

Post-production technology and quality of rice

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Globally, rice ranks second to wheat in terms of area harvested, but in terms of importance as a food, it provides more calories per hectare than any other cereal crop. An hectare of rice can sustain 5.7 persons for a year compared to 5.3 for maize and 4.1 for wheat. In Asian diets, milled rice provides 40-80 percent of the calories and at least 40 percent of the protein. Rice has one of the most nutritious protein content (100 percent digestible) among the cereals. Besides its importance as food, it provides employment to the largest sector of the rural population.

The importance of post-production technology of rice has increased due to the increased yields from the high-yielding varieties. Losses that had been small in absolute terms expanded proportionately with increased farm-level yields. The problem of determining the magnitude and source of losses in the post-harvest sequence of operations is important and complex. All post-production operations such as handling, threshing, drying and storage are inter-depen-

dent. A close relationship between performance at the processing level and operations at farm level has been reported. When rice is improperly threshed, dried and cleaned at the farm level, it is impossible to achieve high milling efficiency at the processing plant. In Pakistan, the post-harvest losses amount to 17.2 percent. To improve the quality or quantity of processed rice, there is a need to consider the entire post-production operation as a system. The present paper deals with the quality of rice as influenced by post-production technology.

HARVESTING

It is very important to harvest the crop on time, otherwise grain losses may result from feeding by rats, birds and insects and from shattering and lodging. It is well-established that both early and late harvests are detrimental to the grain yield and milling returns of rice.

Timely harvesting ensures good grain quality, a high market value and improved consumer acceptance. An Indian study revealed that harvesting between

27 and 39 days after flowering at high moisture content (18-23 percent) gave maximum head rice recovery. Harvesting before or after that period resulted in an increase of broken grains. In the Philippines, an estimated 10 percent of the rice crop is lost when grains are left in the field to dry to 14-16 percent moisture before harvest. Under normal harvesting conditions in Thailand, total losses run from 60 to 120 kg/ha.

THRESHING

Threshing methods for rice vary from country to country. The methods are generally classified as manual, animal or mechanical. Threshing losses vary with the thresher used.

Threshing losses of four types of machines indicated that grain losses were large stationary thresher, 8.14 percent > manual thresher, 6.82 percent > IRRI-designed axial-flow thresher, 2.07 percent > IRRI-designed portable thresher, 1.97 percent.

DRYING

There are two methods of drying: natural (sun-drying and aeration) and artificial (mechanical). Sun-drying is most widely used primarily because of its low cost. Paddy post-harvest losses during drying in ASEAN countries are estimated to range from 10 to 37 percent. These losses are broken down as shown in Table 1.

While losses attributed to drying *per se* range only from 1 to 5 percent, a significant portion of the losses incurred in storage and milling is related to drying. Improper drying, especially during the wet season,

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Table 1. Paddy losses during drying

Harvesting	1-3 percent
Handling	2-7 "
Threshing	2-6 "
Drying	1-5 "
Storage	2-6 "
Milling	2-10 "

Source: D de Podua (1979)

contributes to losses due to rotting and down-grading of the quality of milled rice as characterised by a high broken percentage, discolouration and mould infestation.

Of the 54.4 million mt of paddy production in the ASEAN region, approximately 40-50 percent is harvested during the rainy season. At the current estimate of 5 percent loss, some 2.7 million mt valued at 326.4 million U.S. dollar are wasted annually. Losses related to drying are influenced by factors such as post-harvest practices, the location where drying is done, marketing operations and other factors related to the physical environment. A study at farm level indicated 10 percent paddy losses in Indonesia. In Philippines, dry losses account for reduction of monetary value of 5-58 percent due to yellowing and quality deterioration.

Mechanical drying produces significantly higher head-rice recoveries than sun-drying. Total rice recovery, however, is usually only marginally greater than that allowed after sun-drying, although the recovery is a function not only of the method of drying but also the type of rice mill in

which the rice is processed. Sun-drying of small amounts of rough rice is relatively easy to control and can give a good quality of dried rice. In an Indonesian study, differences in losses due to drying were negligible. Quality tests showed a head rice percentage of 53 percent for controlled sun-drying compared to 52 percent for mechanical drying using an IRRI batch type-dryer.

PARBOILING

It is a hydrothermal treatment of rough rice prior to milling. Parboiling of paddy is common in many rice-producing countries, including Pakistan. It affects the milling, storage, cooking, nutritional quality and ultimately consumer preference. In the parboiling process, rough rice is soaked, steamed and redried before milling.

Parboiling gelatinizes the starch within the rice grain, thus causing swelling and fusion of starch within the kernel. A pre-parboiling moisture content of 30-35 percent (wet basis) and 26 kcal of heat/kg of rough rice are needed.

Advantages of parboiling are:

- *Easier dehulling
- *Reduction in the number

of broken rice during milling

*Harder grain, which are less vulnerable to insect attack during storage

*Higher contents of B vitamins

*Cooked parboiled rice is less sticky than freshly harvested raw rice

Disadvantages of parboiling are:

*Parboiled rice becomes rancid during storage

*Longer cooking time is required

*Additional cost is involved in the drying operation following parboiling

*Parboiled rice requires more energy to achieve the same degree of milling

MILLING

Rice milling involves the removal of hulls and bran from rough rice to produce polished rice. Milling ranges from hand-pounding with the simple wooden mortar and pestle to the modern mills. The milling efficiency of different systems is shown in Table 2.

A big quantity of rice is lost during the milling process. A good rice milling operation should:

Table 2. Milling efficiency of rice as affected by four milling systems

Milling process	Total	Head	Broken
	husk + bran		
	%	%	%
Hand-pounding	40.0	40.0	20.0
Stell hullers	36.6	46.5	16.9
Disc-shellers	32.5	55.9	11.6
Rubber rollers	30.0	62.0	8.0

Source: Esmay et al (1979)

- produce the maximum yield of edible rice;
- ensure the best possible quality;
- minimize losses; and
- minimize the processing cost.

The time of harvest and season affect the milling yield of rice. The percentage of head rice decreases with time less abruptly in the wet season than in the dry season. Earlier and more severe breakage of the grain due to sun-cracking occurs during the dry season.

It is well-known that milling brings about changes in chemical composition and degree of milling determines the amount of nutrients in the residual milled rice. The effect of milling on the yield and the nutritional quality of rice is shown in Table 3.

Protein, fat, vitamins and minerals are present in greater quantities in the bran removed than in the remaining endosperm. On the other hand, milling process removes a large proportion of the phytate, which adversely affects the utilization of some of essential dietary minerals and trace elements, particularly zinc. Fibre, which interferes with mineral as well as protein utilization is also removed during milling. Among cereals, rice has a comparatively high content of essential amino acids and fairly low content of glutamic acid and other non-essential amino acids. However, lysine is still the first limiting amino acid followed by threonine. The amino acid composition was unaffected by the degree of milling, but the lysine concentration was slightly lower

in white rice than in brown rice. In the highly refined white rice, the protein content was reduced to 86 percent and the mineral content to 23 percent of corresponding levels in brown rice. Milling was accompanied by an increase in true protein digestibility and corresponding decrease in biological value. Thus, net protein utilization of different rices was uniform. A total of 33 percent of the utilizable protein and 22 percent of the digestible energy in brown rice have been reported to be removed during milling process.

STORAGE

Rice, like other cereal grains is subject to deterioration because of change in temperature and relative humidity. Insects and diseases become more active

under these conditions. It is generally considered that 13 percent (wet basis) moisture content is an acceptable value for rice. Low temperature and low moisture are necessary for long-term storage of rice for seed. Rice seed of 10-14 percent moisture content can be stored in good condition at 18°C for more than two years. A study in the United States indicated that seed storage at 44°C temperature and 55 percent relative humidity resulted in progressive loss of seed viability. A maximum moisture content of 12 percent is recommended for seed rice, but up to 14 percent usually is the safest in bulk storage.

Rice is usually stored as rough or milled rice. Rough rice is stored for home consumption in sacks or wooden boxes, cans,

Table 3. Effect of milling on the yield and nutritional quality of rice (% dry basis)

Rice Material	Rough	Brown	Under milled	Milled	Over milled	
Milling yield (%)	100	82	77	72	68	64
Ash	2.9	1.3	0.8	0.6	0.4	0.3
Protein (N x 6.25)	8.6	9.9	9.3	9.2	8.8	8.5
Fat	2.5	3.0	1.5	1.2	1.1	1.0
Starch + sugar	69.1	85.8	92.2	92.5	92.5	92.6
Crude fibre	12.2	0.9	0.2	0.1	0.3	0.1
Tannin	0.5	0.4	0.4	0.3	0.3	0.3
Energy kj/g	18.4	18.3	18.1	18.1	18.1	17.9
Zinc (ppm)	24	33	20	18	17	16
Copper (ppm)	2.8	2.7	2.6	2.2	1.9	1.8
Iron (ppm)	38	8.8	7.0	4.1	2.2	2.4
Phytate-p (mg/g)	2.1	2.2	0.7	0.2	0.1	0.1
Lysine (g/16gN)	3.53	3.52	3.49	3.29	3.37	3.27
True protein digestibility (%)	87.8	95.0	98.8	99.3	100.0	100.0
Biological value (%)	72.6	66.1	64.6	64.4	64.9	63.3
Net protein utilization (%)	63.7	62.8	63.8	63.9	64.9	63.7

Source: Pedersen and Eggum (1983)

drums and small granaries. Rough rice to be sold is stored either in the farmer's house or in a warehouse. It is desirable to store the commodity in gunny sacks on wooden platforms that allow free passage of air between grain sacks and the floor. For storage bins, any construction material is satisfactory if it results in a storage structure that will keep the grain dry, cool and free of insects and other pests. If dried, rough rice is to be stored for few months or if damp rice is to be held before drying the storage structure should be eq-

uipped for aeration.

Losses due to pilferage, rats, birds and insects are the major rice storage problems. The moisture content of dried grains often increases during storage causing bacterial and fungal diseases. Some farmers treat their stored rough rice with chemicals. Empty jute sacks often contain insects and should be treated with chemicals or fumigated before use for rice.

Nutritional losses during storage may result from insects or micro-organism attack, ranci-

dification of oil, changes in proteins or losses in vitamins. All these become more rapid as the grain moisture or storage temperature is increased.

The mechanization of post-production operations can reduce the losses in quantity and marketable quality of rice. As all the post-harvest operations are inter-dependent, each operation should be treated with an awareness of its interaction with others, to have a significant impact on the quality or quantity of processed rice.

MASSIVE PLAN TO CHECK WATER-LOGGING AND SALINITY

The Government has undertaken a massive programme for the control of water-logging and salinity. Under a modified strategy, efforts are being diverted to check the twin-menace in the areas having water-table within five feet from the surface round the year.

So far, the Government has completed 30 projects with an investment of Rs. 10 billion and provided protection to 8.5 million acres. At present, 14 projects are being implemented which will cover an area of another seven million acres and would cost the Government another Rs. 10 billion.

Private sector is also being involved in the sweet water zones and the Government is providing assistance to sink tubewells to control water-table and supplement irrigation. In addition, a strategy is being evolved to reduce Government's liability through the transition of SCARP projects.

Potential uses of major rice milling by-products

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Rice milling is a big agricultural industry in Pakistan in terms of volume of raw material. About 5 million tonnes of paddy is annually produced in the country. Dehusking of paddy is done because husk has little food value due to high contents of silica and crude fibre. The brown rice thus obtained has bran layers which need to be removed on account of relatively fibrous, impermeable to water and somewhat difficult to digest. Essentially, removal of bran layers is what constitutes rice milling.

Generally milled rice is consumed by people. But being a fairly high-cost commodity, it has limited use in industrial products. However, rice milling by-products viz., husk, bran, rice germ and polish have several food, feed and pharmaceutical uses. Proper utilization of these by-products can decrease effectively the milling cost of rice and consequently make it more competitive in the international market.

Now, let us discuss these rice-milling by-products in some details.

Husk

Husk or hull, the woody protective coating of rice grain generally constituting 20 to 23 percent of rough rice (paddy), is the first by-product in the sequence of milling operations. It possesses low bulk density and thus occupies a large volume. It has high abrasive property and is difficult to handle. Its utilization potential is low because of very low protein, oil and other useful mineral constituents. However, it contains high silica (90 to 95 percent of the ash) and crude fibre (45 percent d.b.) contents. Its most important constituent is pentosan (21 percent) and, thus, is a good raw material for manufacturing of furfural. Considerable effort has been made to find uses for husk but very little has been achieved in practice.

The major use of husk is as fuel for raising steam in the rice mill for parboiling or running the mill through a steam engine. Generators are being run by steam which, in turn, generate electricity to run the mill.

At present, husk is used primarily in animal feeds. The total by-products of milling

operation are sometimes utilized as "rice-milled feed", which usually contains about 61 percent husk, 35 percent bran and 4 percent polish. Ground husk can also be used in small quantities in animal feed as roughage; the husk-bran mixture produced in the huller mill is being partly used as animal feed. Finely ground husk is also suitable for use in phenolic resins and phenol-formaldehyde plywood glues.

Rice husk can be used for the manufacture of methyl alcohol, acetic acid and other useful products but it is not a common practice because other cheaper sources are available in abundance.

Husk can also be used as anti-caking agent for fertilizers, to lighten soil, as a cleansing agent in industry, as poultry litter, as a loose insulating material in building and cold storage, for packaging and for hard boards. Rice husk board is preferred by people for a large number of advantages. Specific and significant commercial advantages which rice husk board enjoys over plywood and particle boards are its cheap production, water resistance, termite resistance, fire and flame retardation, suitability for use in both tropical and temperate climates, strength and utilization of a waste material as the primary raw material input. Thus, due to its durability, aesthetic qualities and excellent workability, rice husk board can be used beneficially in residential and non-residential construction as well as in furniture and other wood-based industries.

The importance of proper

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