Rice parboiling

FAO
AGRICULTURAL
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BULLETIN

56

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AND
AGRICULTURE
ORGANIZATION
OF THE
UNITED NATIONS

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by
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This manual provides information of a technical and economic nature on the processes and equipment for the parboiling of rice. Based on direct experience in the design, establishment, technical operation and management of commercial parboiling and milling plant, its aim is to serve as a practical aid for rice millers as well as for officers working in the public sector on development, investment, marketing and training. In this respect, consideration has been given to the problems faced by developing countries.

CONTENTS

1. THE PARBOILING PROCESS

The food eaten by the ancient Babylonians, Hittites and Jews 4 000 years ago and called *arisah* in the Bible was none other than bulgur or wheat (*Triticum vulgare*) which had been prepared in the traditional way. The wheat was first soaked in cold water, then cooked for a short time and was finally dried in the sun so that all its starch was gelatinized.

The American Indians who lived in the regions around the Great Lakes of Minnesota ate wild rice (*Zizania aquatica*), a distinct type of grass that grows in water. This was originally sun dried by the Indians for storage and conservation. However, when large metal pots became available about a century ago they were used for "parching" the rice. A large iron or copper kettle would be placed over a slow fire and partially filled with wet rice. The rice was stirred constantly with a paddle until it became completely dry or "parched". Today, the most common process of wetting, overheating and drying is the "parboiling" of rice (*Oryza sativa*) which takes place before the mechanical processes of husking and polishing.

Though statistical data are lacking, it has been estimated that more than 80 million tonnes of paddy are parboiled annually throughout the world, i.e. about one-fifth of the world's total rice crop — forecast as 403 million tonnes in 1982-1983.

Southeast Asia and the countries of tropical Africa have long been among the major producers of parboiled rice for consumption and export. In recent times, some countries in the Americas and in Europe have also begun producing or consuming parboiled rice. The term *parboiling* (also known as *boiling* or *overheating,* or *hydrothermic rice treatment)* covers the processing of the paddy (or rough rice) before milling.

Water and heat are the two main elements in the process. After steeping followed by heating, which involves the action of steam, the rice must be dried before milling and storage. Even shelled or cargo rice may be processed in this way if special methods are used.

The purpose of the process is to produce physical, chemical and organoleptic modifications in the cereal, with economic, nutritional and practical advantages. The main changes caused by parboiling the paddy are:

— the water-soluble substances (vitamins and mineral salts) are dissolved and spread throughout the grain, thus altering their distribution and concentration among its various parts (see Fig. 1.2, A and B);

— drying will reduce the moisture content to optimal level, irrespective of the degree of moisture the paddy possesses before processing;

— the starch grains embedded in a proteinaceous matrix, constituting the endosperm mass, swell and expand until they fill up all the surrounding air spaces;

— the orderly polyhedral structure, characteristic of rice starch, is replaced by a homogeneous and compact mass of gelatinized starch;

— the protein substances are separated and sink into the compact mass of gelatinized starch, becoming difficult to distinguish under the microscope and less liable to extraction;

— the oil globules contained in the endospermic elements, formed by granular deposits of aleuron, are dissolved;

— the enzymes present in the rice kernel are partially or entirely inactivated;

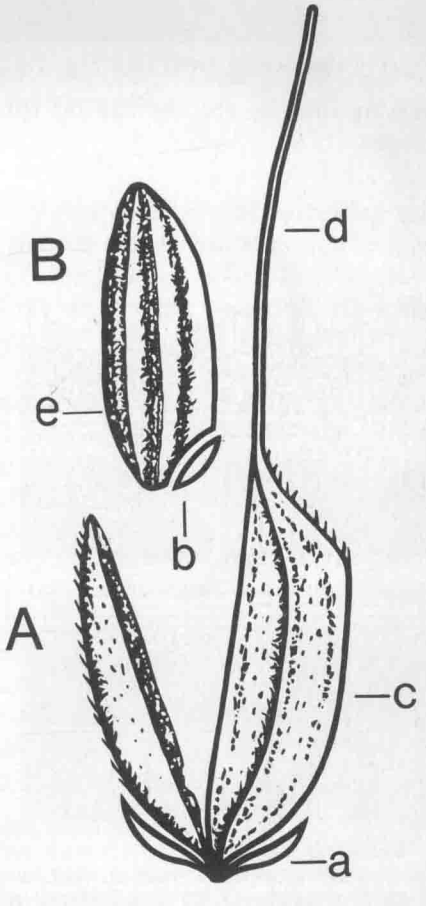

Figure 1.1. *Parts of a grain of paddy: A. husk; B. shelled grain; (a) empty glumes; (b) embryo or germ; (c) lemma; (d) awn; (e) caryopsis*

— the oil-soluble substances in the germ and in the outer layer of the endosperm are to some extent dissolved and spread;

— all biological processes, whether dormant or active (germination, proliferation of fungus spores, growth of eggs, larvae or insects, etc.), are permanently prevented.

These changes affect the results obtained during milling, storage and subsequent cooking, and include the following:

— the milling yield is higher and the quality improved, as there are fewer broken grains;

— the grain structure becomes compact and vitreous, whether the particular variety of paddy treated possessed this texture or not, even if the texture of some caryopses was entirely or partly chalky;

— the milled rice becomes translucent and shiny;

— parboiled paddy and milled parboiled rice keep longer and better than in the raw state, as germination is no longer possible and the endosperm has a compact texture making it resistant to attacks by insects and to absorption of moisture from its environment;

— the grains remain firmer during cooking and are less likely to become sticky;

— a greater amount of water is absorbed during cooking, causing the rice to swell (see Fig. 1.3);

— after cooking the rice absorbs less fat from added condiments;

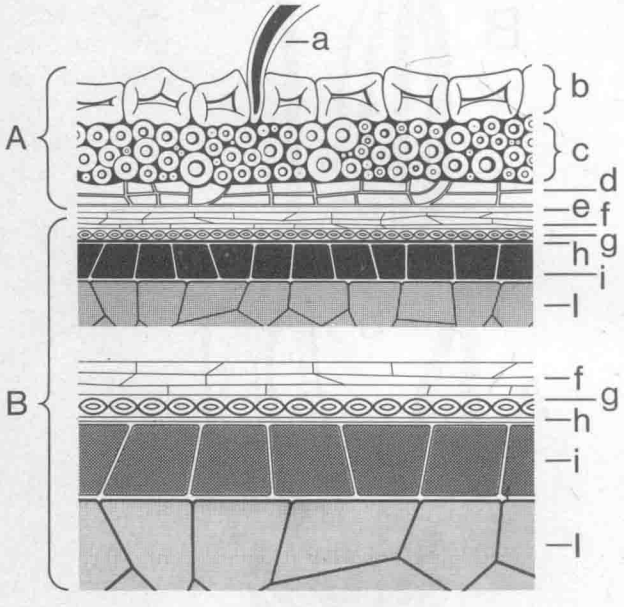

Figure 1.2. *Cross-section of a paddy grain: A. husk; B. brown rice; (a) hair; (b) outer epidermis; (c) spindle-shaped cells; (d) square cells; (e) inner epidermis; (f) pericarp layers; (g) tegmen; (h) perisperm; (i) endosperm layers containing granular deposits of aleuron; (j) starchy endosperm*

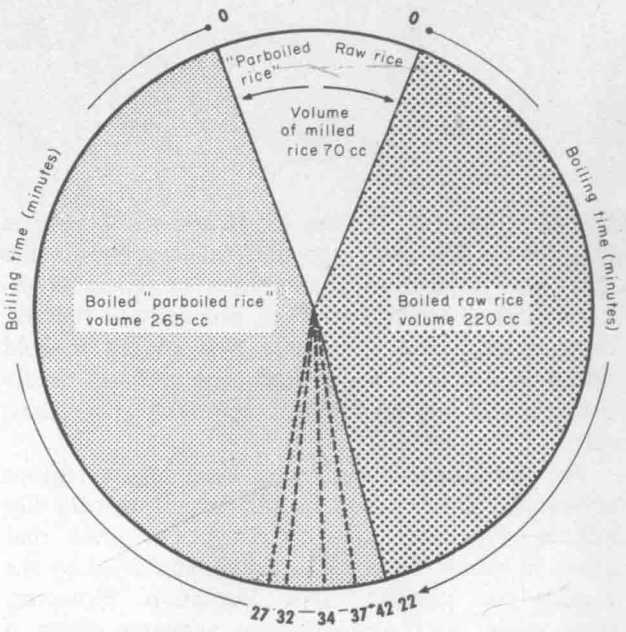

Figure 1.3. *Comparison of amount of swelling between parboiled and raw rice, depending on cooking time*

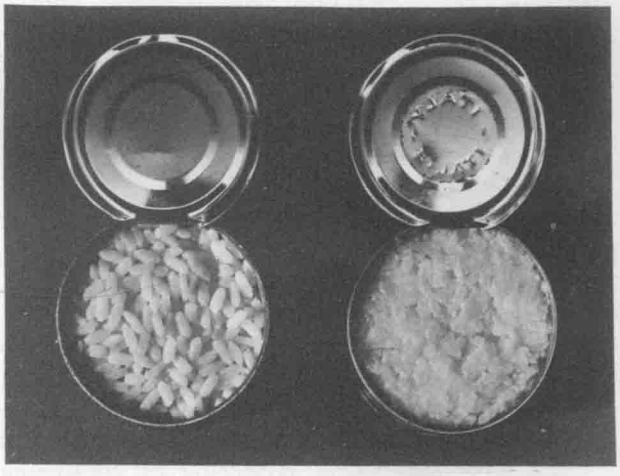

Figure 1.4. *Comparison between cooked and canned parboiled and raw rice: left, parboiled rice*

— when cooked, the rice keeps longer and it will not go rancid so easily (see Fig. 1.4);

— the nutritional value of the rice is greater because of the higher content of vitamins and mineral salts that have spread during parboiling into the endosperm. This is even true where polishing has removed the outer layer of the endosperm and the germ (see Fig. 1.5);

— after cooking, parboiled rice is more digestible because of its firm texture and consistency; the soft mass which it forms in the stomach is easily accessible to the gastric juices; [1]

— fewer solids are left behind in the cooking water (see Fig. 1.6).

[1] Borasio and Gariboldi, 1963.

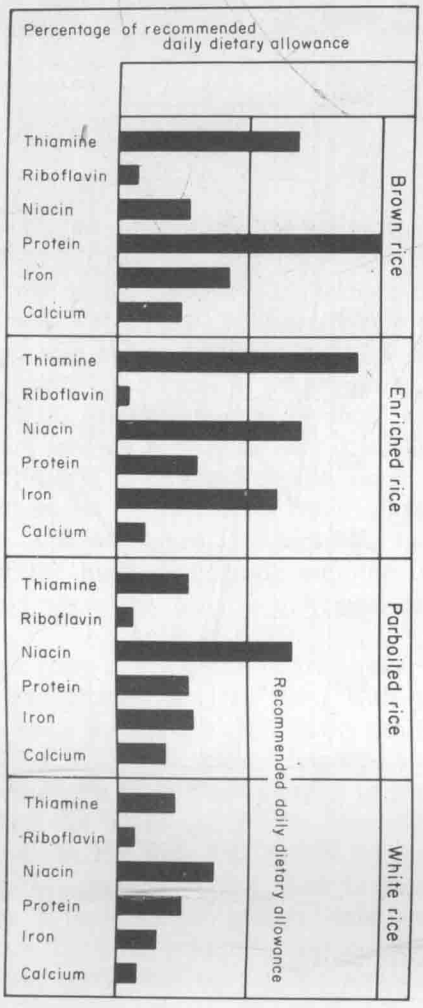

Figure 1.5. *Content in vitamins, proteins and mineral salts of parboiled rice compared with other types of rice (courtesy* Hoffman Laroche, Basel)

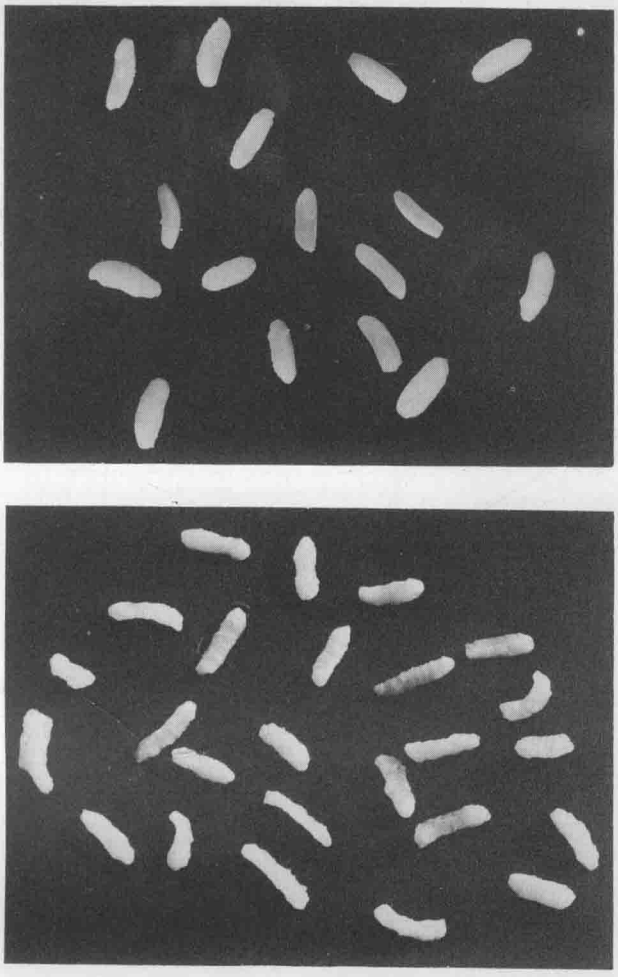

Figure 1.7. *Comparison between cooked grains of parboiled (above) and raw rice (below)*

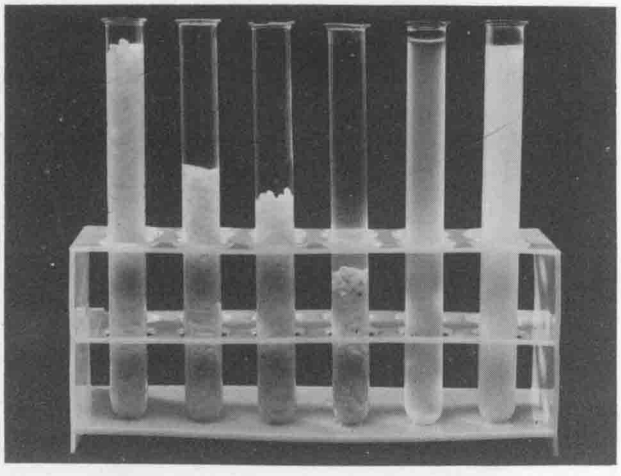

Figure 1.6 *Comparison between increases in volume of two varieties of rice in the parboiled (two left) and raw (two centre) states. The two test tubes on the right contain cooking water from the parboiled and raw rice respectively*

The various changes that parboiling brings about in the rice are closely related to the techniques used. Lack of competence or experience may not only cancel the advantages described but even result in reducing the food value the cereal originally possessed. If the paddy is allowed to ferment during or after steeping, if it is not properly dried out and if it is inadequately milled, the taste, flavour, smell and colour of the rice will be such as to make it unacceptable for consumption.

A study [2] recently conducted among Indians who habitually eat parboiled rice has shown that it constitutes the second most important source of aflatoxin in the human body. A strain of *penicillium citrinum* has in fact been isolated [3] in samples of parboiled rice put on sale for human consumption, and this may cause calcification of the urinary system and decalcification of some bones in the body.

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[2] Parpia, unpublished report.

[3] Parpia states that parboiled rice is the second largest source of aflatoxin in the normal Indian diet after unrefined peanut oil. This is so because, for want of adequate drying facilities, rice only partially dried is often bagged and stored in warehouses. Evaporation is slow and pockets of high moisture are created, where fungal growth invariably occurs.

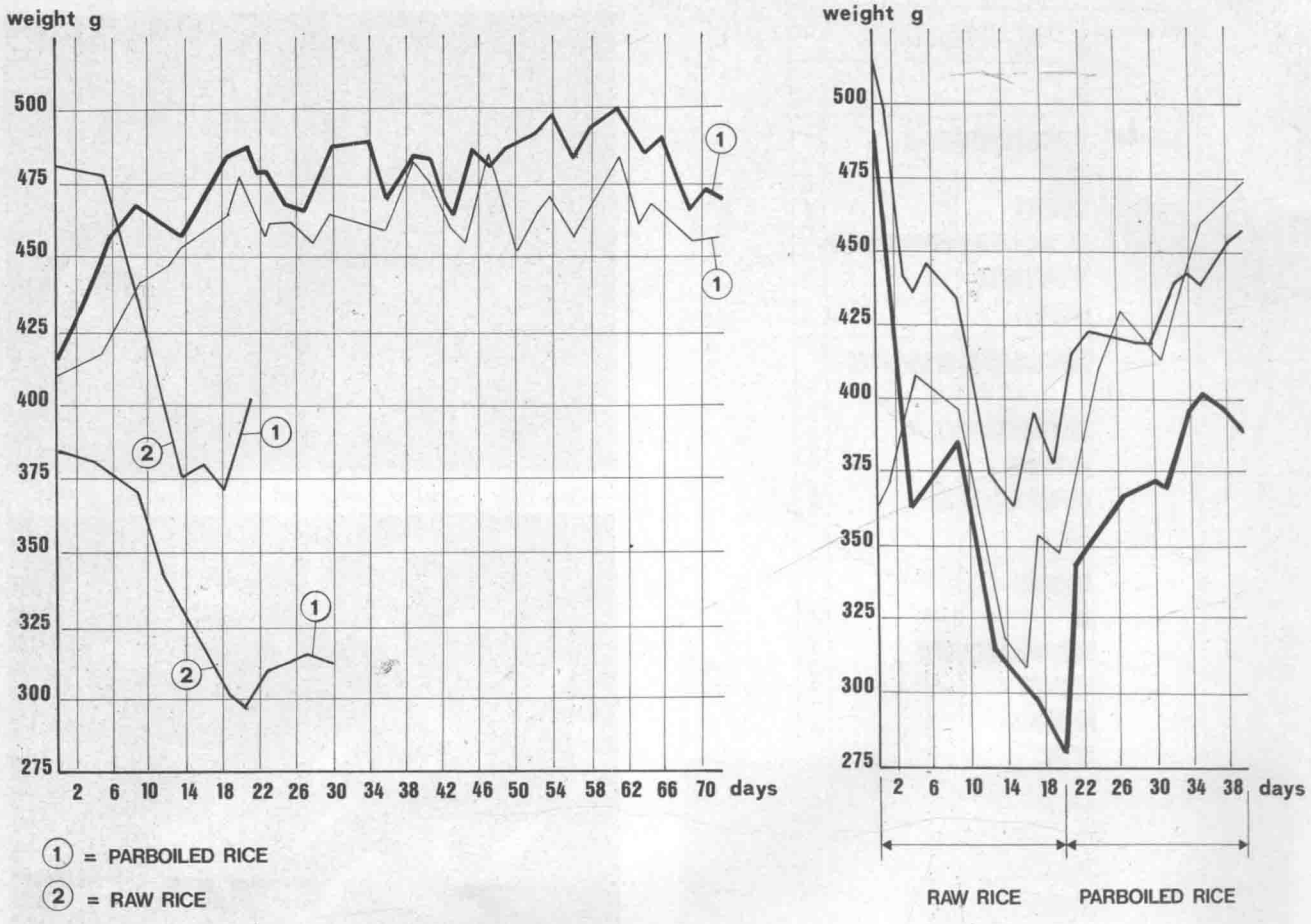

Figure 1.8. *Changes in the body weight of pigeons fed with milled parboiled and milled raw rice*

Apart from this, many other problems which have up to now hindered extensive consumption of parboiled rice must be considered. Some of these problems relate to its particular colour, odour and taste, its hardness and the presence of partly or completely darkened grains. In describing the technology and development of parboiled rice production throughout the world, this monograph seeks to be informative about the technical aspects involved in producing a kind of parboiled rice with properties that enable it to replace ordinary white rice, to the advantage of the consumer.

2. ORIGINS

Second only to milling by the primitive method using pestle and mortar, parboiling is certainly the most ancient process applied to threshed paddy. It is not known for certain, however, where the practice began, but almost certainly it was in Southeast Asia or in tropical Africa. In some regions of equatorial Africa, certain varieties of local paddy are thoroughly sprayed with water and dried in the sun and the process is repeated several times to make the paddy easier to husk. As a result of absorption of water and subsequent evaporation, the woody fibres of the husk disintegrate and the two husk halves come apart so that it is quite easy to free the grain.

In some parts of India and in Sri Lanka, paddy is put in earthenware or iron jars, with sufficient water to cover it, and it is then slowly heated over a fire (see Fig. 2.1). The water is brought to the boil and the paddy is stirred and allowed to cook in the steam until the husks partly split open. The rice is then dried in the sun and milled by pestle and mortar. This method is still used in rice-growing areas on a domestic or artisan scale and is the forerunner both of primitive commercial systems still in use today and of modern industrial techniques.

This process was used in ancient times for the practical advantages it offers, namely:

— pounding by pestle and mortar becomes much easier;

— the edible rice contains fewer broken or finely crushed grains;

— the taste, flavour and hardness of the cooked product are preferred by the consumer;

— the rice keeps for a considerable time after cooking without becoming sticky, rancid or mouldy.

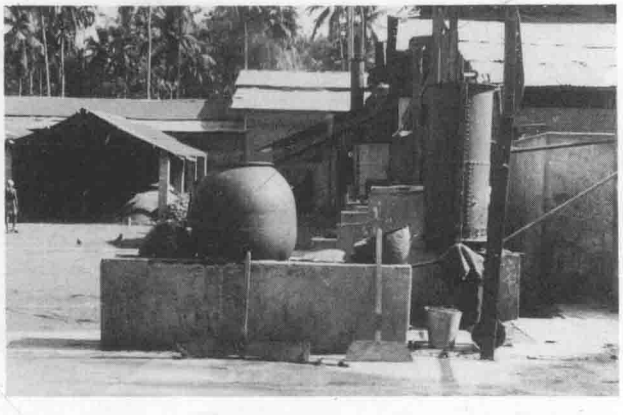

Figure 2.1. *An iron jar used in Sri Lanka until the Second World War for parboiling rice*

These are considerable advantages for the peasants who work in fields far from their homes, or for those on the desert fringes where there is little fuel for cooking food.

Other primitive methods of producing parboiled rice still in use today in the Far East and in Africa, are described below.

Figure 2.2. *Parboiling by the* chatty *method in Pakistan*

In Pakistan, the *chatty* method, typical of the southern regions, consists of filling small earthenware jars with paddy and water, and standing them on a bed of rice husks mixed with huller bran. The bed is then set alight with red-hot ashes. Combustion is slow and the water in the jars is gradually brought up to 50-60°C. The paddy remains from six to twelve hours in the hot water and absorbs enough of it to become ready for the steaming stage (see Fig. 2.2.). The excess water is poured off and the grain is put in large iron containers, which are wide and shallow, and they are set over a furnace fired with rice husks. The damp rice is stirred continuously and a little water is added from time to time to compensate for evaporation. This heating operation may last from 30 to 60 minutes, after which the rice is spread out to dry in the sun on a hard earth or concrete floor.

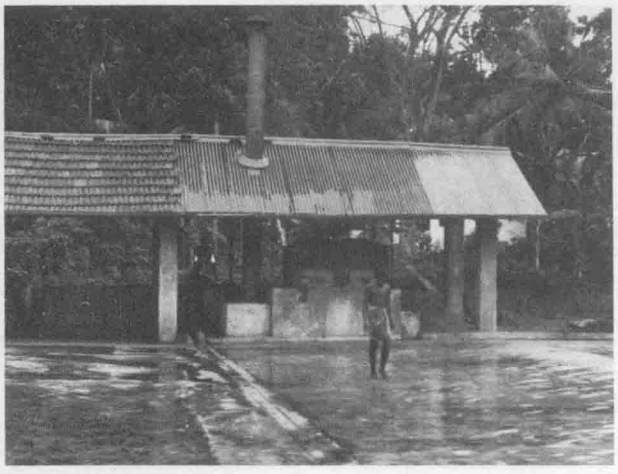

Figure 2.3. *A primitive parboiling plant in India: the drying floor is in the foreground*

In India and Sri Lanka, the rice is steeped in water at ambient temperature and left in concrete tanks for 12 to 48 hours. The paddy is then drained and heated in an iron tank, usually rectangular in shape, which is placed over a furnace fired with rice husks or wood (see Fig. 2.3.). This tank is divided horizontally, 6 or 7 cm above the heated bottom, by a sheet of iron, which has small holes in it. The holes are so small that the rice cannot fall through. The upper part of the tank is then filled with rice and the lower part with water. The water is brought to the boil so that the steam passes upward through the rice and heats it. This process may be continued for 30 minutes to two hours and then the rice is spread out on a floor to dry naturally.

In Liberia, freshly harvested paddy (either in panicle or loose-grain form) goes through a process called "aging" or "curing" before milling. This process does not have all the advantages of parboiling, but it does slightly improve the cooking quality of the rice. The paddy is put in a mud or metal pot and some water is added to the bottom. The pot is then set over a fire and heated until the water has completely evaporated (after about 30 minutes or even more). The steamed paddy is then dried before hand pounding. When rice is processed in this way the breakage caused by pounding is fairly high.

In Ghana and Nigeria, empty oil drums are often halved and used for parboiling paddy. They are mounted on two rows of bricks and a wood fire is lit underneath (see Fig. 2.4.).

Rice parboiling methods vary from one area to another. The oldest method consists of bringing the water to the boil, pouring in the rice and leaving it to soak for 12 to 16 hours. Some of the water is then poured off and the rest is boiled until the rice, which is stirred continuously, has completely absorbed the water. It is then spread out on a mat or threshing floor and dried before being milled in a mortar. A variation of this system is to remove the soaked rice from the container after 12 to 16 hours

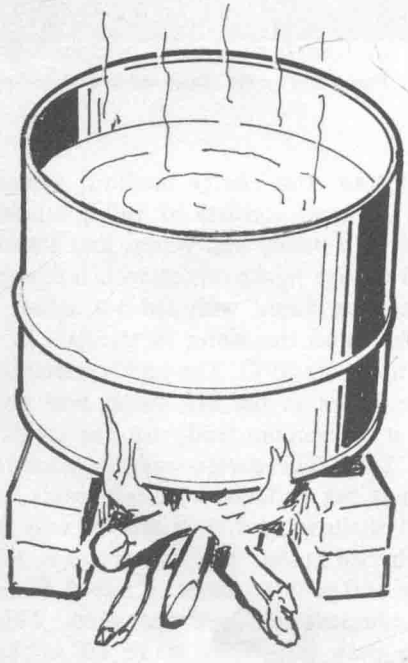

Figure 2.4. *Halved steel drums are still used today for parboiling rice in West Africa*

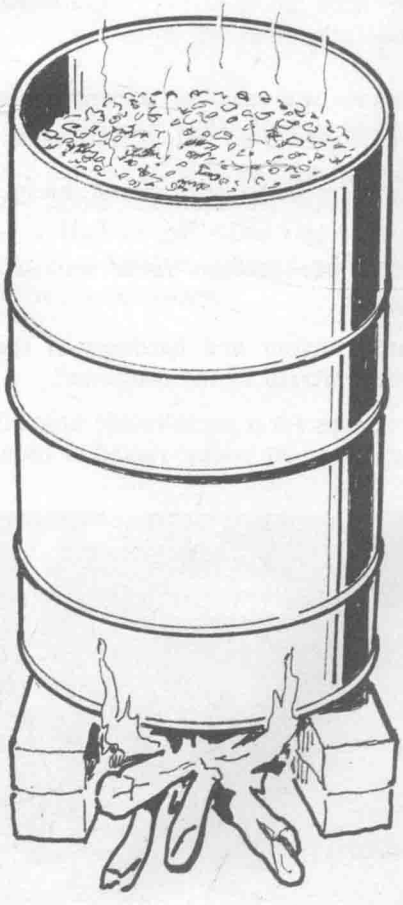

Figure 2.5. *Steaming soaked rice in a drum half (with perforated bottom) placed over the other half partly filled with water*

and pour it into a cane basket. The basket is put on top of the soaking container which is partly filled with water and boiled over the fire. In this way the rice is steam-heated until all the starch is gelatinized.

Half an oil drum can be used instead of a cane basket to heat the soaked rice (see Fig. 2.5). Before use, the bottom of the drum should be perforated with a nail or graver to make numerous well-distributed holes, slightly smaller than a grain of rice.

In some regions of Central and South America, primitive Indian and Pakistani parboiling methods are still in use. They were probably brought to these regions in the nineteenth century by Indian and Pakistani coolies who were hired on long-term contracts after the abolition of slavery to work on the large estates. Parboiled rice is mostly consumed in areas where there were once large plantations of cane sugar, coffee and cotton, etc. The parboiled rice produced in this way is known locally as *amarillento* or *amarillecido* (yellowed).

3. LATER DEVELOPMENTS

The introduction of mechanized milling in the Far East and the consequent adoption of the boiler and steam-driven engine to operate the mills have resulted in the use of pressurized steam for parboiling. One of the most widespread methods in use in the Far East is to steep the rice in concrete tanks and heat it by the injection of steam produced by the boiler (see Fig. 3.1).

The steeping tank is generally square or rectangular and can hold several tonnes of paddy. It has a flat bottom and is slightly raised above ground level so that the water can be drained off through a hole in one side of the tank covered with a piece of wire netting to hold back the rice. The depth of the tank is determined by the average height of the workers who empty it manually and load the paddy into baskets. Enough water is added to keep the paddy submerged throughout the steeping time, which lasts from 12 to 48 hours or even more. When steeping is finished, the water is drained off and the damp rice is carried manually to the pan in which it is heated by steam injection.

This pan is usually either cylindrical or rectangular in shape; it is open at the top, and at the bottom is conical or pyramidal, ending in a guillotine shutter through which the product is unloaded. It may be constructed of iron sheeting or concrete, whichever is most economical. Two or more of these pans are placed at one side of the steeping tanks so that they can be filled by workers walking along the edges. The shutter at the bottom is situated some distance above the ground to facilitate unloading.

In the middle of the pan there is a perforated vertical pipe. Steam from the boiler passes through the holes and penetrates the mass of damp rice. The holes start a few centimetres lower than the level reached by the rice when the pan is filled up. If the pan is very wide there may be more than one perforated pipe so that the steam can spread more evenly throughout the rice.

Sometimes, instead of the pan described above with one or more vertical perforated pipes and a conical base and unloading shutter, a flat-bottomed cylinder is used, with perforated pipes fitted into it vertically from below (see Fig. 3.2). In this case the cylinder is tipped over to empty, turning it on two pivots or trunnions.

One method of heating rice by pressurized steam is especially popular in some regions of Africa. The rice is put in oil drums without a lid (see Fig. 3.2). The steam distribution pipe (one end of which is closed and pointed, and the other connected by a hose pipe to the pressurized steam supply) is pushed down into the rice until it reaches the bottom of the drum. The entire parboiling plant consists of a number of drums and one or more steam supply points, because steeping takes place in the same drums or containers.

After all the methods described above, the rice can be subsequently dried in the sun, spread out on beaten earth or cement floors, or it can be artificially dried, thanks to modern technology. Artificial drying was in use in very large plants in Burma even before the Second World War. In some of these plants the rice is dried by being spread on heated concrete floors which are roofed over. The floors are heated by hot water circulating through pipes sunk into the concrete.

All the operations concerning the movement of the paddy toward the steeping tanks, and from there to the containers in which it is heated, as well as spreading, turning and collecting the paddy from the drying floors, are usually done manually and the grain is carried in basket or on trolleys.

In one large plant in Thailand, the paddy is steeped in an enormous concrete tank sunk below ground level. Dumper lorries carry the dry paddy down a ramp to the edge of the tank. A power

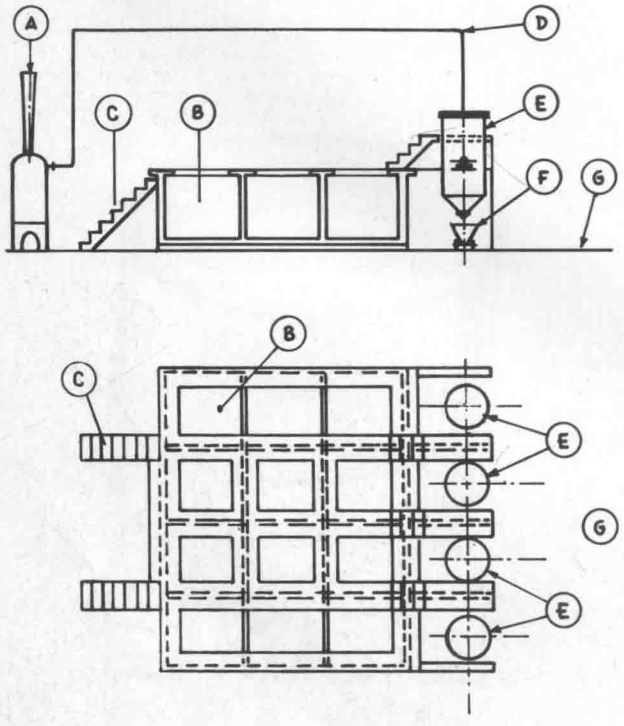

Figure 3.1. *Typical parboiling plant in the Far East: A. boiler; B. concrete steeping tank; C. flight of steps; D. steam pipes; E. open steaming vat; F. trolley; G. drying floor*

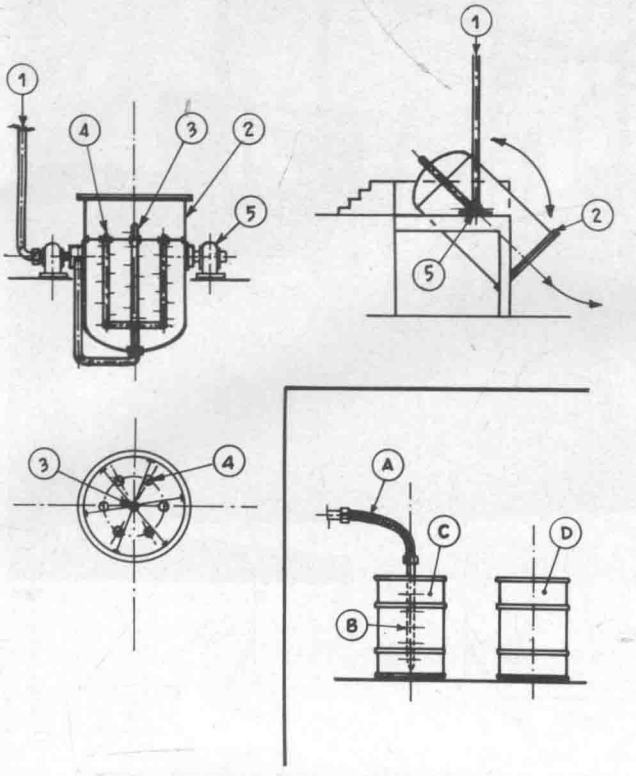

Figure 3.2. *Traditional parboiling methods. Tip-over steaming tank, and (inset) drum-type parboiling container: 1. steam pipe; 2. iron cylinder; 3. central steam injection pipe; 4. radial steaming pipes; 5. pivot; A. steam hose pipe; B. perforated steaming pipe; C. drum during steaming; D. drum ready for steaming*

shovel spreads and levels it. After steeping, the power shovel loads the wet paddy back into the lorries. These lorries are fitted with several layers of perforated pipes lying parallel to the loading platform and ending with a manifold for receiving steam. When loaded, the lorry is driven to the boiler and the manifold connected to the pressurized steam supply. The rice is then steamed for a period of 20 minutes to one hour. Afterward the lorry proceeds to the drying floor and tips out the rice.

The most important improvement upon traditional methods is the replacement of natural by artificial drying, since the former could only be done in fine weather (see Fig. 3.3). Steeping was sometimes prolonged more than necessary because lack of sunshine made it impossible to proceed with steaming and drying. In fact, the paddy cannot be taken out of the water unless steaming follows immediately, otherwise germination might begin. It is almost impossible for paddy immersed in water to germinate in a tropical climate where the temperature of the water is such that the amount of dissolved oxygen is insufficient. On the other hand, if the product is heated and not dried at once, its colour becomes deeper and its flavour stronger.

An exception to the traditional production of parboiled rice as previously described is an Indian process locally called *do-bhamp* or "double steaming". Steam is blown through the dry paddy before steeping as an initial heat treatment. The equipment used for this system is no different from that described above; masonry tanks are used for steeping. Upright pans, open at the top and fitted with perforated pipes, are used for steaming, and beaten earth or cement floors for drying. Instead of being put into the steeping tank, the raw paddy is first loaded into the heating pans and steam is injected into it while still dry. This operation requires special skill since heating must take place without causing the surface starch of the caryopsis [1] to gelatinize and harden, which would prevent the paddy from absorbing water. Thus, in order to avoid excessive heating, the rice in the steeping pan is covered with a jute sack, and when pressure causes the sack to lift as the steam reaches the upper surface of the rice, the steam supply is cut off.

This particular method seems to offer the advantage of making the seed sterile so that during steeping there is less organic fermentation of the rice and of the impurities mixed with it. In addition, hot dry paddy poured into the water raises its temperature and facilitates steeping, which is thus concluded in a shorter time.

The *do-bhamp* or double-steaming method needs further investigation because preheating dry paddy almost certainly controls enzymatic reactions such as "amylases" [2] and "lypase" [3] which affect the colour, flavour and smell of the edible product.

In these primitive commercial methods a distinction is made between steam produced under pressure in a boiler and steam rising from the water placed underneath it. In both cases, however, the

[1] The rice fruit is a caryopsis in which the single seed is fused with the wall of the ripened ovary (pericarp) forming a seed-like grain. The dehulled rice grain (caryopsis) is called brown rice because of the brownish pericarp. See International Rice Research Institute, 1965.

[2] Raghavendra Rao and Juliano, 1970.

[3] Voramitte and Hermas, 1968.

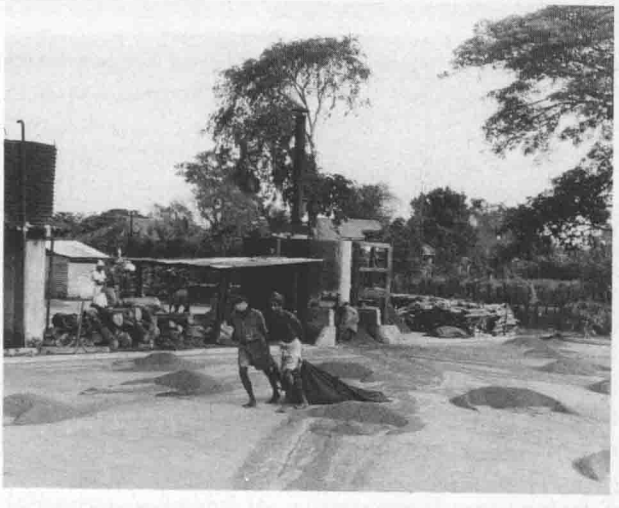

Figure 3.3. *Sun-drying parboiled rice in the Far East*

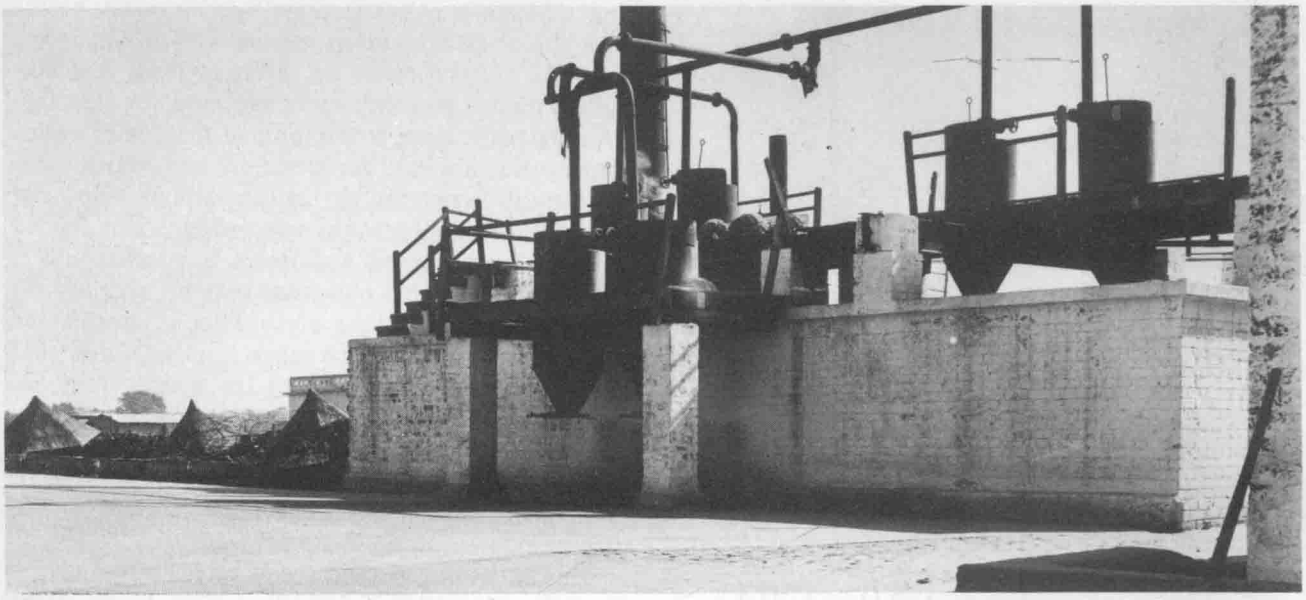

Figure 3.4. *Parboiling plant in Nepal using the double-steaming method*

Figure 3.5. *Parboiling plant in Ghana equipped with concrete soaking tanks and tip-over steaming pans*

heating operation is carried out at atmospheric pressure in open containers. Only modern industrial systems use pans able to withstand pressure. Thus, one difference between ancient or primitive methods and modern methods is the manner in which the rice is exposed to the action of steam, i.e. whether at atmospheric pressure in an open pan or in a closed pressurized container or autoclave. [4]

A village-type method recently developed in India includes some characteristics of advanced industrial methods. It involves heating rice by steam under pressure, using a simple steam generator instead of a boiler.

The equipment (see Fig. 3.6) consists of a pressure vessel which has a perforated false bottom in-

[4] The term "autoclave" means a strong closed vessel of metal in which liquid can be heated above boiling point under pressure. Etymologically, the word indicates a self-closing vessel, in which the tightness of the joints is maintained by the internal pressure, but this characteristic is frequently lacking in the actual apparatus to which the name is applied.

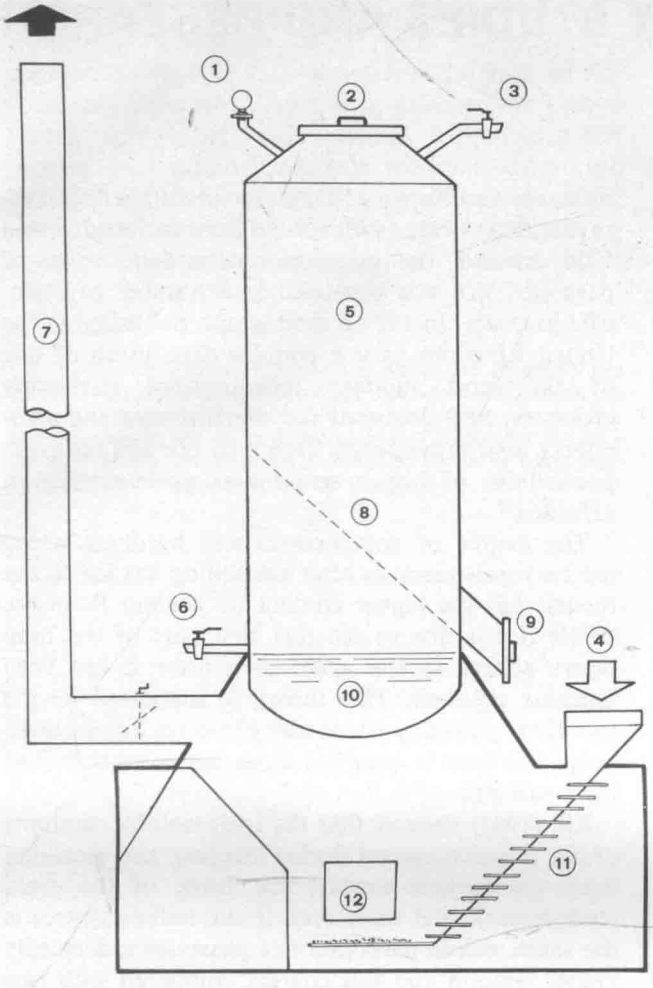

Figure 3.6. *Pressure parboiling unit using a simple steam generator: 1. pressure gauge; 2. paddy and water inlet; 3. steam exhaust valve; 4. husk feed hopper; 5. pressure chamber; 6. water overflow pipe; 7. chimney; 8. perforated false bottom; 9. paddy discharge door; 10. water tank; 11. grate for furnace; 12. ash door*

clined at 45° to facilitate the discharge of steamed paddy through a gasketed side door. It also has a 20-litre water tank at the base. At the top of the vessel is a steam-tight hinged door for pouring in the water and the paddy. The vessel is set over a furnace fired by paddy husks.

Water is poured into the vessel by means of a hose pipe until it starts to come out of the water overflow pipe and then when the steam exhaust valve at the top of the vessel begins to emit steam, the feed door is opened and the paddy poured in. Water is then poured in until it reaches the top level of the paddy and it is drained off after a few minutes. This helps to remove intergranular air and to fill the intergranular space with water. After open steaming has been carried out for a period of 15-30 minutes, the feed door is closed and pressure is gradually allowed to build up. After an additional 15-20 minutes the steam exhaust valve is opened and the paddy is discharged from the side door.

4. EARLY STUDIES AND RESEARCH

The introduction of machinery into rice processing which occurred at the beginning of the twentieth century, led to an even greater preference among consumers in the Far East for the resulting highly polished white rice with its more pleasing appearance as opposed to the type milled by pestle and mortar. Increasing urbanization of populations naturally favoured consumption of the machine-milled product.

The negative result of this apparent progress was the spread of beriberi epidemics in many regions of the Far East. [1] Between 1932 and 1935, in the Madras presidency alone, statistics showed that the incidence of this disease among the registered population increased from 17 000 to over 35 000 cases.

Medical hygiene and diet research and the studies undertaken in the effort to contain and combat the spread of beriberi took the lead in drawing attention to parboiled rice and to the processes used in preparing it. Observations made and experience gained by Eijkman (1897), Fraser and Stanton (1909) and Vedder (1913) clearly show that undermilled rice and rice given parboiling treatment prevent the spread of beriberi among rice-eating peoples. The explanation given was that the presence of most of the outer layers of the caryopsis in undermilled, and especially in parboiled, rice prevented the onset of this disease. It was assumed that what Vedder termed a "life-giving substance" was present in the rice bran. Fraser and Stanton, and Funk (1914) tried to discover and isolate this substance, but it was not until 1926 that Jansen and Donath (1926a, b, c) managed to extract it in crystallized form from rice bran. It was vitamin B_1, which its discoverers proposed calling Aneurina because of its antipolyneuritic effect. Windaus, Tschesche and Ruhkopf (1932) succeeded in obtaining it in crystallized form from yeast, and studied its chemical composition. This, however, was only finally clarified by Williams (1935) who, the following year, also produced it by synthesis (Williams, 1936). He named the substance Thiamine to indicate the presence of sulphur in its molecule. The hypothesis of many research workers, whose observations and experience had established the fact that undermilled and parboiled rice possess greater food value than highly polished rice, was at last proved by scientific analysis.

During the period between the two world wars, further studies were published, among which those by Jones and Taylor (1935), Auriol (1937) and Aykroyd (1930, 1932, 1940) should be mentioned. From 1930 onward, the question of the food value of parboiled rice was discussed in a number of scientific journals. In 1939 a monograph published in the United Kingdom gave a popular description of one of the most modern industrialized parboiling processes, and discussed for the first time the technology used in preparing parboiled rice and the great possibilities of improvement and modernization it afforded.[2]

The degree of compactness and hardness which the caryopsis assumes after parboiling has led to the theory that the higher content of vitamin B_1 in the edible rice is due to the fact that part of the bran layers adhere to the grain even after it has been machine polished. This theory is supported by the fact that, polishing times and pressures being equal, much less bran is obtained from parboiled rice than from raw rice.

Kik (1943) showed that the hydrosoluble vitamins of the B group spread during steeping and steaming from the surface toward the inside of the grain (endosperm), and that, even if the milling degree is the same, edible parboiled rice possesses a decidedly higher vitamin and salt content compared with raw rice.

Further research and studies on parboiling were intensified after 1946 when interest in the process became widespread, favouring its introduction in the United States and Europe. Simultaneously with this revival of interest in developed countries, moves were made in some Far Eastern countries to rationalize and industrialize production along modern lines. What was achieved, however, was mainly due to the research and studies carried out in India.

Studies on and the development of parboiling up to the present day may be divided into three periods.

Before the beginning of the twentieth century. Technology was of the ancient tradition, differing from region to region, and preparation was mainly on a domestic scale;

From the start of the twentieth century to the outbreak of the Second World War. This period was characterized by the introduction of machinery and modernization in rice milling. The parboiling process also became industrialized. Steam produced under pressure in boilers was used for steaming great masses of rice.

[1] In 1937 the League of Nations' Intergovernmental Conference of Far Eastern Countries on Rural Hygiene, at its Java meeting, agreed that the tendency to use undermilled or home-pounded rice was decreasing. This was condemned from the nutritional standpoint.

[2] Rice Conversion Ltd, 1939.