2025 [10] and Ndindeng *et al*., 2025 [13], who reported that income and liquidity constraints strongly influence the adoption of improved rice processing technologies.

Table 2: Logistic regression results for propensity score (PS)

Covariate	Estimate	Std. Error	z value
(Intercept)	-16.150	5.100	-3.17
Sex	2.513	1.078	2.33**
Age	0.015	0.037	0.41
Marital status	1.517	0.889	1.71*
Educational level	0.084	0.081	1.03
Household size	0.175	0.118	1.48
Processing experience	-0.019	0.063	-0.31
Extension contacts	0.814	0.288	2.83**
Number of trainings attended	0.336	0.165	2.04**
Estimated annual income	0.001	0.000	2.15**
AIC: Akaike Information Criterion	57.485		
Null deviance	83.178		

Source: Field Survey, 2025. Significant at 1% (***), 5% (**), 10% (*) level of probability.

Marital status showed a positive but weaker effect on adoption (Estimate = 1.517, z = 1.71*, $p < 0.10$) at the 10% level of probability, suggesting that married processors were slightly more inclined to adopt the technology. This may reflect greater household responsibilities and a stronger motivation to pursue stable and higher-quality income-generating activities. Similar associations between marital status and technology adoption were reported by Abubakar *et al*. (2023) [1], who noted that married households often exhibit greater risk aversion but higher commitment to productivity-enhancing investments.

Other variables, including age, household size, education level, and years of processing experience, did not show statistically significant effects on adoption. This suggests that access to information, training, and financial resources may be more critical determinants of adoption than demographic characteristics alone. This finding diverges from some studies that report experience and education as significant adoption drivers (Arouna *et al*., 2023) [6], but it supports evidence from Obianefo *et al*. (2023) [14], who observed that exposure to programme support rather than personal characteristics explained much of the variation in adoption outcomes among rice processors in Anambra State.

The treatment effect analysis revealed a clear and substantial difference in mean output between adopters and non-adopters of the false-bottom parboiling technology. Conventional processors recorded a mean output of 16,553.49 kg, whereas processors who adopted the false-bottom technology achieved a considerably higher mean output of 33,636.57 kg. The associated t-value of 8.07***, significant at the 1% level of probability, confirmed that this difference is statistically robust and unlikely to be due to chance. The finding implied that adoption of the false-bottom parboiling technology more than doubled rice output relative to conventional processing methods. For this study, higher output should not be interpreted as a mere increase in volume, but as an outcome of improved processing efficiency and reduced post-parboiling losses. Improved technologies enhance grain strength, reduce fissuring, and limit breakage during milling, thereby increasing the proportion of marketable rice. This finding is in agreement with Ndindeng *et al*. (2025) [13], who reported that improved parboiling systems significantly increase head rice yield and reduce processing losses across sub-Saharan Africa.

Table 3: Treatment effect from PSM

Treatment effect	Mean output	t-value	Degree of Freedom	Pr(>|t|)
Conventional	16553.49	8.07***	30	0.000
False-bottom	33636.57			

Source: Field Survey, 2025. Significant at 1% (***), 5% (**), 10% (*) level of probability.

The observed output gains are also aligned with earlier empirical evidence showing that false-bottom parboiling improves heat distribution and moisture control, leading to more uniform gelatinization and fewer defects such as black patches and chalkiness (Meresa *et al*., 2020 [11]; Obianefo *et al*., 2023 [14]). Itadare *et al*. (2025) [9] similarly found that adoption of improved parboiling technologies translated into higher recoverable rice output through reduced breakage and improved milling efficiency. Based on this finding, the treatment effect analysis provided strong empirical support for the effectiveness of the false-bottom parboiling technology. The results reinforce the argument that technology adoption under the Value Chain Development Programme delivers tangible improvements in rice quality and processing efficiency.

The robust regression results further reinforce the positive and statistically significant impact of false-bottom technology adoption on rice quality outcomes. The overall performance of the regression models was strong. The controlled model recorded an R-square of 0.760 and an adjusted R-square of 0.712, while the uncontrolled model recorded an R-square of 0.677. These values indicate that adoption alone explained a substantial proportion of the variation in rice quality outcomes, and that including control variables modestly improved explanatory power. The high explanatory strength of the models underscored the central role of false-bottom technology adoption in determining rice quality outcomes, lending further empirical support to its promotion under the Value Chain Development Programme.

When control variables were included, adoption recorded an estimate of 0.760 with a t-value of 9.59***, significant at the 1% level of probability. Without controls, the adoption coefficient remained positive and significant at 0.664 with a t-value of 11.03**, also significant at the 1% level. This consistency of the adoption effect across both model specifications suggests that the observed improvement in rice quality is strongly attributable to technology adoption rather than to differences in processors' socioeconomic characteristics. This finding aligned with Ndindeng *et al*. (2025) [13] and Itadare *et al*. (2025) [9], who reported that improved parboiling technologies consistently enhance output quality through better heat regulation, reduced grain fissuring, and lower breakage rates. Obianefo *et al*. (2023) [14] also observed that once improved processing practices are adopted, quality outcomes improve regardless of individual processor characteristics, supporting the dominance of technology effects over socioeconomic factors.

Table 4: Robust regression from PSM

	With control			Without control		
	Estimate	Std. Error	t value	Estimate	Std. Error	t value
(Intercept)	10.990	1.064	10.33	9.709	0.043	228.12
Adoption	0.760	0.079	9.59***	0.664	0.060	11.03***
Sex	-0.045	0.063	-0.72			
Age	0.006	0.002	2.27**			
Marital status	-0.018	0.051	-0.343			
Educational level	-0.007	0.005	-1.54			
Household size	-0.002	0.007	-0.24			
Processing experience	0.002	0.004	0.38			
Extension contacts	-0.017	0.014	-1.21			
Number of trainings attended	-0.003	0.009	-0.32			
Estimated annual income	-0.102	0.080	-1.27			
F-stat.	15.550			121.7		
R-square	0.760			0.6772		
Adjusted R	0.712			0.6716		

Source: Field Survey, 2025. Significant at 1% (***), 5% (**), 10% (*) level of probability.

Among the control variables, age emerged as the only factor with a statistically significant effect at the 5% level (Estimate = 0.006, t = 2.27**). This suggests that older processors may derive slightly greater quality benefits from adoption, possibly due to accumulated processing experience, better judgement in handling parboiled rice, and more cautious adherence to recommended procedures. This result aligned with findings by Meresa *et al*. (2020) [11], who noted that experience enhances the effective use of improved parboiling techniques. However, it contrasts with studies that reported diminishing returns to age due to declining physical capacity (Arouna *et al*., 2023) [6], indicating that the effect of age may be study-specific.

5. Conclusion and Recommendations

This study examined the effect of false-bottom rice parboiling technology on rice quality parameters in Awka North Local Government Area of Anambra State, with emphasis on differences in observable quality attributes and the causal effect of adoption on output quality. The findings clearly showed that false-bottom parboiling technology delivers superior rice quality outcomes compared to conventional parboiling practices. Statistically significant differences were observed across key quality parameters like rice appearance, texture, cleanliness, cooking time, and level of broken grains. Rice processed using the false-bottom technology was whiter, cleaner, more uniform, less broken, and required shorter cooking time, attributes that are strongly associated with consumer preference, higher market value, and competitiveness in Nigerian rice markets. Although aroma and black patches showed mixed statistical outcomes, though, the practical differences still favoured the improved technology, particularly in reducing processing defects linked to poor heat control.

Beyond the descriptive quality differences, the impact evaluation results provided robust evidence that adoption of false-bottom technology significantly improves rice quality outcomes when selection bias is accounted for. The propensity score matching (PSM) analysis observed that adopters achieved substantially higher output than non-adopters, more than doubling mean output levels. This output gain reflects improved processing efficiency, reduced losses, and enhanced grain integrity rather than mere scale effects. The robustness checks further confirmed that adoption remained a strong and significant determinant of rice quality outcomes even after controlling for socioeconomic characteristics, with adoption alone explaining a large proportion of the variation in quality indicators. Taken together, these results provide compelling empirical support for the effectiveness of false-bottom parboiling technology under the Value Chain Development Programme and demonstrate that technology adoption, rather than processor characteristics, is the primary driver of improved rice quality in Awka North.

However, since the study found that a clear quality and efficiency gains was associated with false-bottom parboiling, government agencies and development partners should prioritize the scaling up of this technology among rice processors in Awka North and other rice-producing areas.

6. References

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