PrOpCom

Making Nigerian Agricultural Markets Work for the Poor

Monograph Series # 18

Financial Analysis of Parboiling and Milling Techniques in the Kura Kano Corridor

Prepared by

Professor Olabisi Ogunforowa

March 2007

Funding for this programme is provided by the United Kingdom's Department for International Development (DFID)

40 Mississippi Street, Maitama, Abuja, Nigeria • Tel: +(234) 9 413 8291/2 • Fax: +(234) 9 413 829

Disclaimer

The PrOpCom Monograph Series seeks to provide a broader dissemination of the information and views collected through the efforts of the various service providers and consultants undertaking work in support of the PrOpCom programme. We believe this information will be useful in informing the policy dialogue in Nigeria and for improving the planning and execution of agricultural and agribusiness activities within the country.

The documents in this series represent the final deliverables as presented by the engaged service providers or consultants in responds to terms of reference of contracts let by PrOpCom in execution of its programme. They have not been further edited or editorially polished. Consequently, there is wide variation in the editorial quality of these documents. Nevertheless, the information contained in these document is deems useful for policy and planning purposes.

The views and opinions expressed in these documents are solely those of the authors of the document and do not necessarily represent the views of PrOpCom, SAII Associates, Chemonics International or PrOpCom's funding agent, the Government of the United Kingdom's Department for International Development (DFID)

Information from these documents can be freely used and quoted on condition that it is properly sourced to the concerned document.

Financial Analysis of Parboiling and Milling Technologies in Kura-Kano Rice Corridor

Summary of Findings and Recommendations

Pursuant to the implementation of its mandate, PrOpCom's conducted rice commodity chain analysis, one of its target commodities. The study revealed that improvement in all aspects of processing technologies and marketing was the key to moving the Nigerian rice industry to higher levels of technical and financial efficiency.

As a follow-up to the Bida rice processing study, which made a comparative analysis of technical and financial efficiency of three systems of parboiling and milling paddy rice, this study was designed to further deepen the assessment of the technical and financial efficiency of 5 parboiling and 6 milling technologies commonly found in Kura-Kano rice corridor, including those introduced by SG 2000 and TADCO Nigeria Ltd.
Specific tasks of the study focused on qualitative and quantitative analysis of the following determinants of technical and financial efficiency in rice processing:

- Comparative analysis of technical efficiencies and cost effectiveness of the five parboiling and milling technologies
- Financial viability analysis of custom/contract parboiling and milling operations
- Comparative analysis of the technical efficiency and financial viability of the integrate parboiling and milling technologies
- Comparative analysis of broken/head-rice and milling ratios under integrated rice processing technology.
- The effects of winnowing, polishing and post milling hand-picking on rice quality, cost and returns
- Sensitivity analysis to identify and prioritise productivity and profit-enhancing variables that require special attention of management in the course of rice processing business.

The study made a few propositions on the strategies for using the findings of the study to advance rice processing practices to higher level of technical and financial efficiency, quality driven international competitiveness and consumer acceptability.

The technical and financial efficiency analysis of parboiling and milling technologies was designed to generate benchmark information for advising processors who engage in contract parboiling and milling, and/or integrated processing operations. The analysis would, in addition, identify key processing milestones, which could be used by PrOpCom to advise existing rice processing stakeholders and other potential investors on the most technically efficient, cost effective and profitable combinations of integrated parboiling and milling technologies.

Data for the study was collected over a period of about 33 days using cost route approach. A total of 30 bags of paddy of the same variety were used for the study. Six bags of paddy were distributed to each of the five parboiling technologies, while a bag of the parboiled paddy from each of the parboiling technologies was delivered to each of the six mills for milling. Price and technical coefficients, as well as fixed costs were collected through formal and informal interview with the stakeholders. Input-output variables were measured in both physical and value terms.

Main Findings

Parboiling Technologies

Parboiling is the central activity in rice processing and an important operation that determines rice quality. It consists of three major activities namely, soaking either overnight in warm water or in hot water for 4-5 hours, steaming and drying either in the sun or under the shade. Other pre parboiling operations practiced to improve the quality of the raw paddy include sieving and washing of the paddy before soaking. Considerable variation in the equipment and processes of parboiling largely determined the quality of parboiled paddy and, invariably, rice

The study revealed that only Liman engaged in contract parboiling; others engaged in contract parboiling only in combination with contract milling. Contract parboiling was generally less profitable but contract milling was more profitable and widely practiced as a way of increasing capacity utilization and revenue. The study also revealed that improved parboiling and milling systems of TADCO, Kura and to some extent Dawanau were more profitable than the traditional systems of Liman and Garko.. It was also observed that pre parboiling operations such as sieving and washing of raw paddy increased the quality and price of the rice.

The parboiling equipment recorded varying degrees of capacity utilization. The low value (33%) recorded by the women parboilers in Garko could be attributed to the fact that they parboiled only 1.5 bags of paddy in two days of the week. Both Hanigha and Dawanau had high volume parboiling equipment, which accounted for the high percentage of 82% and 68%, respectively. However, despite the high volume, Dawanau recorded 68% capacity utilization because they only parboiled paddy for 8 months in a year. There was a general mismatch between all the parboiling and milling capacities of all the systems, but Garko and Liman had the highest mismatch of 1% and 2%, respectively. This mismatch found expression in low capacity utilization, high depreciation and reduction in profit per bag.

The washing paddy efficiency ratio, a function of the quality of paddy, reflects the thoroughness of washing, which impacts positively on rice quality. Garko parboiling women system do not normally wash paddy, probably because of the acute scarcity and high cost of water. However, in the alternative, the Garko women deliberately sourced for clean and good paddy variety. The high washing efficiency ratio recorded for TADCO (10%) and Kura (10%) was as a result of thorough washing of the paddy. This translated into better quality and higher price of their rice samples

If all the parboiling systems were to be engaged in contract parboiling, three of the parboiling systems (Liman, Garko and TADCO) would be sustaining losses, while Dawanau and Hanigha would be making positive margins. The highest loss was sustained in Garko (-158.97N) as a result of the high variable and depreciation costs, partly a consequence of low capacity utilization and high input cost. Dawanau recorded a positive value of 134.58N per bag because it was enjoying economy of scale (parboiling equipment handles 7 bags/batch of parboiling), which conferred lower cost per unit of parboiled paddy. Hanigha parboiling system was only marginally profitable, with a margin of 6.86N per bag.

The total cost of parboiling, as a percentage of total processing cost, is the percentage of parboiling cost compared with the total processing cost. The highest value of 96.72% was recorded for Kura, while the lowest value of 88% was recorded for Liman. These values further confirmed the findings of previous research, to the effect that parboiling operations accounted for a very high percentage of total cost of rice processing. Critical analysis of the structure of parboiling cost indicated potentially rewarding area of rice processing where the application of cost reduction strategies, and work and method study activities could pay the highest dividends. The analysis revealed that cost reduction strategies directed at variables such as paddy, fuel/energy, water and labour would pay the highest dividend

Milling Technologies

There was considerable variation in the installed and running capacities, of the mills. All the mills undertook a two-pass milling process within the range of 6 to 15 minutes milling time. All the milling systems recorded low values of capacity utilization, except Hanigha/Kura that recorded capacity utilization of 51% due to the large number of its contract milling activities. Liman recorded the lowest capacity utilization of 2% as a result of serious power failure. Other general constraints to capacity utilization identified in the mills included low parboiling capacity; low demand for the local rice; non availability of paddy all year round; erratic supply of electricity; low capital for inventory build-up; lack of storage facilities; and varietal preference by parboilers.

Four of the systems recorded positive milling margins, with TADCO having the highest margin of N269.83, while Liman recorded a loss of N134.91. Hanigha recorded a loss N11.53 because the low fee of N100/bag, which was designed to serve as promotional strategy to capture the milling market in Kura area.

Milling Ratios

Milling ratio is an indicator of the total rice recovered from raw paddy from a given milling technology. Milling ratio is a function of the following factors:

1. Efficiency of parboiling
2. Efficiency of the mill
3. Efficiency of the operators' skill, and
4. The variety of paddy.

When the average milling ratios were computed for each of the parboiling systems, TADCO parboiled paddy recorded the highest milling ratio of 68.33%, closely followed by Hanigha at 67.5%. It was however difficult, if not impossible, to determine the relative contributions of each of the 4 factors to the milling ratio. Accordingly, processors should ensure best practices in all the factors in order to achieve optimum milling ratio.

Broken Head Rice Ratios

The efficiency of parboiling and milling systems determines the broken/head rice ratio, which in turn impacts the quality and, consequently, the price of milled rice. The method of drying, as well as post parboiling storage before milling, affect milling and broken/ head rice ratios. Shade drying and post parboiling storage before milling have also been reported to affect the proportion of broken/head rice ratio. When the average broken/head rice ratios were computed for each of the parboiling and milling systems, Hanigha parboiling system gave the least percentage of broken rice (13%), while Garko milling system gave the least percentage. The low figure in Garko milling was attributable to post milling hand picking and not the efficiency of the mill.

The inference to be drawn from the analyses of the milling and broken/head rice ratios is that a combination of TADCO parboiling and Kura milling systems would produce the best and most efficient rice processing system. If it were possible to get Kura mill of lower cost and capacity, then this could be combined with the efficient and low capital outlay TADCO parboiling system. This would solve some of the major problems of small-scale women parboilers and it might also lead to other knock-on improvements in technical efficiency such as increased mill capacity utilization arising from the proliferation of more efficient small scale parboilers particularly women.

Financial Efficiency of Integrated Parboiling & Milling Technologies (Hypothetical/Normative Combinations)

The results showed that the truly integrated systems such as Garko integrated (CL), TADCO integrated (DI), and Hanigha integrated (EH) were profitable. However, when Garko, TADCO and Hanigha **parboiling** were combined with Liman milling (CG, DG and EG), losses were sustained. The reason for these losses could be attributable to imported inefficiencies of Liman's **milling**. On the other hand, a good example of imported efficiency was the combination of Garko parboiling and TADCO milling (CI), which generated gross margin of N1, 177.73 as against N745.6 when Garko parboiled paddy was milled in Garko mill (CL). TADCO and Hanigha integrated systems (DI and EH) recorded superior performance in most of the indices of financial efficiency. This further confirmed that TADCO and Hanigha parboiling and milling equipment were more efficient than the others.

These results provided valuable insight into possible combinations of parboiling and milling systems that, all things being equal would be technically and financially appropriate to different categories of investors, in particular, prospective small and medium scale rice processors. The information generated from this analysis could be combined with the profile of investment costs of different parboiling and milling systems and used for developing appropriate parboiling/milling combinations for different categories of prospective investors in rice processing. Three of such recommended normative combinations, which would be appropriate for low and medium capital investors are: (a) the low cost, but efficient and slightly bigger TADCO parboiling equipment with (preferably lower capacity and cost) Hanigha mill (DH), and (b) TADCO parboiling equipment with Dawanau mill plus polisher (DJ). (c) For high capital and high volume investors, EI and EH, both of which combined high parboiling and milling efficiencies, are recommended.

Effect of Polishing and Post Milling Picking on Rice Quality, Cost and Returns

The inferences to be drawn from these analyses are:

- Polishing with Dawanau mill (J) improved rice quality and added value, even though there was some weight loss. It eliminated post milling winnowing characteristic of Dawanau milling machine K without polisher.
- The superiority in technical efficiency of Kura milling systems (H) over Garko milling system (L) was translated into financial superiority of N482.16 when Kura parboiling system was used.

- The superiority in technical efficiencies embodied in TADCO (I) and Kura (H) milling technologies resulted in financial superiority of N474.54 and N263.49, respectively, over the Garko milling system.
- The in-built technical efficiencies in TADCO and Kura parboiling and milling systems made post milling winnowing and handpicking unnecessary.

Sensitivity or Parametric Analysis
Sensitivity analysis helps to pinpoint critical variables that require special attention of management in the course of rice processing operations.
Two of such crucial variables examined in this study were:

- changes in the prices of raw paddy; and
- changes in the price of rice.

1% change in the price of paddy resulted in approximately 1.8% change in the level of profit. 1% change in the price of rice resulted in 2.65% change in the level of profit. Comparatively, therefore, a change in the price of rice produced greater impact on the level of profit than a change in the price of paddy. The implication of the analysis is that rice quality improvement is financially more rewarding than strategy to purchase paddy at lower price. In practical terms, however, profit would be maximized when rice quality and price improvements are combined with strategies to reduce the cost of paddy

Strategies for Moving Rice Processing Practices to Higher Level of Technical and Financial Efficiency.

A great challenge in milling remains the imbalance between milling capacity on one hand and inadequate supply of raw and parboiled paddy on the other. Solving this puzzle remains yet the greatest challenge to increasing capacity utilisation and mill output. The millers need enhanced capital and storage facilities to stock paddy and avoid widely fluctuating seasonal variations in supply and prices of paddy. In addition, improved parboiling technologies and increased parboiling capacity are prerequisites to increasing milling efficiency and capacity utilization. As observed, the mills at TADCO and Kura were not only faster, but they also gave cleaner and better-polished rice. However, operator’s skill and paddy throughput need enhancement. The daily breakage of sieves was found to be the direct result of the use of un-sieved paddy and poorly trained mill operators.

The challenge is how to increase parboiling capacity to meet the needs of the small to medium milling enterprises in order to raise the utilization of mills to near installed capacities. The Kura Hanigha and the Dawanau Mass Volume Parboilers could undergo further customisation to meet the massive demands for parboiled paddy. However, the major problems of the Hanigha include the high start-up investment and operating costs; and the propensity for over-cooking that gives the rice honey colour. Some structural improvements are therefore necessary before its wider adoption. The Dawanau Mass Volume traditional parboiling is characterised by low cost investment, high depreciation rate, as well as the problem of over-cooking of paddy during operation. Improvement in Dawanau parboiling, particularly in its technology and construction materials, is essential before it becomes attractive to an investor.

The small scale parboilers, most especially women, parboiling half (½) to one (1) raw paddy bag daily, estimated to be responsible for the parboiling of 80-90% of all parboiled paddy output within Kura-Kano corridor, need improvement in their efficiencies and parboiling volumes. Introduction of TADCO parboiling equipment to the small processors, most especially women parboilers in the rice corridor, could double parboiled paddy output while increasing technical and financial efficiencies. This is important because women constitute the majority (90%) of the parboilers in this corridor, TADCO parboiling equipment is an improved parboiling technology, a hybrid between the traditional and Hanigha parboilers, in terms of engineering design, capacity, performance and output.

In addition, the capital needed for purchasing the equipment may be affordable to this category of processors. Introduction and propagation of the improved TADCO parboiling technology have the potential to, in the short run; double the total throughput of parboiled paddy by enhancing capacity utilization, quality and quantity of the milled rice output from the different under- utilized mills in the corridor. Uses of TADCO parboiler can double the incomes of the women parboilers in the rural areas, in the medium and long term.

Method and work-study analysis conducted during this study revealed that labour productivity could be improved by making minor adjustments in the procedures currently being used to accomplish parboiling and milling tasks. This could reduce wastages, and contamination of paddy and milled rice. Better quality and higher quantity of outputs could be achieved through improvement in the layout and configuration of milling and parboiling equipment and facilities
There is a glaring need for interventions in the following areas:

- Capacity building for business services development; consisting of entrepreneurship, financial analysis and business management, record keeping, packaging and branding, procurement, marketing etc.
- Capacity enhancement plans and programme for the operators of parboiling and milling equipment.
- Capacity building for trade groups formation, development, and consolidation.
- Awareness creation to sensitise consumers about the availability of good quality Nigerian rice.

Based on observed factors and practices of different millers and parboilers, of standardized procedures manual on parboiling and milling best practices could be developed to serve as a guide to processors. This could be use in capacity enhancement, outreach and advocacy services.

Quality, branding and packaging of locally processed rice have to be supplemented with marketing advocacy, campaigns, advertisement and other strategic public relation techniques. Rice consumers need attitudinal and value re-orientation. Appropriate packaging and branding for high quality locally processed rice is indispensable before its entry into the segmented imported rice market, where it could attract premium pricing and high sales volume.

Suggested approaches to operationalising these recommendations include demonstrations, SIF part funding of innovations, engagement with Kura/Hanigha, TADCO, Dawanau and other processors, fabricators, marketers etc.

Main Report

1. Study Background

The quality of the local rice still remains a major concern for the future of the Nigerian rice sector. Previous rice sector studies have identified poor physical appearance and cleanliness as the major problems of the rice delivered to the Nigerian markets. In consequence, the demand for better quality imported rice had been increasing steadily over the last two decades, creating rice supply-demand gaps, which had to be filled through official and unofficial imports.

PrOpCom recognized technology development and transfer, and improvement in market efficiency as pre-requisites to sustainable increase in productivity, income and employment. PrOpCom also recognized that the starting point in the design of intervention catalytic activities was to conduct chain analysis and need assessment study. Accordingly, and pursuant to the implementation of its mandate, PrOpCom's conducted rice commodity chain analysis, one of its target commodities. The commodity chain analysis identified inefficient parboiling and milling as the major cause of poor quality of local rice. The study also clearly revealed that improvement in all aspects of processing technologies and marketing was a viable area of catalytic intervention activities that could take the Nigerian rice industry to higher level of quality driven international competitiveness, consumer acceptance, and technical and financial efficiency.

It was in the context of these findings that the Bida rice processing study was conducted, with the main objective of making comparative analysis of technical efficiency and financial viability of three systems of parboiling and milling paddy rice. The study revealed yet untapped opportunities for improving the technical efficiency and profitability of rice processing, particularly in the area of improved technology of parboiling, which was identified to be a pressure point that might have a considerable impact on rice quality and cost. Parboiling accounted for an important portion of total rice processing costs. And if improved parboiling technology could reduce these costs and improve rice quality such that it was financially attractive to invest in the technology, then overall processing costs might be reduced, and an important constraint to operating rice mills closer to capacity would have been removed, and rice quality improved[1]. The Bida rice study also identified the potential for the development of a universally applicable model for identifying "weak links" and "capability gaps" that prevented the maximization of quality acceptance, technical and financial efficiency in rice processing. Most importantly, the study identified poor mastery of parboiling and milling techniques as a major factor exacerbating rice quality problems, resulting in low market price, which in turn led to very low returns to rice processing activities.

It was clear from the above exposition that the major challenge to improvement in rice quality was the development of low cost but technically efficient and cost effective parboiling and milling technologies. Therefore, as a follow-up to the Bida study, PrOpCom decided to further deepen the assessment of the technical and financial efficiency of 5

[1] PrOpCom's Report on Rice Commodity Chain Analysis

parboiling and 6 milling technologies commonly found in Kura-Kano rice corridor, including those introduced by SG 2000 and TADCO Nigeria Ltd.

Objective of the Study

The major objective of the study is to make comparative analysis of technical and financial efficiency of 5 parboiling and 6 milling technologies commonly found in Kura-Kano rice corridor. Specific objectives include the following:

- Comparative analysis of technical efficiencies and cost effectiveness of the five parboiling and milling technologies
- Financial viability analysis of custom/contract parboiling and milling operations
- Comparative analysis of the technical efficiency and financial viability of the integrate parboiling and milling technologies
- Comparative analysis of broken/head-rice and milling ratios under integrated rice processing technology
- The effects of polishing and post milling hand-picking on rice quality, cost and returns
- Propose the strategies for using the findings of the study to move rice processing practices to higher level of technical and financial efficiency, quality driven international competitiveness and consumer acceptability.

The technical and financial efficiency analysis of parboiling and milling technologies was designed to generate benchmark information for advising processors who engage in contract parboiling and milling, and /or integrated processing operations. The analysis would, in addition, identify key processing milestones, which could be used by PrOpCom to advise existing rice processing stakeholders and other potential investors on the most technically efficient, cost effective and profitable combinations of integrated parboiling and milling technologies. PrOpCom also intends to use the deliverables from the financial analyses for other purposes, which include:

- identification of priorities for increasing the profitability of rice processing in Kura-Kano rice corridor;
- increasing value addition to rice processors by adopting more efficient processing technologies;
- increasing income, generate employment and improving livelihoods of stakeholders involved in the processing and marketing of rice; and,
- creating greater awareness of existing and yet to be popularised improved processing technologies; and
- removing constraints to efficient rice processing operations.

II. Methodology

Data for the study was collected over a period of about 33 days using cost route approach. A total of 30 bags of paddy of the same variety were used for the study. Six bags of paddy were distributed to each of the five parboiling technologies, while a bag of parboiled paddy from each of the parboiling technologies was delivered to each of the six mills for milling. Price and technical coefficients, as well as fixed costs were collected through formal and informal interview with the respondents. Input-output variables were measured in both physical and value terms. Annex 2 provided some guidelines on the categories of data collected

The weights of paddy and milled rice were taken, and all weights of milled rice were taken immediately after milling in order to ensure uniformity in moisture content. Because of the differences in the weights of raw and parboiled paddy, all the weights of the milled rice were extrapolated to the equivalent weight of 75kg. This standardization was necessary because all prices and costs of inputs and outputs, as well as the fee charged for all contract parboiling and milling operations in the study area, were based on per bag of 75kg.

After milling, the quantities of broken rice from 1 kg of each of the 30 samples were obtained through the use of a specially made wooden sieve. The quantity of broken rice from each of the samples was obtained by extrapolation. This was used to calculate the broken/head-rice ratio for each of the rice samples.

Rice samples had different quality attributes that conferred different market prices. Market survey was conducted in three different markets in the study area. The buying and selling prices of the rice samples were obtained from various rice traders in Dawanau, Sabon Gari and Yankaba markets. A standard measure for marketing rice is the “Mudu” – a metal bowl that measures, approximately, 2.5kg of rice in Kano but 3.4kg in Garko market. The 30 rice samples were displayed in each market, and traders asked to grade and price each sample based on their own criteria for quality. The price quoted in each of the markets varied according to quality parameters such as cleanliness, proportion of broken to head rice, polished or unpolished, presence of red streaked, chaff and white belly grains. The buying and selling prices were collected in Naira/mudu and later converted to price/kg (Table 13). The prices of husk/bran, a by-product of milling, and charcoal and ash, by-products of parboiling, were obtained and used to calculate the total revenue from processing operations.

Data Gathering Problems

Input-output data were measured in both physical and value terms. Physical measurement of variables in the study area presented major problems due to lack of standard measures, poor level of education and varying degrees of adulteration of local measures, which made conversion into standard measures rather unreliable. Value measurement of variables such as rice price based on quality assessment presented problems because of market segmentation, and imperfect competition, all of which characterised rural markets. Other factors that could lead to incorrect measurement included variability in post milling moisture content and level of impurities. Casual and family labour were commonly used in rice processing. However, there was a preponderance of the use of hired labour, mostly women. Measurement of labour input was problematic in the following respect:

- Difficulty of correctly estimating the often-fragmented input of different categories of hired and family labour.
- Lack of uniform standards of labour conversion ratio for different labour categories
- Variability in wage rate and lack of correspondence between wage and hours of work.

Wood fuel, charcoal and corn stalks were major sources of energy for parboiling operation. Apart from the difficulty of valuing the quantity of wood fuel and corn stalks used, there were difficulties in valuing the coal and ash generated. Yet, they were quoted as by-products of parboiling, which were sold at different prices, depending on location and demand. Appropriation of electricity and water used for processing operations was, in most cases, subjective at best. Measuring the quantity of husk and bran separately proved difficult if not impossible because of equipment layout and the types of milling technology in use by the different mills. In fact, attempts made to collect the combined mixture of bran/husk were not often successful mainly due to milling layout, machine configuration and milling practices. A collection of the husk/bran mixture from polished and unpolished rice was possible only in a limited way, where approximate values of 20 kg and 19 kg per bag of paddy were established for polished and unpolished rice, respectively. Other difficult-to-measure parameter was the weight of total paddy and wastages of milled rice experienced at many stages of the milling process.

The purchase values of parboiling and milling equipment, rather than the replacement values, were recorded, because most of the respondents had no idea of their replacement values. A linear depreciation method was applied rather than other more accurate methods such as sum-of-the-year digits and declining- balance methods.

In summary, it is important to recognize that the array of physical measurement and valuation problems might have inadvertently resulted in some data inaccuracy. The methods adopted to minimize the negative impacts of data inaccuracies were the use of “cost route” approach and sensitivity/parametric analysis, which though expensive and time consuming, guaranteed, to some extent, greater level of accuracy. Sensitivity analysis provided some confidence frontier within which the values of key performance indicators remained valid.

III. Rice Processing Activities in Kura-Kano Rice Corridor

Parboiling Technologies

Parboiling is the central activity in rice processing and an important operation that determines rice quality. Parboiling is the hydrothermal treatment of raw paddy before milling and consists of three major activities namely, soaking, steaming and drying. Other pre parboiling operations practiced to improve the quality of the raw paddy included sieving of paddy before washing and soaking. Soaking involves allowing the rice kernel to absorb water so as to increase its moisture content. There were basically two methods of soaking, namely, warm water soaking in which the paddy was heated in warm water and allowed to soak overnight; and hot water soaking in which paddy was heated with hot water and allowed to soak for about 5 hours.

Steaming, which was a process of heat-treating wet paddy with steam followed soaking. Steaming equipment was usually with or without false bottom. Drying was done in order to bring down the moisture content after steaming. The paddy was either dried on drying slabs, tarpaulin, and polythene mats or stone floor. Whichever methods adopted for soaking, steaming and drying, the essence was to improve the quality of rice by reconditioning its structure and making it harder so as to make it resistant to breakages during milling. The cooking characteristic was also improved in terms of lower starch content and longer storage after cooking. The general inputs required for any parboiling operations included the raw paddy, parboiler, firewood or charcoal, buckets, washing tanks or basins, water, drying slabs or mats and labour.

The 5 different parboiling technologies assessed in this study were:

A) The traditional system of parboiling used by women in the Kura-Kano corridor

B) A high volume, but otherwise traditional parboiling system used by parboilers in the Dawanau market

C) An improved system of parboiling introduced by SG 2000

D) An improved system of parboiling introduced by TADCO Nigeria Limited

E) An improved system of parboiling introduced by Hanigha Nigeria Limited

Table 2 presents a comparative analysis of the characteristic features of the different parboiling technologies. Full details of the features of each system and their effects on cost and quality were presented in **Annex 3**

Table 2: Comparative Analysis of Parboiling Technologies and Processes (A – E)

Parboiling Technology	Construction Materials	Installed Capacity (Bags/day)	Parboiling Operations								
			Pre-Parboiling Sieving	Washing			Parboiling			Drying	
				To Remove Floaters	With Detergent	Wet Cleaning	Soaking		Steaming	Sun	Shade
							Hot Water	Overnight	False Bottom		
A-Liman	Metal	2	No	Yes	No	No	Yes	Yes	No	Yes	Yes
B-Dawanau	Metal	20	No	Yes	Yes	No	Yes	Yes	No	Yes	No
C-SG 2000	Metal	0.75	No	No	No	No	Yes	Yes	Yes	Yes	Yes
D-TADCO	Metal	14	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
E-Hanigha	Metal	14	No	Yes	No	No	Yes	No	Yes	No	Yes

Milling Technologies

Paddy or the rice grain consists of the hull or husk (18–28%) and the brown rice (72–82%). Brown rice consists of an outer layer called bran (6-7%), the germ or embryo (2-3%), and the edible portion – the endosperm (89-94%) (Chen et al, 1998). Rice milling operation is the separation of the husk (de-husking or de-hulling) and the bran (polishing) to produce the edible portion for consumption. Although, in theory mill recovery is between 71 and 73%, in practical terms, however, only 68 to 70%

is obtained from a good variety of paddy. Sources of loses during milling are many, but could be greatly reduced with the adoption of a combination of technical efficiency enhancing factors. Amongst the technical efficiency measures are: -

1. Parboiling uniformity and efficiency, which depend on paddy variety, and uniformity in parboiling, in particular steaming and drying.
2. The type of milling equipment and its configuration; energy source, milling shed layout, including availability of paddy handling equipment.
3. Operator's milling skill, in terms of expertise in equipment handling and control, and in productivity enhancing work methods.
4. Availability and use of pre-milling cleaning system that includes de-stoner, paddy cleaner, manual sieving, and contaminations – free milling practices

The 6 different milling technologies assessed in this study were:

A) The rubber roller Chinese mill owned by Liman.
B) The disc operated Chinese mill owned by Mohammed Kura.
C) The integrated Chinese mill operated by TADCO Nigeria Limited.
D) The small Indian mill at Dawanau market that uses the polisher.
E) The small Indian mill at Dawanau market that does not use the polisher.
F) The small Indian mill that does not use the polisher at Garko.

Full details of the characteristic features of the mills are presented in Annex 4. Table 3 also presents a summary of the technical details of the six mills, while Table 4 contains a summary comparative analysis of the milling technologies examined in this study.

Table 3: Types of Rice Mills and Rated Capacities.

Mill Types	Brand Name	Rate Capacity (Metric Tons)	Running Capacity (Metric Tons)	Milling Passes. (Minimum)	Milling Time per bag (mins)
Liman's Rubber Rollers Milling. (G)	Chinese Combine Rice Mill.	1. 2	0.60–0.80	2	13
Dawanau Mill + Polisher. (J)	Indian Engle-Berg. (Steel Roller)	0.5	0.25–0.30	2	15
Dawanau Mill – Polisher. (K)	Indian Engle-Berg. (Steel Roller)	0.5	0.25-0.30	2	14
Garko Mill. (L)	Indian Engle-Berg. (Steel Roller)	0.5	0.30-0.35	2	13
TADCO Mill.	Chinese Blower Rice Polisher.	2.0	1.00-1.20	2	6
Kura Mill (H)	Chinese Blower Rice Polisher.	0.8	0.40–0.50	2	10

Source: Kura-Kano Rice Processing Financial Analysis Study (2007).

Table 4: **Comparative Analysis of Milling Processes**.

Type of mill	Capacity kg/hr	Energy Source	Labour u man day	MILLING				POST MILLING		
				Paddy Sievin Manua OR Mecha	Dehu sking Steel OR Rubbe Roller	Polishi Fixed OR Rotatir Chamb	Winno wing Pressure & Gravity OR Aspiration	Win nowi (mar ual)	C O O Li N G	Hand picking
Combine Rice Mill	1.200	Electrici	2	Mecha	Rubbe Rollers	Rotatir	Aspiration	Non	Yes	No
Dawanau (Engle-B) + Polisher	500	Generato	2	Non	Steel Rollers	Fixed	Pressure & Gravity	Non	No	No
Dawanau (Engle-B) – Polisher	500	Generato	2	Non	Steel Rollers	Fixed	Pressure & Gravity	Yes	No	No
Garko Mill (Engle-Berg)	500	Generato	2	Non	Steel Rollers	Fixed	Pressure & Gravity	Yes	No	Yes
TADCO Mill (Blower Rice Mill)	200	Electrici	4	Manua	Steel Rollers	Rotatir	Aspiration	Non	Yes	No

It was generally observed that the following practices would enhance better utilization of milling labour, ensure cleanliness and contamination free operation and enhance the quality of milled rice:

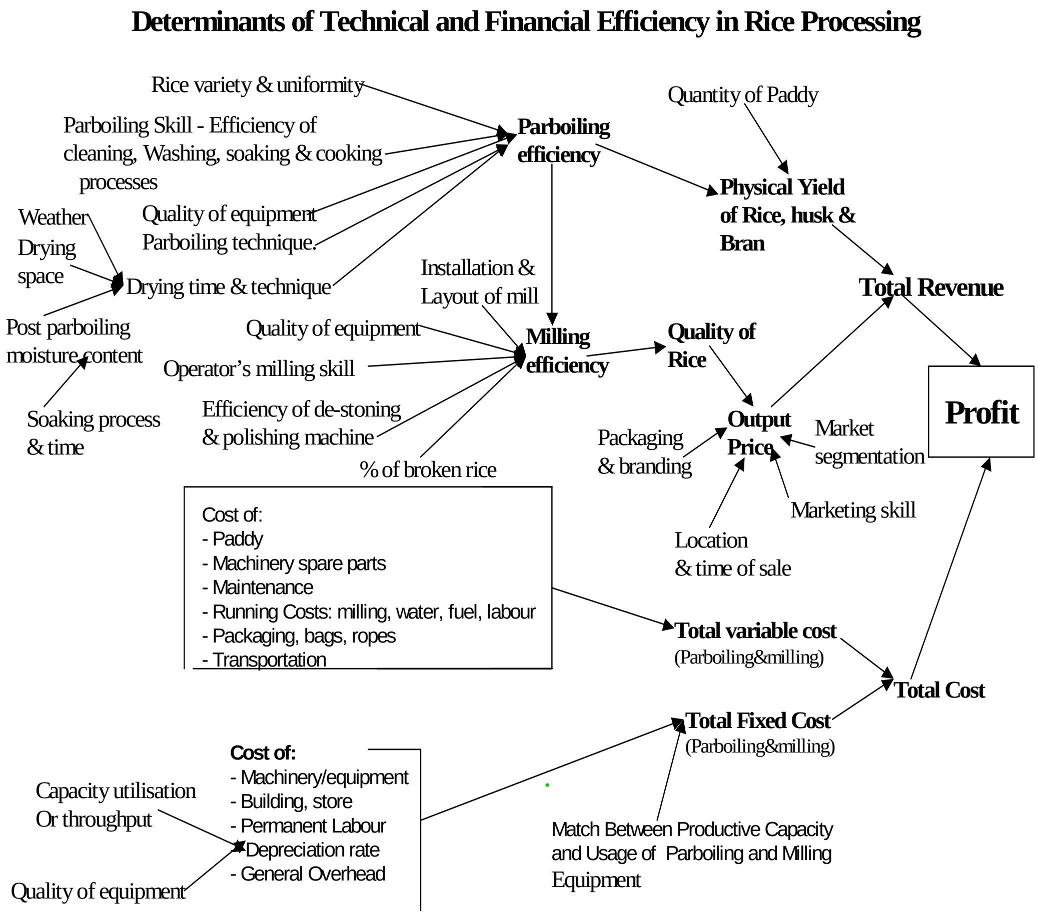
- pre-cleaning of parboiled paddy;
- adoption of adequate and sound milling practices; and,
- proper mill installation and provision of necessary paddy handling equipment.

A great challenge in milling remains the imbalance between milling capacity on one hand and inadequate supply of raw and parboiled paddy on the other. Solving this puzzle remains yet the greatest challenge to increasing capacity utilisation and mill output. The millers need enhanced capital and storage facilities to stock paddy and avoid widely fluctuating seasonal variations in supply and prices of paddy. In addition, improved parboiling technologies and bigger parboiling capacities are prerequisites to increasing milling efficiency and capacity utilization. As observed, the mills at

TADCO and Kura were not only faster, but also gave cleaner and better-polished ice. However, operator's skill and paddy throughput need enhancement. The daily breakage of sieves was found to be the direct result of the use of un-sieved paddy and poorly trained mill operators.

IV. Determinants of Technical and Financial Efficiency in Rice Processing

Chart 1 is a summary presentation of the determinants of efficiency of parboiling and milling technologies in qualitative terms.



The determinants of efficiency of parboiling are:

a. technical attributes such as post parboiling moisture content, which affects the drying time and, ultimately, milling efficiency; and the uniformity of "cooking" which affects milling efficiency as well as the quantity and quality of rice output; washing/soaking time and methods;
b. cost effectiveness in terms of the duration of parboiling, which has implication for fuel and labour cost; and efficiency in the application of all parboiling inputs, which has implication for the resource productivity; and,
c. quality of parboiled paddy, which depends on the paddy variety, the skill of the parboiler, the quality of the parboiling equipment, the duration and mode of drying.

Uniformity of paddy has eliminated varietal driven variability in the quality of raw paddy.

The determinants of milling efficiency include:

a. the efficiency of the parboiling system, which affects the quality of parboiled paddy;
b. the quality and capacity of the of the milling equipment, which affect the time and cost of milling, as well as the quality of milled rice;
c. the installation configuration and mill layout, which affect labour productivity and the milling time;
d. the quality of paddy rice; and,
e. the operator milling skill

Technical efficiency is a necessary but not sufficient condition for financial efficiency or profit maximization. In other words, technical efficiency is an essential requisite to financial efficiency. The following section, therefore, examines, in quantitative terms, other cost minimization and revenue maximization measure required to maximize financial efficiencies in the five parboiling and six milling systems when operated on contract and integrated basis.

Analytical Content

A). Comparative Analysis of the Technical and Financial Efficiency of the Five Parboiling and Six Milling Equipment

Some previous research findings of financial viability studies revealed that integrated parboiling and milling systems were potentially more financially viable than contract parboiling and milling systems. To verify the true situation in Kura-Kano rice corridor, our analyses focused on the following 30 real and hypothetical integrated parboiling/milling combinations:

1	A/G	7	B/G	13	C/G	19	D/G	25	E/G
2	A/H	8	B/H	14	C/H	20	D/H	26	E/H
3	A/I	9	B/I	15	C/I	21	D/I	27	E/I
4	A/J	10	B/J	16	C/J	22	D/J	28	E/J
5	A/K	11	B/K	17	C/K	23	D/K	29	E/K
6	A/L	12	B/L	18	C/L	24	D/L	30	E/L

Note: A-E: 5 Parboiling Technologies; G-L: 6 Milling Technologies.

Of the 30 integrated combinations, only A/G, B/J, B/K, C/L, D/I and E/H could be regarded as truly integrated; all other combinations are hypothetical and, therefore, conceptually normative. There are many factors that may impact the validity of the technical and financial efficiency indicators derived from such normative combinations. Using Liman Parboiling and Kura milling integrated combination (A/H) as an example, these factors include:

- imported inefficiency or efficiency in parboiling system A into milling system H, with implication for the total cost of production and profitability;

- mismatch between parboiling capacity of A and the milling capacity of H, resulting in capacity under utilization and inflated depreciation per unit of output;
- over or under capitalisation in parboiling equipment and facilities in A and milling equipment and facilities in H, with implications for the magnitude of annual depreciation; and,
- differences in parboiling skill of A and milling skill of H, with consequence for resource productivity and the quality of parboiled paddy and milled rice.

All these factors have implications for costs; quality and yield of parboiled paddy and rice, and price of rice; and, consequently, the profitability of each of the hypothetical or normative parboiling and milling combinations. In spite of these reservations, however, the design could still provide the basis for generating useful information for the promotion of profitable processing combinations, as will be demonstrated later in this report. It was believed, however, that the analysis of the truly integrated samples (A/G, B/J, B/K, C/L, D/I and E/H) is most likely to generate more realistic and true-to-type decision-making parameters regarding the comparative financial efficiency of integrated rice processing systems.

Following from the above exposition, the major issues in the comparative analysis of financial efficiency of integrated processing systems could be encapsulated in the following questions:

- Are the integrated parboiling and milling technologies financially viable?
- What is the superiority rating of the financial efficiencies of the 30 hypothetical combinations of integrated parboiling and milling technologies?
- Are there significant differences between normative and truly integrated combinations?

To obtain the financial efficiency of each of the 30 parboiling and milling combinations, the cost of parboiling a unit weight (1 bag) of paddy in each of the parboiling equipment was added to the cost of milling in each of the milling equipment to obtain the total cost of processing in each of the parboiling/milling combinations. The total cost was deducted from the revenue earned from the sale of milled rice and any by-products from each of the parboiling/milling combinations to obtain the processing margins. Other financial efficiency indicators were derived thereafter.

B). Parboiling Efficiency:

The major issues in the comparative analysis of the five parboiling technologies could be encapsulated in the following questions:

- Are the five parboiling systems technically and financially efficient?

- What is the superiority rating of the technical and financial efficiencies of the five parboiling systems, particularly when operated under contract arrangement?

Since there was no market for parboiled paddy, it was difficult to assess the financial efficiency of a parboiling system until after the parboiled rice had been milled. Under contract parboiling system, however, parboiling margin could be calculated by deducting the total cost of parboiling (variable and fixed) from the fee charged per unit weight of paddy. The magnitude of the cost of parboiling unit weight of paddy was the proxy to the cost effectiveness of the parboiling technology, which, together with the parboiling fee, was used to derive the parboiling margin, which was then used as the basis for the comparative analysis of the financial efficiency of the five parboiling systems.

The superiority of the 5 parboiling technologies (A-E) was determined by milling each unit weight of the 5 parboiled paddy samples in one mill (any of the rows, representing 6 cost centres). In other words, eliminating equipment and/or skill driven variability in the milling operations permitted the determination of the technical and financial efficiency of each of the parboiling equipment.

C). Milling Efficiency:

The major issues in the comparative analysis of the seven milling technologies could be encapsulated in the following questions:

- Are the six milling systems technically and financially efficient?

- What is the superiority rating of the technical and financial efficiencies the six milling systems, particularly when operated under contract arrangement?

Under contract milling system, milling margin was calculated by deducting the cost of milling from the fee charged. The magnitude of the cost of milling unit weight of paddy was also used as a proxy to the cost effectiveness of the milling technology.

Processing parboiled paddy rice (approximately 1 bag, making allowance for any loss during parboiling process) from a given parboiler (any of the columns, representing 5 cost centres) in each of the 6 different mills. In other words, the efficiency (technical and financial) of each milling machine was determined by eliminating any equipment and/or skill driven variability in the parboiling operations.

D). Measures of Efficiency

Comparative analysis of the different systems of parboiling and milling was made using a combination of qualitative and quantitative criteria/measures.

- Qualitative criteria include consumers/market preference with respect to physical appearance and the proportion of broken, white belly and blackened-tips grains.
- Quantitative criteria include various measures of technical and financial efficiency presented below.

Measures of Technical Efficiency

Some of the important measures of technical efficiency used in this study included:

i Yield of parboiled paddy rice per unit weight of raw paddy – parboiling efficiency.

ii Yield of processed rice per unit weight of parboiled paddy - milling efficiency

iii Floaters per unit weight of paddy – a function of quality of rice paddy, and efficiency of sieving and washing operation
iv Breakages and stones per unit weight of parboiled paddy – a function of parboiling and milling efficiency
v Parboiler units per unit of milling equipment - match between productive capacity and usage of milling equipment

Measures of Financial Efficiency

Some of the financial efficiency indicators used in this study included:

i Gross Margin = Total Revenue – Total Variable Cost
iii Profit or Net Margin = Total Cost – Total Revenue
v Benefit-Cost Ratio = Total Revenue/ Total Cost
vii Return on Capital = Profit/Total Cost x 100
ix Return to Labour = Profit/Total Labour Cost x100
xi Break-even Point = <u>Total Fixed Cost</u>
Unit Price – Variable cost/unit output

V. MAIN FINDINGS

A.: **Comparative Analysis of Total Fixed Costs (Investment) of Parboiling and Milling Technologies**

The magnitude of total fixed costs provides useful guide to prospective investors about the level of investment needed to start rice-processing business. This comparative analysis was designed to provide the basis for making recommendations on possible combinations of parboiling and milling equipment, based on the technical and financial efficiencies of the 30 hypothetical combinations developed in subsequent sections of this report.

Tables 5 (A-E) summarised the structure of fixed costs for the all the five parboiling systems, while T**ables** 6 (A-F) summarised the structure of fixed costs for all the six milling systems. Parboiling investment costs ranged from a minimum of N5,700 for the SG2000 equipment to a maximum of N719,313 for the Kura equipment. TADCO equipment, which was a structurally modified but slightly bigger version of SG 2000 equipment, was estimated at only N35,249, inclusive of sieving, washing and drying materials.

On the other hand, milling investment costs ranged from a minimum of N186,200 for the Garko equipment to a maximum of N1,121,000 for the Kura equipment. From this analysis, it was clear that Kura integrated system was the most highly capitalised, while Garko hypothetical integrated system was the least capitalised. In between were the TADCO, Dawanau and the Liman integrated systems.

B: Comparative Analysis of Technical and Financial Efficiency of Parboiling Technologies

Table 7 presents the input-output coefficients of all the parboiling systems under study, while **Table 8** presents a summary of the comparative analysis of measures of technical and financial efficiencies of the parboiling systems under study. **Capacity utilization** is the ratio of the quantity of raw paddy parboiled in a given period over the installed capacity of the parboiling equipment. The value of capacity utilization has implication for the magnitude of variable and fixed cost (annual depreciation) per unit of output of the system.

Garko parboiling technology recorded the lowest value of 33% while Liman parboiling technology had the highest percentage of 95%. The low value recorded by the women parboilers in Garko could be attributed to the fact that they parboiled only 1.5 bags of paddy in two days of the week, while 95% capacity utilization recorded by Liman was based on the fact that his two parboilers could parboil only two bags of paddy in a day, thereby utilizing his capacity almost to the fullest. Both Hanigha and Dawanau had high volume parboiling equipment, which accounted for the high percentage capacity utilisation of 82% and 68%, respectively. However, despite his high volume, Dawanau recorded 68% capacity utilization because he operated for only 8 months in a year.

The installed parboiling-milling capacity ratio measures the degree of correspondence between the capacities of the parboiling equipment and that of the milling equipment. There was a mismatch between all the parboiling and milling capacities of all the systems, but Garko and Liman had the highest mismatch of 1% and 2%, respectively.
Liman's milling machine remained idle most of the time as a result of power shortage, which was the only source of energy. At full capacity utilisation, TADCO mill required about 213 bags of paddy in a day of 8 hrs, yet his parboiling capacity was only 14 bags per day. Dawanau parboiling system had the highest ratio of 55%, which could be attributed to the fact that his equipment could parboil 7 bags of paddy at a time, and parboiling was carried out twice per day.

The **washing paddy efficiency ratio** is the ratio of the quantity of floaters removed during washing to the weight of raw paddy. This measure is a reflection of quality of paddy variety. The higher the quantity of floaters removed during washing, the poorer the quality of paddy; it also reflects the thoroughness of washing, which impacts positively on rice quality. There was no value recorded for Garko parboiling system because the women do not normally wash paddy, probably because of scarcity and high cost of water. However, in the alternative, the Garko women deliberately sourced for clean and good paddy variety. The high washing efficiency ratio recorded for TADCO (10%) and Kura (10%) was as a result of thorough washing of the paddy (see **Table 2)**

Parboiled paddy to raw paddy ratio is the percentage of parboiled paddy obtainable from a given weight of raw paddy. All parboiled paddy from all the parboiling systems had a ratio above 90%, but Hanigha recorded the highest value of 97%, while TADCO recorded the lowest ratio of 91%. The factors responsible for these values could be attributed to the amount of floaters removed during washing, wastages during washing processes, as well as the level of post parboiling moisture content, which unfortunately we were unable to measure in this study..

Contract parboiling was usually undertaken for a fee. Parboiling margin is the difference between the fees charged for parboiling a bag and the total cost of parboiling a bag.
The total cost of parboiling, as a percentage of total processing cost, is the percentage of parboiling cost compared with the total processing cost. The highest value of 96.72% was recorded for Kura, while the lowest value of 88% was recorded for Liman. These values further confirm the findings of previous research reports to the effect that parboiling

operations accounted for a very high percentage of total cost of rice processing. Thus, an understanding of the structure of parboiling cost (see Table 7) is a potentially rewarding area of rice processing where the application of cost reduction strategies, and work and method study activities could pay the highest dividends.

Three of the parboiling systems (Liman, Garko and TADCO) sustained losses, while the remaining two (Dawanau and Hanigha) made positive margins. The highest loss was sustained in Garko (-158.97N) as a result of the high variable cost incurred in parboiling, as well as its high rate of depreciation, a consequence of low capacity utilization. Dawanau recorded a positive value of 134.58N per bag because it was enjoying economy of scale (7 bags/batch parboiling equipment), which conferred lower cost per unit of parboiled paddy. Hanigha parboiling system was only marginally profitable, with a margin of 6.86N per bag.

C. Comparative Analysis of Technical and Financial Efficiency of Milling Technology

Table 9 presents the input-output data of the 6 milling systems under study, while **Table 10** presents a summary of the comparative analysis of measures of technical and financial efficiencies in the six milling systems under study. **Capacity utilization** is the ratio of the quantity of parboiled paddy milled in a given period over the installed capacity of the milling equipment. All the systems recorded low values of capacity utilization, except Hanigha that recorded capacity utilization of 51% due to the large number of contract milling activities the system engaged in. Liman again recorded the lowest capacity utilization of 2% as a result of serious power failure. However, the analysis revealed other general constraints to capacity utilization in mills. These included:

- low parboiling capacity;
- low demand for the local rice;
- non availability of paddy all year round;
- erratic supply of electricity;
- low capital for inventory build-up;
- lack of storage facilities; and,
- varietal preference by parboilers.

Like the parboiling systems, there was a mismatch between the parboiling equipment and the mills. Only Dawanau recorded a ratio of about 55%; all the other systems had a very low ratio, with Liman recording the lowest (2%). **The milling margin** was the total cost of milling subtracted from the fee charged for milling. Four of the systems recorded positive values with TADCO having the highest margin of N269.83, while Liman recorded a loss of N134.91. Hanigha recorded a loss N11.53 because the fee charged for milling was the lowest (N100), even though it was an integrated mill that dehusks and polishes. The low fees charged was a promotional strategy designed to capture the milling market in Kura area. Unlike parboiling systems, the mills thrived on contract milling as a way of boosting their capacity utilisation and income.

The total cost of milling as a percentage of total milling cost, was, in general and as expected, relatively low compared with the total processing cost. The highest ratio of 10.66% was recorded by Liman, while the lowest ratio of 0.87% was recorded by TADCO.

D. Comparative Analysis of Milling Ratios Under Integrated Rice Processing Technology (Hypothetical/Normative Combinations)

Milling ratio is an indicator of the total rice recovered from raw paddy from a given milling technology. Milling ratio is a function of the following factors:

5. Efficiency of parboiling
6. Efficiency of the mill
7. Efficiency of the operators' skill, and
8. The variety of paddy.

Table 11 shows the comparative analysis of the milling ratios of the 30 hypothetical integrated combinations. By subjecting parboiled paddy from each of the parboiling systems to all the mills (G-L), considerable variations were recorded in the milling ratios. For example, when parboiled paddy from Liman, Dawanau and Garko were milled in all the mills, Dawanau's mill without the polisher recorded the highest milling ratios of 68,69 and 69 percent respectively. On the other hand, when Hanigha and Kura parboiled paddy were milled in all the milling systems, Kura mill recorded the highest milling ratio of 72%. When the average milling ratios were computed for each of the parboiling systems, TADCO parboiling recorded the highest average milling ratio of 68.33%, closely followed by Hanigha at 67.5%.

However, when the milling systems were kept constant and parboiled paddy from different system (A-D) was milled in each of the mills, different milling ratios were also observed. Kura mill ranked the highest with an average milling ratio of 69%. The analysis clearly revealed that Kura mill recorded the best milling ratio at an average of 69% for all the parboiling systems under study. On the other hand, when the parboiling system was kept constant for all the mills, TADCO milling system recorded the highest average milling ratio of 68.33%.

The inference that could be drawn from this analysis was that, since milling ratio is a function of parboiling and milling efficiencies, a combination of TADCO parboiling and Kura milling systems would produce the best and most efficient rice processing system. If it were possible to get Kura mill of lower cost and capacity, then this could be combined with the efficient and low cost TADCO parboiling system. This would solve some of the major problems of small-scale women parboilers. It might also lead to other knock-on improvement in technical efficiency such as increased mill capacity utilization arising from the proliferation of more efficient small-scale parboilers, particularly women.

Comparing the milling ratios of the six truly integrated systems, Kura integrated came first while TADCO integrated came second. It would appear, therefore, that each parboiling system had been conditioned to adapt to its own milling system.

E. Comparative Analysis of Broken-Head Rice Ratios of Integrated Rice Processing Technologies.

The milled rice consists of head rice and broken rice. Different parboiling and milling systems give rise to different broken/head rice ratios. The efficiency of parboiling and milling system determine the broken/head rice ratio and the proportion of broken/head rice impacts on the quality and, consequently, the price of milled rice. The method of drying as well as post parboiling storage before milling affect broken/ head rice ratio. Shade drying and post parboiling storage before milling have been reported to affect the proportion of broken/head rice ratio. Rice processors therefore devote considerable attention to ensuring lower proportion of broken rice because of its implication on market preference, price and revenue.

Comparative analyses were carried out on the 30 parboiling-milling combinations and the result presented in **Table 12.** The Table shows that Hanigha parboiling system gave the least percentage of broken rice (13%). This indicated that Hanigha parboiling had the best technical efficiency with respect to broken/head rice ratio. Our observation also revealed that Hanigha usually engage in shade drying, a practice that minimizes the incidence of broken rice during milling. The milling of the study samples was done within a short period after parboiling, which might also explain the low percentage of broken rice. With respect to the milling systems, Garko milling topped the list and the reason was due to the fact that all the samples milled in Garko were subjected to hand picking.

F. Comparative Analysis of Financial Efficiency of Integrated Parboiling & Milling Technologies (Hypothetical/Normative Combinations)

The indices of financial efficiency used in this analysis were gross margin, net profit; benefit cost ratio and returns to operating capital. The average market survey prices in **Table 13** were used to calculate the performance indices. **Tables 14, 15,16,17 and 18** show the structures of financial analysis for the parboiling systems of Liman, Dawanau, Garko, TADCO and Kura, respectively, while **Table 19** summarises the comparative analysis of the financial efficiency of the corresponding integrated parboiling and milling systems.

Most of the hypothetical parboiling and milling technologies recorded positive gross margin, net profit, benefit cost ratio and returns to operating capital. A few hypothetical combinations (CG, DG, HG) recorded negative profits. The results also showed that the truly integrated systems such as Garko integrated (CL), TADCO integrated (DI), and Hanigha integrated (EH) made positive profit. However, when Garko, TADCO and Hanigha parboiling were combined with Liman milling (CG, DG and EG), losses were made. The reason for these losses could be attributable to imported inefficiencies of Liman's milling. On the other hand, a good example of imported efficiency was the combination of Garko parboiling and TADCO milling (CI), which generated gross margin of N1, 177.73 as against N745.6 when Garko parboiled paddy was milled in Garko mill (C/L). However, TADCO and Hanigha integrated systems (DI and EH) recorded superior performance in most of the indices of financial efficiency. This was a clear demonstration that TADCO and Hanigha parboiling and milling equipment were more efficient than the others. However, when Hanigha parboiled paddy was milled in both Hanigha and TADCO equipment, EI (N1685.8) was greater than EH (N1481.4), implying that TADCO milling was superior to Hanigha's. In fact, the superiority of TADCO milling manifested when paddy from four of the parboiling systems was milled in TADCO (BI, CI, DI and EI).

These results provided valuable insight into possible combinations of parboiling and milling systems that, all things being equal would be technically and financially appropriate to different categories of investors, in particular, prospective small and medium scale rice processors. The information generated from this analysis could be combined with the profile of investment costs of different parboiling and milling systems **(Table 20)** and used for developing appropriate parboiling/milling combinations for different categories of prospective investors in rice processing. Two of such recommended normative combinations, which would be appropriate for low and medium capital investors are the low cost, but efficient and slightly bigger, TADCO parboiling equipment with (preferably lower capacity and cost) Hanigha mill (DH), and TADCO parboiling equipment with Dawanau mill plus polisher (DJ). For high capital and high volume investors, EI and EH, both of which combined parboiling and milling efficiencies, are recommended.

G. Comparative Analysis of Financial Efficiency of Integrated Parboiling & Milling Technologies (Real/Positive Concept)

Table 21 Shows the comparative analysis of the six real parboiling and milling combinations (AG, BJ, BK, CL, DI and EH). The performance rating of integrated systems with respect to profitability were in the order of TADCO integrated, Kura integrated and Dawanau with polisher. However, when profit per bag was based on rice as the only output of processing, the performance ranking still remained unchanged.

H. Effect of Winnowing, Polishing and Post Milling Picking on Rice Quality, Cost and Returns

Pre and post milling activities such as winnowing, polishing and picking are designed to improve the quality and price of rice. However, these operations not only add value, they also decrease the weight of rice and increase processing cost. A few traders, particularly in areas where the price of rice is neutral to quality, prefer not to polish for fear of losing weight and, thus, revenue. Millers, on the other hand, are conscious of added milling time and energy, both of which increase the cost of milling. The questions that would most likely be of interest to all rice processors and traders are:

(a) Is it financially rewarding to do pre-milling sieving and post-milling winnowing, polishing or hand picking?

(b) Could these pre and post milling activities be more profitably embodied in more efficient parboiling and milling technologies and processes, as in Kura and TADCO systems, to the extent that winnowing and hand picking time and costs could be eliminated?

The financial implications of polishing and post milling handpicking treatments are presented in **Table 22.** For example, when paddy was parboiled using Dawanau technology and milled in Dawanau mills J + polisher, a weight loss of 0.55kg was sustained due to polishing; but polishing gave a price advantage of N2 per kg, which translated into a revenue advantage of N57.65 per kg. Our investigations further revealed that rice traders were appreciative of the quality advantage of polishing and this explained the heavy demand on the Dawanau's milling machine J with polisher.

When paddy was parboiled with TADCO technology and milled in Garko mill (TADCO/Garko D/L), (accompanied with post milling hand picking), there was a weight loss of 3.14 kg due to picking, and an increase in cost to the tune of N200/bag for hand picking labour. However, post-milling picking did not confer any price advantage (D/L - N88.33 as against D/I- N93.33); rather there was a loss of revenue to the tune of N540.45 per bag due to loss of weight. The same conclusion was drawn when Kura/Kura integrated system (E/H) was compared with Kura/Garko integrated operation (E/L). A loss weight in (3.63kg) and revenue to the tune of N482.16/bag, was sustained as a result of subjecting Kura parboiled rice to Garko milling technology and post milling handpicking treatment.

Milling Garko parboiled paddy in Garko (C/L), TADCO (C/I), and Kura (C/H) mills further reinforced the point. The revenue from Garko milled paddy (C/L) was lower than the revenues from TADCO (C/I) and Kura (C/H) milled paddy by N474.54 and N263.49, respectively. The envisaged quality and price advantages attributable to post milling handpicking were not strong enough to compensate for the weight losses of 3.05kg and 3.27kg respectively, and increased processing cost. The inferences to be drawn from these analyses are:

- Polishing with Dawanau mill (J) improved rice quality and added value, even though there was some weight loss.
- The superiority in technical efficiency of Kura milling systems (H) over Garko milling system (L) was translated into financial superiority of N482.16 when Kura parboiling system was used.
- The superiority in technical efficiencies embodied in TADCO (I) and Kura (H) milling technologies resulted in financial superiority of N474.54 and N263.49, respectively, over the Garko milling system.
- The in-built technical efficiencies in TADCO and Kura parboiling and milling systems made post milling winnowing and handpicking unnecessary.

I. Sensitivity Analysis With Prices of Paddy and Rice

Sensitivity analysis helps to identify and prioritise productivity and profit enhancing variables that require special attention of management in the course of rice processing business. Sensitivity analysis was used to determine the effects of changes in the level of some variables considered to be crucial to productivity and profitability, and whose changes could significantly modify the projected levels of key performance indicators, particularly profit. Two of such crucial variables examined in this study were:

- changes in the prices of raw paddy; and
- changes in the price of rice.

Using Garko parboiling and milling integrated combination (C/L) as an example, the cost of raw paddy represented 82.28% of the total cost of parboiling, while the revenue from rice represented 82.01% of the total revenue from rice processing.

Table 23: Sensitivity Analysis With Prices of Paddy and Rice

Prices	Change in Price of Paddy (N)		% Change in price of paddy	Processing Profit/bag **(C/L)** (N)		% Change in profit	Effect of 1% change in profit
	A	B		A	B		
Paddy	3000	2600	13.33	1634.91	2034.91	24.47	1.8
	3000	4500	50	1634.91	134.91	91.7	1.8
Rice	89.83	84.00	6.49	1634.91	1353.82	17.19	2.65
	89.83	97.00	7.98	1634.91	1980.61	21.15	2.65

Thus, changes in the prices of paddy and rice are key variables that would impact the level of profit. A reduction in the price of paddy from N3000 to N2600 per bag (13.33% change in price) increased the profit margin from NN1634.91 to N2034.91, an increase of 24.47%. On the other hand, a 50% increase in price of paddy (N3000 to N4500) reduced the profit margin from N1634.91to N134.9 per bag, representing 91.7% reduction in profit per bag. Either way, 1% change in the price of paddy resulted in approximately 1.8% change in the level of profit.

Similarly, if the buying price of N84/kg of rice was used in the cost and returns calculation instead of the selling price of N89.83 (a 6.5% change), profit was reduced from N1634.9 to N1353.82, a change of 17.19%. If, on the other hand, improved marketing strategy and or sales in segmented markets could fetch N97.0 per kg of rice (a 7.98% change in price), profit level would change from N1634.9 to N1980.61, a change of 21.15%. Either way 1% change in the price of rice resulted in 2.65% change in the level of profit. Comparatively, therefore, one percent change in the price of rice produced greater impact on the level of profit than one percent change in the price of paddy. The implication of the above analysis is that rice quality improvement is financially more rewarding than strategy to purchase paddy at lower price. In practical terms, however, profit would be maximized when rice quality and price improvements are combined with strategies to reduce the cost of paddy.