

A GUIDE TO A INDUSTRIAL RICE PROCESSING UNIT

1 - Presentation

1-1 Nature of the Activity

Industrial processing of paddy - or rough rice - leads to a product which is ready to be consumed by urban consumers. Processed rice offers sufficient guarantees for preservation, and is adapted to consumers' demands in terms of taste, nutritional value and ease of use.

Rural and localized consumption supplied by village-type rice mills will not be covered in this guide. Furthermore, indirect consumption through ready-made dishes or side-dishes, which will be simply mentioned.

Therefore, two main types of markets will be considered :

- Domestic urban market, with demands that may vary, but which are occasionally strict and precise with regards to taste, presentation and packaging (sometimes reduced to bags of a few kilos).
- Export markets with high quality requirements, in which final packaging is, in most cases, carried out in the country of final destination.

1-2 Alternatives

* Raw Materials :

There are numerous varieties of rice, each with its own characteristics (round, semi-round or long ; large range of sizes...) and distinct organoleptic properties (aromatic or non aromatic, glutinous or non glutinous...).

* Finished Products

- Type of product: the three main categories of rice are known as : cargo rice (husked brown rice), white rice, and parboiled rice. International standards recognize a large number of categories, based on:

- . the proportion and dimension of breakage during processing (9 different classes are found in the export standards of Thailand, for instance),
- . the degree of whitening and polishing
- . special treatments (parboiling, pre-cooking, glazing, enrichment).

These different factors act on one another : parboiling, for instance, has significant consequence as to the colour, degree of whitening and proportion of broken grains.

Adequate cleaning has a major influence on the effectiveness of whitening. Similarly, thorough sorting (according to dimension or colour) determines the final composition of lots. All of the factors must be considered, especially if the criteria for quality are strict.

- The types of packaging: these vary according to the market and the type of treatment the rice has undergone. For example, cargo rice, which is more susceptible to rancidity, might require airtight packaging. Inversely, glazing of white rice will allow for simpler packaging. Two main types of packaging can be identified. Namely, bags with a large capacity (50 kg) for export and wholesale, and consumer packaging (plastic bags or cardboard boxes, generally 1 kg capacity).

***Technology :**

All rice mills present a common sequence as far as husking and whitening operations are concerned (except in the production of cargo rice), which can be supplemented by other treatments such as :

a) parboiling : this process comes between precleaning and husking, and therefore concerns the paddy. There are numerous advantages to this process, both for the processor (higher milling yield, reduced rate of breakage, better quality of by-products) and for the consumer (improved nutritional properties, greater firmness, better cooking quality, and reduced stickiness).

Nevertheless, parboiled rice is often rejected by consumers who find it inadaptable to traditional tastes (particular yellow colour, taste and odour, often worsened by higher susceptibility to rancidity) which considerably reduces the potential markets.

b) After whitening, polishing and final grading, and before packaging: treatments carried out at this stage aim at improving the appearance of the rice, its nutritional properties, or its ease of use.

The principal treatments are :

- **glazing** : consists of coating the kernels with a solution of glucose and talc powder, which gives the rice a shinier appearance. This treatment is gradually disappearing.

- **enrichment** : is effected in the same way by addition of vitamins and minerals.

The market is very limited and largely confined to the United States,

- **pre-cooking** : which significantly reduces the cooking time at the household level. It was arrived at through experimentation with diverse methods, but in the industry, it has consisted of a short soaking in boiling water followed by rapid drying.

All of the above mentioned operations are performed on white rice.

1-3 Types of Possible Units

The three following units have been selected as examples (capacities in tons of paddy/hour).

Unit A : large capacity unit (10 t/h), modern, designed to serve a relatively large domestic urban market of consumers with medium-high purchasing power and attachment to traditional products; demanding with regards to the taste and appearance of the product (whiteness, size, rate of breakage) but not the packaging. Parboiling is ruled out because of rejection by this category of local consumers.

Unit B : medium capacity unit (3 t/h), fitted with a modern parboiling process, products are destined for an export market with high standards (notably Western Europe). The characteristics of parboiled rice make it suitable either for the consumer or for its use in the food industry (prepared dishes).

The three fundamental steps in parboiling (soaking, steaming and drying) must be mastered and entirely mechanized in order to obtain a perfectly homogeneous product.

Unit C : reduced capacity unit (1 t/h), linked to the emergence of a new and limited urban market, which demands products which have significant added value (packaging in particular). Includes a pre-cooking unit. It aims at a category of consumers with medium-high purchasing power, who are concerned with their modern yet classic appearance of certain new food products, in addition to the demands described for Unit A.

2 - TECHNICAL AND ECONOMIC GUIDE

2-1 Description of the Unit

2-1-1 Finished Products

UNIT	A (10 t/hr paddy)	B (3 t/hr paddy)	C (1 t/hr paddy)
Required paddy quality	excellent	good	excellent
Type of finished product	White rice	Parboiled rice	Pre-cooked rice
Type de Packaging	50 Kg sacks 5 Kg sacks	50 Kg sacks (export)	cartons and bags < 1 Kg
Production			
Hourly	6,5 to 7 t/hr	2 to 2,2 t/hr	0,65 to 0,7 t/hr
Annual	40 000 t	12 000 t	4000 t

2-1-2 Technological Choices

The sequence of possible operations is summarized in the following table. In the most complex process, production of pre-cooked rice from parboiled paddy, the complete sequence must be carried out.

OPERATIONS	TECHNOLOGICAL OPTIONS	SOLUTIONS		
		LINE A	LINE B	LINE C
Precleaning Destoning	Compulsory in all cases, vibrating or rotating sieves, single or double action aspirators, centrifugal or magnetic separators	indifferent, double preferable indispensable for security of machinery		
Pre-grading	Desirable for batch homogeneity according to length or thickness perforated or indented cylinders	thickness grading compulsory		
Soaking	Sequence for parboiling only Temp. 60 to 70°C ; fixed or rotary container vacuum then pressure or not	absent	65 - 70°C rotary yes	absent
Steaming	At atmospheric pressure 100°C or under pressure T > 100°C fixed or rotary container	absent	under pressure rotary	absent
Drying	Artificial or natural usage of vacuum in initial phase 2 stages : high T/low T	absent	artificial present present	absent
Husking	Compulsory sequence in all cases removing husk from cargo rice abrasive grindstone/rubber rollers	Rollers	Rollers	Rollers
Husk separation	Separating husk and fragments from cargo rice and non-husked paddy, simple aspiration or combination with sifting fragments and bran	simple	simple	simple
Paddy separation	Separating cargo from unhusked paddy. Machine with compartments or multiple inclined sieves	Indifferent		
Whitening	Abrasion of exterior layers of grain by vertical cone (Europe) or horizontal cylinder (Japon)	preferably vertical cone		
Polishing	Indispensable sequence for obtaining "finish of quality" vertical cone or horizontal cylinder fitted with leather straps	Indifferent		
Length grading	Separation of whole grain from fragments by rotary indented cylinders or oscillating sifters (plan-sifters)	Indifferent		
Colour grading	Removing discolored grain with photo-electric cell	Compulsory in all cases		
Mixing	By volumeter mixer	same		
Soaking	Specific sequence for pre-cooking hot or boiling water, duration varies from a few minutes	absent	absent	boiling water
Drying	Sublimation or hot air duration and temperatures vary	absent	absent	hot air
Weighing bagging	Sequence depending on destination (wholesale or retail) automatic for distribution or transportation	absent	absent	hot air
Packaging	Simple cardboard box or with individual dose in plastic bags	absent	absent	individual bags

2-2 Economic Analysis

2-2-1 Investments

	A	B	C
Equipment	FOB price \$US	FOB price \$US	FOB price \$US
Storage handling	\$ 640 000	\$ 400 000	\$ 320 000
Classic unit (Cleaning, grading, sorting, weighing, bagging)	\$ 1 900 000	\$ 800 000	\$ 500 000
Parboiling (soaking, steaming, drying)		\$ 650 000	
Pre-cooking			\$ 800 000
TOTAL EQUIPMENT	\$ 2 540 000	\$ 1 850 000	\$ 1 620 000
Building			
Surface area of the building	10 000 m2	8000 m2	6000 m2
Surface area of the grounds	40 000 m2	25 000 m2	15 000 m2
Other investments			
- Energy (husk boiler)	Electrical equipment \$ 160 000	Husk boiler \$ 300 000	Husk boiler \$ 480 000
- Compressor, water treatment	\$ 130 000	\$ 240 000	\$ 350 000
- Packaging	\$ 300 000	\$ 160 000	\$ 450 000
Total investment	\$ 5,2 million	\$ 3,8 million	\$ 4,1 million

2-2-2 Functioning

	A	B	C
Personnel*			
Skilled labour	60	25	35
Unskilled labour	40	30	15
Consumption (annual)			
Rice	60 000 t	18 000 t	6000 t
Energy	20 Kwh/t paddy	20 Kwh/t paddy	20 Kwh/t paddy

* The number of personnel needed can vary as much as 20 people depending on the type of packaging and the distribution chosen.

3 - KEY FACTORS TO THIS PROJECT'S SUCCESS

3-1 Supply

The raw material procured must meet two principal requirements :

- homogeneity in variety, which minimizes rejects and simplifies the functioning of the production line,
- proper drying prior to procurement, by the producer. This must be done progressively as rapid drying causes the grains of rice to crack, which results in an excessive proportion of breakage during processing and a lower yield. The moisture content after drying must be between 13 and 14 %; an excessive moisture content might lead to an overloading of the machines.

In the case of paddy procured for parboiling, the influence of prior drying is less, since the milling yield is greatly improved by gelatinization and hardening of the endosperm induced by the parboiling process. In addition, the moisture content can be readjusted during the final drying phase of the parboiling process.

The content in impurities, immature or chalky grains, etc., is a problem of lesser importance, since the latter can be eliminated rather easily during pre-cleaning and the sorting and grading operations.

3-2 Technology and Equipment

The stages of white rice production are generally well mastered nowadays, but obtaining uniform degree of whiteness requires the use of sensors (photo-electric cells) connected to a system for automatic adjustment of the degree of the milling.

A colorimetric grader is a sophisticated piece of machinery, but becomes indispensable when one wishes to obtain a certain level of quality.

For parboiling, soaking time should be minimized and water temperature should be kept within certain limits. These factors stimulate enzymatic activity and certain biochemical modifications of the rice, but are also responsible for the appearance of strong odours and flavours and an important change in colour. The use of vacuum and/or hydrostatic pressure allow better monitoring of this operation.

As far as parboiling phase itself is concerned, the uniformity of vapour distribution is of prime importance, as well as the duration of its application. The use of high temperature vapour, therefore high pressure, and continuous agitating of the product also leads to an improved control of this phase.

For the drying phase, the above mentioned precautions should be taken for moisture content below 16 %, with rest periods between two drying phases. During the initial phase of drying, drying speed can be maximized without risk by using high temperature air or applying vacuum.

For the pre-cooking process, the treatment should be sufficient enough to permit a short cooking time at home (< 10 mn) but should neither lead to loss of nutrients nor provoke stickiness.

Drying should be done progressively so as to prevent breakage during the subsequent handling and packing operations. Such constraints are more easily overcome with previously parboiled rice.

3-3 Personnel

During the course of all the processing phases, and particularly during parboiling operations, the process parameters should be adjusted to the specific features of the different batches of paddy.

It is indispensable to have trained personnel who are aware of the quality requirements that are to be met. The maintenance of a fully automated whitening line also requires highly qualified personnel.

3-4 Quality Control

This is usually performed with standardized laboratory equipment (huskers, laboratory cones, whiteness meters), but also relies to a large extent on visual estimation (discoloured, immature grains, etc.).

3-5 Marketing and Commercialization

For high quality white rice, the key factor is the regularity of the production in both volume and in quality.

For high quality parboiled rice, either a knowledge of export markets, particularly in Europe, or a joint venture with an experienced trading company is of prime importance.

For pre-cooked, packaged rice, thorough market surveys should be conducted before any investment decision is made.

3-6 Financing

Adequate provision for the storage of paddy should be foreseen for year-round operation of the factory, in case the storage capacity of the surrounding suppliers is not sufficient.

3-7 Other Specific Problems

Valorization of by-products (husk and bran) is a key factor in the calculation of the economic return of a newly established modern rice mill.

Bran provides significant additional income and is used in animal feed ; husk combustion generates enough energy to make the mill auto-sufficient and eventually supplies vapour for parboiling. Moreover, environmental problems associated with husk disposal are avoided and in certain cases, the ashes resulting from husk combustion can even be sold.

4 - INDUCED ACTIVITIES

For units A and C, the establishment of secondary processing units making use of broken grains (noodle making, rice flour production, beverages made with fermented rice, etc.) can be envisaged.

For unit B (parboiled rice), a side outlet for local production of prepared dishes or canned food can be envisaged, as well as exportation.

In all cases (but especially for unit B, which produces parboiled rice whose bran has a higher oil content) setting up an oil extraction unit can be envisaged, provided there is a secure and regular inflow of raw material. Non-refined oil can be used in the soap industry, and edible oil can be obtained after refining. De-oiled bran, because it is less susceptible to rancidity, can be stocked before being incorporated into animal feed.