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Rice Milling Technologies: A Critical Appraisal

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This study reviewed the rice milling technologies across the globe. It is very glaring that majority of farmers cannot afford the modern mill type because of cost, under-utilization but very efficient if there is enough paddy. The huller mills on the other hand, though high breakages were reported are common within farmers of Africa and Asia. In order to help in the village economy, efforts should be made to upgrade these huller mills so that the high breakages reported can be reduced. In the end, suggestions were given.

INTRODUCTION

Rice (Oryza Sativa L.) is one of the most important cereals foods on which depends about one-fourth of the world's population (Choudhury, 1987). Traditionally, rice has been the staple food and main source of income for million of people, and it will continue to be a mainstay of life for future generations. In many countries, essential development efforts are concentrated on rice to meet domestic need for food and exportation. There is therefore the need to promote good processing programmes of rice aimed at achieving a quality end product.

Rice milling is the process of removing the outer husk and all (or part) of the bran layer from the grain. The husk is totally inedible. If the bran layer is not removed, the product is called brown rice. Although brown rice is available on some markets, it is not popular because it tends to cause digestive disturbances. In the more developed countries particularly, almost all of the bran layer is removed to give a highly polished white rice that is preferred by the market.

The type of milling machines and it s adjustments may cause some good grains to break during milling (Sarker et. al, 1996). A high head rice yield is the most important goal of the rice milling industry. Breakage of rice grains during milling results in loss of milled rice in terms of both quality and quantity. If a rice grain breaks during milling, it loses about 25% of its head rice weight. Cooking quality of broken rice is very poor and so the market price for rice with broken grains is less than that for whole grains. Spadaro and Mathews (1976) estimated that breakage of grains cost the U.S. rice industry $115 million during the 1974-1975 rice processing season or about $2.9 million per rice mill.

Sahay (1990), developed a general purpose abrasive mill to pearl and dehusk cereals and pulses. The mill has an integral milling and cleaning chambers and a 10-grinding wheel rotor driven by a 3.7kw motor. Its capacity is between 96 and 340kg h-1, depending upon the grain being handled, with a maximum dehulling efficiency of 75% and can be owned, operated and manned by small-scale processors in rural and semi-urban areas.

In a survey or rice processing technologies in Sokoto State, Nigeria, Yahuza (2000), noted that 70% of the millers have the followings as the major problems confronting the village mills. Instability of electricity; breakage of shaft; breakage or weakening of the sieves; cutting of the belt as well as the cost and fluctuation in prices of diesel. However, to a few number of processors involved in hand pounding, the drudgery involved in pounding is the main problem. The milling process is done with equipment ranging from the large complex modern systems to the simplest pestle and mortar. Since large quantities of paddy are lost during the milling process, it is necessary to review the technologies involved and their latest development.

METHODOLOGY

This study reviews the rice processing technologies across the globe. Although there exist a vast number of milling machineries world wide, but for the purpose of this study, they are principally categrorize into three. One of the hullers, the rather simple machines that removes the husks and bran in one operation. Its defects are that it is expensive to operate, has low rice out turn, and produces too many broken grains. A second type is the modern rice mill, which is highly

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efficient. The mill has a high capacity, and it recovers more total rice as well as head rice. Finally, the last of course comes under the collective term 'hand pounding'. The chief virtue of hand pounding is that it gives a medium polished rice with a high thiamine content. It also provides some employment that helps in the maintenance of the village economy. The Nigeria's experience of milling was also discussed along with a recent development in some Asian countries. In the end some suggested approaches were given.

RESULTS AND DISCUSSION

Hullers

The machine was originally designed for removing the outer hulls of coffee, but later adopted for the milling. The machine consists of a solid fluted cylinder rotating at 500 to 600rpm within a hollow stationary cylinder the lower half of which is perforated with slots of 0.06 to 0.3 inches. The flute on the cylinder is so arranged as to carry the paddy to the centre from the seeding end, get it milled by the scouring action at the centre of the cylinder and then carry it to the other end where milled rice is discharged. The grain suffers excessive breakage and gets overheated due to friction. Power consumption is large as energy is wasted in crushing of hulls. Various modifications have been made out of this. An example is the sheller mill.

Most of the mills installed in the Asian countries were of the "huller" type.

In order to better understand the comparison of different methods of hulling, it would be worthwhile to recapitulate the definition of three parameters often used:

- *The hulling yield* measures the degree of hulling which the person supervising the operation, judges acceptable as an indication of the completeness of the operation. This is the preparation 9as a percentage of the weight of hulled grain compared with the initial weight of grain prior to hulling.
- *The theoretical yield* is the proportion of grain (as a percentage of the weight) which represent the optimal consumable portion or the proportion acceptable by the consumer.
- *The hulling efficiency (%)* integrates the two previous parameters. It provides an objective measure of the efficiency of the operation and a comparison between equipment and types of grain in terms of hulling performance. The average recovery efficiency of a steel huller is shown together with the shelter and modern mill in Table 1.

Table 1: Average Recovery Efficiencies of Three Types Mills

Recovery as Percent of Paddy

Types of Mill	Bran plus Hull	Whole Grains (Headrice)	Broken Grains
Steel huller	36.6	46.5	16.9
Shelter mill	32.5	55.9	11.6
Modern mill	30.0	62.0	8.0

Source: Chandler Jr, 1979.

MODERN RICE MILL

The modern rice mill has highly efficient equipment. Paddy is first discharged by means of an elevator on to a set of cleaning sieves from which it gets free of stone, straw, dust, grit etc. It is then husked in the shelter and the shelled paddy is freed of husk in a husk separator. The paddy from the mixture of rice and paddy (remaining unhusked) is removed in the paddy separators and the shelled rice is carried by elevators into a storage chamber from which the rice can be fed to a series of polishing cones for the polishing of rice. The polished rice is delivered by an elevator to a sorting sieve where head rice and broken grains are separated and later collected separately. Two methods are employed in controlling the degree of milling: one is by varying the clearance of the polishing cone from the wire basket between which the rice grains undergo abrasion and get polished. Th other is by varying the r.p.m. of the motor running the cone polisher.

The recovery of polished rice in a mill is termed "percentage out-turn". The out-turn is affected by variety, by whether the rice is raw or parboiled, by rice moisture content, and by the type of mill used. Table 2 shows the total milling out-turn of the different types mill in Sri Lanka.

Table 2: Milling Quality of Different Types of Rice Mills

Quality Criteria	Modern Rice Mill	Semi Modern Rice Mill	Traditional Huller Mill
Total Milling Outturn	69.2	68.8	67.5
Head rice yield	66.1	65.0	60.5
Brokens	4.4	5.0	10.8
Impurities	0.3	0.5	0.7
Amount of bran (kg)	86.9	135.5	130.8

Source: Jayasena and Ilangantileke (1986)

Modern Rice Mills are available in capacities ranging from 1 ton per hour to over 10 tons. The larger the mill, the greater the efficiency, provided enough paddy is available to run the mill full time. The followings are used in describing the performance of a mill:

Milling Recovery (MR): This is a function of weight of paddy before milling and weight of milled grain. It is determined by the expression below:

$$\%MR = \frac{\text{wt of total milled}}{\text{Wt of paddy}} \times \frac{100}{1} \quad (1)$$

Head Rice Recovery (HRR): The milled rice is separated into broken and unbroken grains. The proportion of unbroken grains referred to as the head rice recovery is expressed as:

$$\%HRR = \frac{\text{Wt of whole grain}}{\text{Wt of milled rice}} \times \frac{100}{1} \quad (2)$$

MILLING CAPACITY

This represents the quantity of rice, which would be milled if the mills operated throughout the year for the working hours-considered normal for the country concerned. In some these were 8 hours a day; in others the mill work more or less round the clock for some months and then closed done until the next harvest. Rice milling capacity is usually expressed in tons per hour of paddy. In the United States (FAO, 1972), annual capacity is estimated as; tons per hour x 24 hours per day x 300 days per year x 85 percent efficient operation. Table 5 reflects the average capacities of mills together with their apparent utilization.

Table 3: Number of Rice Mills, Capacity and Utilization.

	Number of Mills	Average capacity per year	Total per year	Amount apparent milled Utilization	
Australia	5	19.2	96	80	83
Ceylon	1100	0.8	955	462	49
Colombia	346	1.6	568	555	59
Hongkong	18	15.7	248	78	51
India	44057	0.6	28485	86.5	50
Morocco	7	4.4	51	19	61
Surinam	236	0.8	198	38	19
Thailand	14099	3.0	42297	5029	12
United States	55	56.6	3115	2225	17
Vietnam	2018	0.9	1871	971	52

Source: FAO Marketing Guide (6), 1972.

In most less developed countries, because both government and private milling operations exist, there is an abundance of milling capacity. From the table, it is very glaring that there is more than enough capacity to meet milling requirement.

HAND POUNDING

Although hand methods are steadily giving way to machine, much of the rice grown over large areas of the far East, the Near East and Africa especially Nigeria is still processed by hand pounding or by primitive mechanical methods using very simple equipment. Up to 1970, for example around 80% of the grain in Indonesia, 50–40% in West Bengal and 50% in the Khmer Republic was hand-pounded (FAO, 1972; Sarker and Farouk, 1989).

The most common method of hand-pounding is by mortar and pestle. The pestle applies a normal force on to the grains kept in the mortar, and the direct action of this force is to break rather than mill the grains. The friction force generated due to relative grain movement helps in milling operation (Sarker and Fareuk, 1989).

There are some advantages in hand-processing. The gross yield of head rice is usually higher, which is important for poor farmers and in times of scarcity. And also because rice processed by machines tend to be highly milled. Hence because of higher degree of milling, machine processed rice is usually less valuable nutritionally than hand-pounded rice. And finally where there is serious rural unemployment, there may be grounds for encouraging labour-intensive manual methods of rice processing.

NIGERIA'S EXPERIENCE OF MILLING

Rice is an important staple cereal in the diet of Nigerians. The average per capita consumption of rice has risen and will continue to rise in the urban and rural areas of the country (Wudiri, 1992). Just like in other African countries, over 70% of rice milled in Nigeria was hand-pounded. This of course has given chance to the introduction of various villages (huller) and giant mills all over the country.

Several attempts have been made in the past to improve on the quality of rice which Nigerians favour. Both the federal and state governments invested heavily in the setting up of giant rice mills which can process about 15-20 tons of rice per hour in strategic rice growing areas of the country. However, these mills have not perform up to expectation (Wudiri, 1992). The traditional small-scale rice production system in Nigeria do not lend themselves easily to the processing systems of the giant mills which are developed for countries in which a single variety of rice is usually produced on up to 1,000 hectares of land.

Majority of our producers are small-scale farmers who grow different varieties on less than half a hectare of land and produce less than a ton of paddy rice in any given season. Each rice variety has its own characteristics. Some are long grained, some are short grained, some are round while others are slender. When these mill owners buy paddy rice from these various small-scale farmers and throw them into their monster machines, the result is garbage. This means that, given the present rice production system in Nigeria, we must encourage small-scale cottage-type of rice processing in which a small quantity of a single rice variety (1 ton) can be processed at a given time.

REGENT DEVELOPMENTS

Losses in the milling process are due either to inherent poor technical performance of milling machinery, or operator ineptitude, resulting in poor milling yields. An example of a milling technology that has been legislated out of existence in some countries is the Engleberg type Single-pass one-step process (Steel huller), which is notorious for breaking the grain in the milling process and yielding as low as 55% milled rice. In 1985, about 50% of the milling capacity in the Philippines Was Engleberg mills. In Bangladesh today, the Engleberg machines is till the predominant mill. India is reported to have outlawed the Engleberg in favour of more efficient mills. No Engleberg machines are found in Thailand. Some part of Asia now have a law that forbids micro-mills of the Engleberg design, but the traders continue to import them from China as coffee grinders for milling rice (Bautista, 2001).

The most significant breakthrough in the rice milling industry has been the development of the husking machines with rubber rollers, which significantly reduce grain breakage. Modern milling plants now have 10 distinct steps in the process. Some set ups are automated to reduce dependence on unskilled operators. The challenge is to bring technological development within the reach of the rural farmers especially in Asia.

SUGGESTED APPROACHES

Given the present rice production system in Nigeria, effort must be made to encourage small-scale cottage-type of rice processing mills in which a small quantity of a single rice variety (about 1 ton) can be processed at a given time.

Since milling by the 'pestle and mortar' equipment involves heavy manual labour and the amount of broken grains is usually high, improvement of the traditional equipments for hand-pounding should be effected with a view to increasing the efficiency of milling, reducing breakage to the minimum and mitigating the hardness of severity to the human worker engaged in hand-pounding.

Modern mills require trained operators and higher level of management than is needed for huller mills. However, local personnel can be trained to run the modern mills. It should not be inferred that every country should replace all of its huller mills with modern types.

In most less developed countries, because both government and private milling operation exist, there is abundance of milling capacity. The problem is with Africa where there are no enough paddy to operate the machine at full capacity. Hence, upgrading the huller mills in such circumstance is better.

CONCLUSION

After having that reviewed the technologies used in rice milling in Africa and past of the world, it seems that traditional technologies carried out by farmers over the years have remained. They are still predominantly in use today because they are well anchored in the culture of the various ethnic groups.

Significant gains have been achieved in rice production world wide, but the development of the rice post production sector has not kept pace to take full advantage of the breakthroughs. Milling loss figures are only indicators of a problem, however, understanding the cause of losses is much more important. One of the key post production system technologies for minimizing losses and improving milled rice quality is in a good and efficient designed rice milling machines.

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