PROCESSING AND MILLING OF PARBOILED RICE

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Introduction

Parboiled rice is a kind of processed rice, which is produced in some countries of Asia, principally India,[11] as well as in Africa, Europe and America.

Parboiling process involves the hydrothermal treatment of paddy before milling. The advantage of the parboiling process stems from the gelatinization of rice starch and hardening of rice kernel that it brings about. As a result, breakage losses during milling of rice can be minimized.

Five major steps in the parboiling process are required, as follows;

1) Soaking paddy in water (cold or lukewarm water) to increase the moisture content.
2) Steaming paddy to achieve partial gelatinization.
3) Drying paddy to save the moisture content for storage and milling.
4) Husking to remove paddy husk from paddy kernel.
5) Milling to remove bran from brown kernel.

The parboiling process is with physical, chemical and nutritional changes in rice, as follows;

1) The milling yield is higher and quality improved as there are fewer broken kernels.[2,3]
2) The preservation of parboiled paddy and milled rice is longer and better than in the raw state. Germination is no longer possible and the endosperm has a compact texture making it resistant to attack by insect and microorganism.
3) The milled rice remains firm during cooking, and its texture becomes unstiky.[1]

4) A great amount of water is absorbed during cooking causing the rice to swell.[4]
5) Its nutritional value is enhanced due to the higher content in vitamins and minerals that have spread into the endosperm during the parboiling process.
6) Soild materials are less in the cooking water.[4]

This investigation was carried out to produce parboiled rice with a medium scale parboiling equipment and the present basic data for optimizing the parboiling process and milling conditions by analysing the relationship between processing conditions (soaking, steaming, drying and milling) and properties of milled rice.

Materials and Methods

Materials tested

Four rice varieties were selected as the materials to be tested in this study. The first three are ISHIKARI, SHIOKARI and MICHIKOGANE which are short grain Japonica type grown in Hokkaido, in 1981 and 1984. The fourth is T 136, which is a long grain Indica type grown at the Experimental Paddy Field of Tsukuba University in 1981.

Some physical properties of these variety are shown in Table 1.

The T 136 variety was first cleaned to remove foreign materials and immature kernels.

TABLE 1. Physical properties of materials

Variety	Crop Year	Crop Place	Moisture content (% w.b.)	Whole kernel (%)	Partially shelled kernel (%)	Shelled kernel (%)	Bulk weight (g/l)
ISHIKARI (Japonica)	1981	Hokkoido	13.9	38.6	60.3	1.1	617
SHIOKARI (Japonica)	1981	Hokkaido	13.8	73.0	25.1	1.9	625
T-136 (Indica)	1981	Ibaragi	11.9	92.9	4.3	2.8	565
MICHIKOGANE	1984	Hokkaido	19.9*	92.5	7.2	0.3	574

* Raw material

Equipment used

1. Apparatus for measuring the water absorption rate during soaking.

The water bath with capacity of 9 liters was used in this study. The materials were placed in stainless-steel tube ($25\phi \times 45$ mm) which have many holes. The water temperature was controlled automatically with electric heaters.

2. Equipment for parboiling process.

The flow diagram of the apparatus used for the experiment is shown in Fig. 1. The soaking and steaming tank is shown in Fig. 2. The component parts of the apparatus are shown in Fig. 3, Fig. 4 and Fig. 5. The apparatus consist of soaking and steaming tank with capacity of 0.52 m^3, basket and dryer. Steam supply to the tank is able to maintain constant temperature condition during soaking and steaming process. The basket was

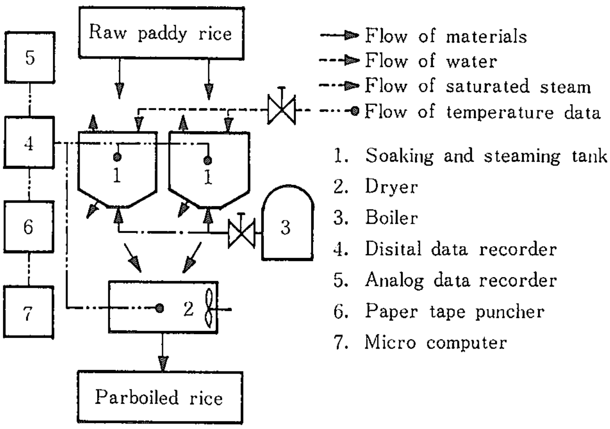

Fig. 1. Flow diagram of medium scale laboratory parboiling equipment.

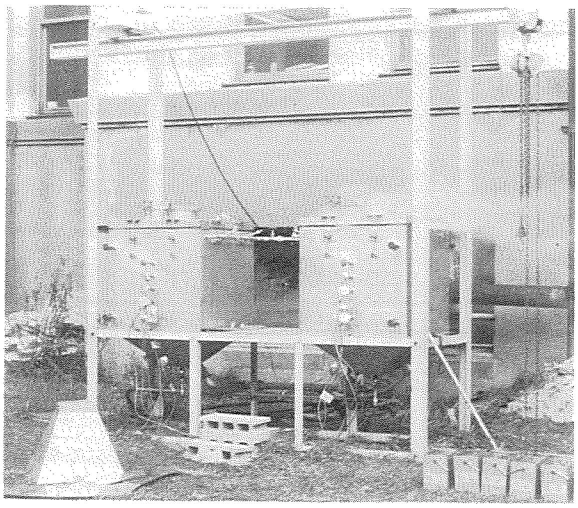

Fig. 2. The soaking and steaming tank.

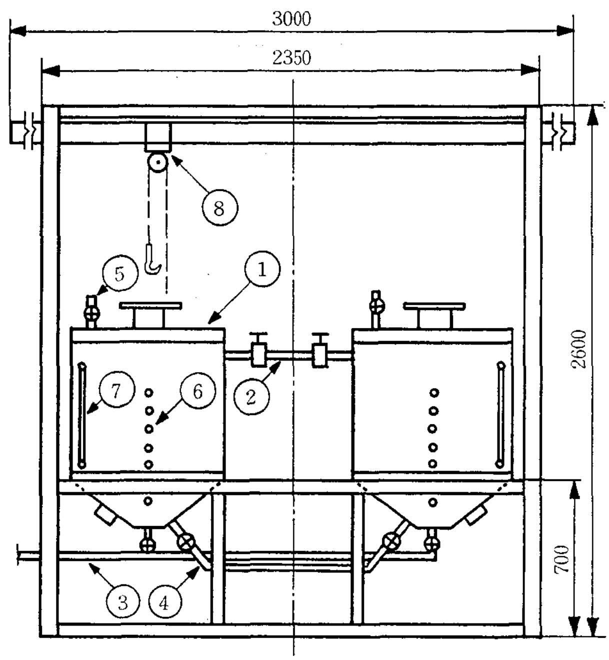

Fig. 3. The soaking and steaming apparatus: 1, Soaking and steaming tank; 2, Water pipeline; 3, Steam pipeline; 4, Drain pipeline; 5, Steam exhaust nozzle; 6, Thermocouple outlet; 7, Water level meter; 8, Chain block to lift up steaming basket.

placed in the tank as shown Fig. 4. The static bed type forced air dryer was used in this study. The dryer (Fig. 5) has twenty drying boxes.

3. Apparatus for dehusking and milling.

The experiment friction type rice husker, the abrasive-roll type milling machine and friction type milling machine were used in this study. Each type of milling machine were operated under the following conditions: 1240 rpm, charge rice of 200 g and #40 emery plate for the abrasive-roll type, and 1500 rpm and outlet pressure of 20.8 g/cm^2 for the friction type.

Methods

1. Water absorption rate during soaking.

The materials of each 10 g were soaked in the water bath at 50, 60 and 70°C. The moisture content of rough rice after the soaking process was measured after centrifugation at 2000 rpm for 10 minutes.

2. Parboiling process.

Each 1000 g rough rice sample was spread evenly in each of ten sample

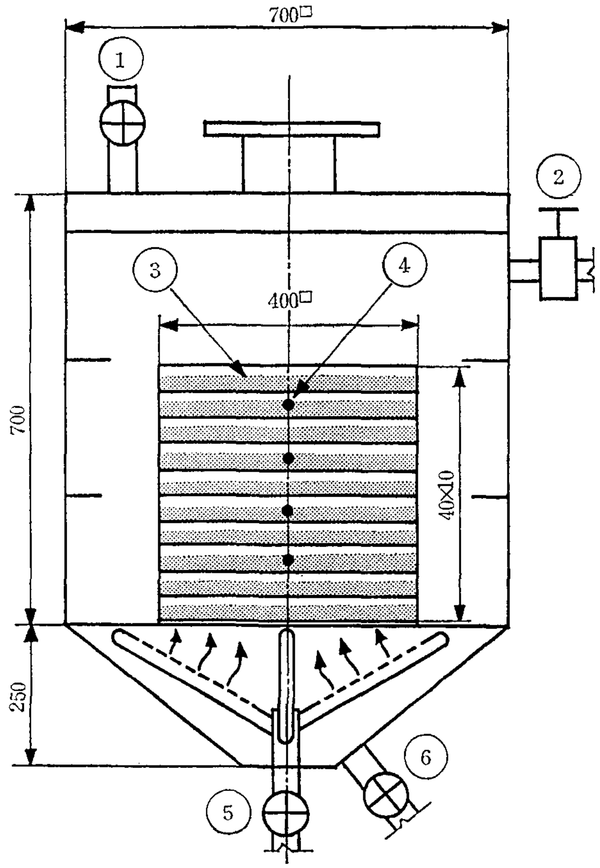

Fig. 4. Steaming baskets in the soaking and steaming tank: 1, Steam exhaust; 2, Watter supply; 3, Rough rice; 4, Thermocouple; 5, Steam supply; 6, Drain.

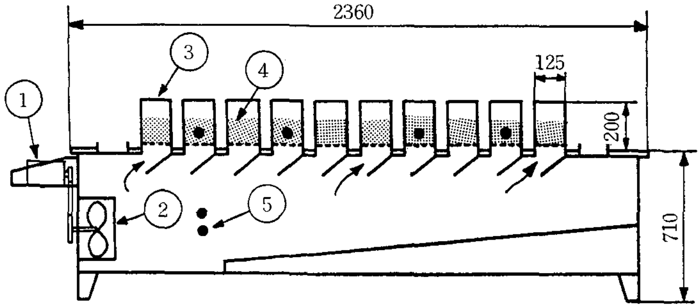

Fig. 5. The dryer: 1, Motor; 2, Fan; 3, Drying box; 4, Rough rice; 6, Thermocouple.

TABLE 2. Parboiling process conditions

N O.	Soaking Temp. (°C)	Steaming Temp. (°C)	Steaming Time. (min)
I -0		Untreated	
I -1	50	80	20
I -2	50	80	30
I -3	60	80	20
I -4	60	80	30
I -5	50	100	20
I -6	50	100	30
I -7	60	100	20
I -8	60	100	30
S -0		Untreated	
S -1	50	80	20
S -2	60	100	30

I- ISHIKARI S- SHIOKARI

trays (total sample weight 10 kg) and placed in soaking and steaming tank. The material was soaked and steamed with parboiling process conditions that are shown in Table 2.

The soaking time was kept constant at 2 hours. The soaking water and steam temperature can be adjusted by means of steam supply. The steam flow was regulated by use of a valve located between tank and steam supply pipe. Measurement of material layers temperature have been made of thermo-couple.

After the steaming process, the material in each layer was removed from tank and introduced into the drying boxes to be dryed up to 14% of moisture content.

3. Physical properties of parboiled brown rice.

The rough rice was dehusked for 2–3 passes with rice husker. Moisture content was determined by dring whole kernel of about 10 g for 24 hours in an oven at 105°C. Rate of fissures and appearance were considered by visual observation. Cracking and crushing hardness of kernel was determined using KIYA hardness meter. The method used to determine Free Fat Acidity was based upon the A. A. C. C. method. The color value of parbolied brown rice was measured with digital color meter and indicated L, a and b unit.

4. Milling characteristics.

Electric energy consumption was determined using a watt meter. Milling yield was determined as the weight percentage of the milled rice for the brown rice. Broken kernels was determined by using experimental broken kernels sorting machine and the result was expressed in weight percentage of total milled rice.

Results and Discussion

1. Water absorption rate during soaking

The results from the experiments for the determination of the soaking period and temperature are illustrated in Fig. 6. The quantity of water absborbed of short grain rice was found to increase compared with long grain rice.[6] The use of very hot water for soaking has been advocated as a means of reducing processing time. If water temperature exceeds that of starch gelatinization, the soaking time is reduced but more water is absorbed

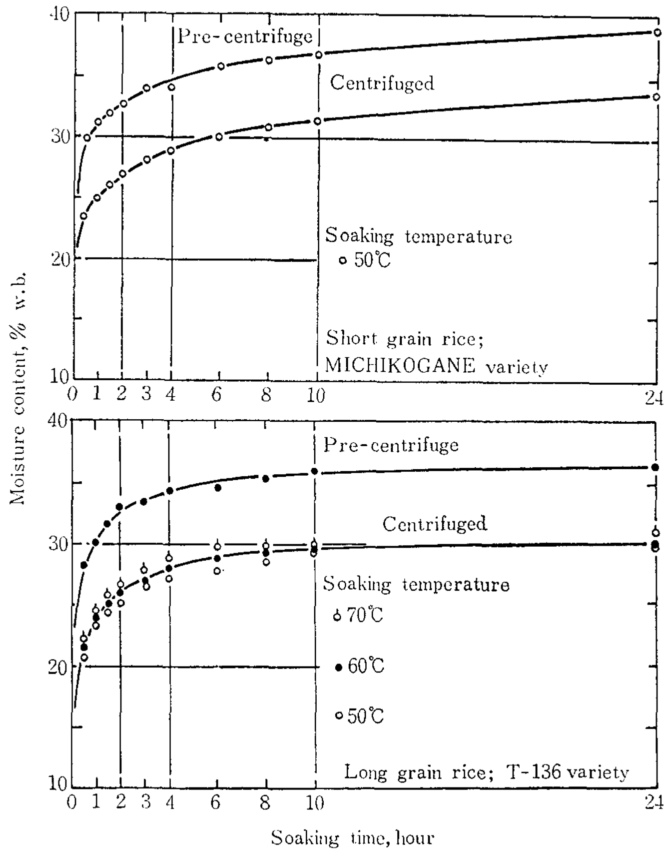

Fig. 6. Moisture content of rough rice after soaking process.

than necessary for moistening the inner part of kernel. In case of more water than necessary is absorbed the paddy rice swells considerably, the husk cracks is developing and the brown rice in the husk is becoming exposed. The mere fact that the husk cracks constitutes a serious drawback as many of substances in the grain are washed out into the water. It is considered that the temperature of soaking water should be below that of rice starch gelatinization, which is about 70°C in the long grain variety[5,10] and about 61°C in the short grain rice. Grain moisture levels as low as 23.5%w. b. after soaking were found to be adequate to obtain high head yield. Therefore, a temperature of 60°C and a period of 2 hours were selected for soaking. The time required for the equlibration of the moisture content was about 24 hours, when long grain rice was soaked, the experiment did not enable to determine the optimum time.

2. Parboiling process

The temperature of the material layers (steaming temperature 80°C) is shown in Fig. 7. The curve in Fig. 7 show that the differential temperature of material layers range from 5 to 10°C. As lower layer is situated near the steam intake, the temperature of lower layer increase rapidly in ealry stage of steaming period. The temperature of middle layers increase with time lag of 3-5 minutes.

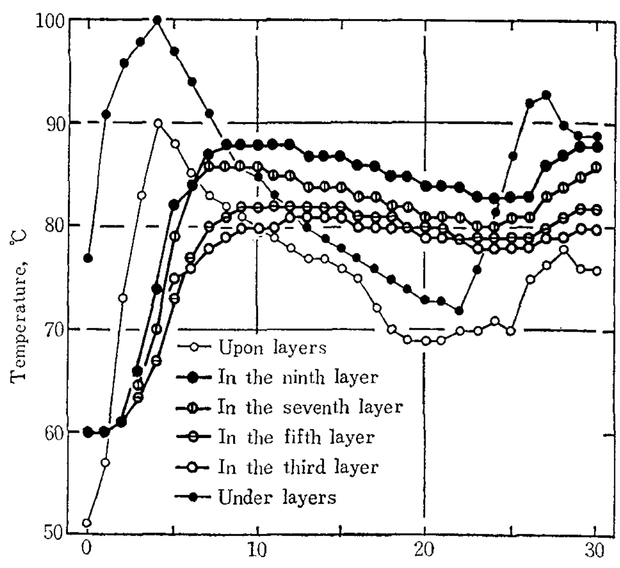

Fig. 7. The temperature of materials layers during steaming (steaming temperature was 80°C).

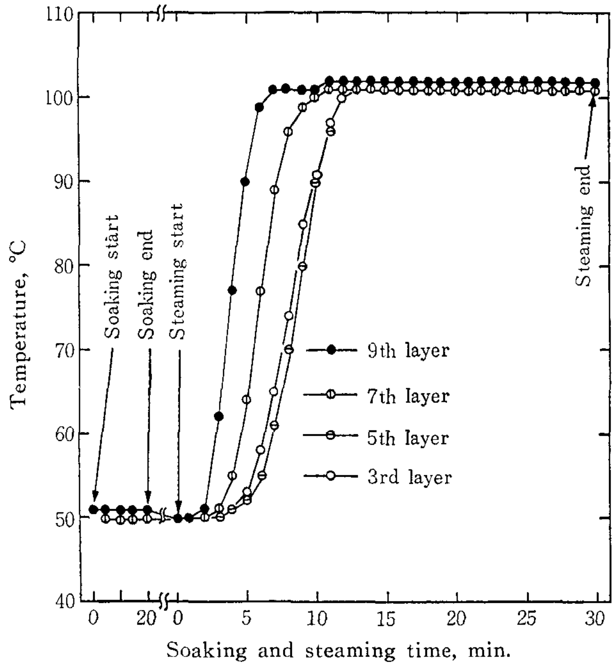

Fig. 8. The temperature of material layers during soaking and steaming (soaking temp. 50°C, steaming temp. 100°C).

Fig. 8 shows the temperature of material layers of Test I-6 (steaming temperature 100°C). The differential temperature did not exceed 5°C. This phenomenon may be ascribe to the difference of steam flow rate. In case of steaming condition of 100°C, the steam flows uniformity all layers.

From the results obtained above, it was found that the optimum temperature of steaming should be 100°C for achieving optimum conditions of parboiling.

3. Physical properties of parboiled brown rice

The physical properties of parboiled brown rice are shown in Table 3. The rate of fissure (include slight fissure kernels) of parboild brown rice kernel was increased as a result of the parboiling process due to the rapid absorption of water during the soaking procedure. It is considered that the high moisture content raw material should be select for the material for parboiled rice.

The cracking hardness (stress applied to produce kernel fissure) of parboiled brown rice was decreased as compared to that of untreated kernel.[7] However, the crushing hardness (stress applied to crush kernel) of parboiled

TABLE 3. Physical properties of parboiled rice

N O.	Moisture content (%)	Rate of fissure (%)	Hardness Cracking (kg)	Hardness Crushing (kg)	Free Fat Acidity* (mg KOH/ 100g D. M.)
I -0**	14.3	3.5	6.2	7.7	17.0
I -1	14.0	76.0	5.1	10.7	8.1
I -2	13.9	73.8	5.9	11.4	10.7
I -3	13.9	62.7	5.7	11.2	9.7
I -4	13.9	66.5	5.9	11.2	11.9
I -5	13.9	70.0	6.7	19.2	11.1
I -6	14.2	62.5	7.7	18.6	11.3
I -7	14.1	51.2	7.4	19.8	13.6
I -8	14.1	64.8	6.8	19.5	13.7
S -0**	14.2	2.0	5.7	7.2	21.5
S -1	14.0	63.3	5.2	9.5	11.8
S -2	14.1	25.2	8.5	19.9	14.7

* Storage period 25–30 days (under room temperature)
** Untreated brown rice

brown rice was increased owing to the viscoelasticity of kernel resulting from the gelatinization that takes place at the temperature 100°C during steaming.

Free fat acidity is determined as an index of deterioration of brown rice. The free fat acidity of parboiled brown rice was lower as compared to untreated materials. This indicates that the activity of emzyme (lipase) decrease during the parboiling process. Fig. 9 shows the relationship between integrated gelatinization temperature and the changes in color value. It can be seen that the L value (Whitness) of the kernel decreased with the increase of the integrated gelatinization.

It also appears that the discoloration of brown rice increased owing to the increase in the integrated gelatinization temperature.

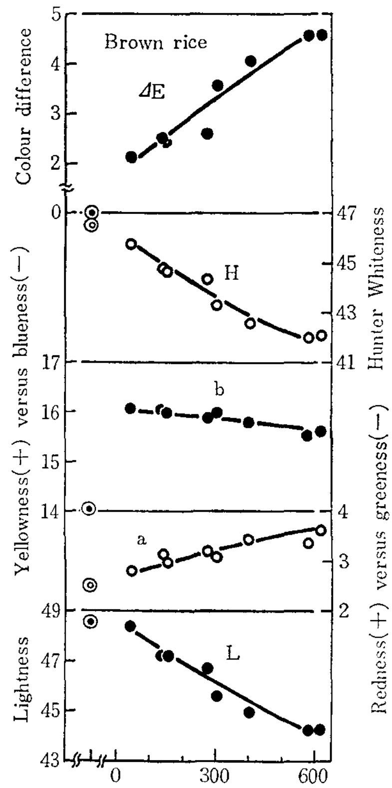

Fig. 9. Color value of parboiled rice.

4. Milling characteristics

Fig. 10 (a), (b), (c) shows the relationship between milling yield and number of passes, milling time and electric energy consumption using the friction type milling machine. Compared with untreated brown rice, milling yield of parboiled brown rice was much higher under the same milling conditions such as number of passes, milling time and electric energy consumption.[8] It was recognized that the milling of

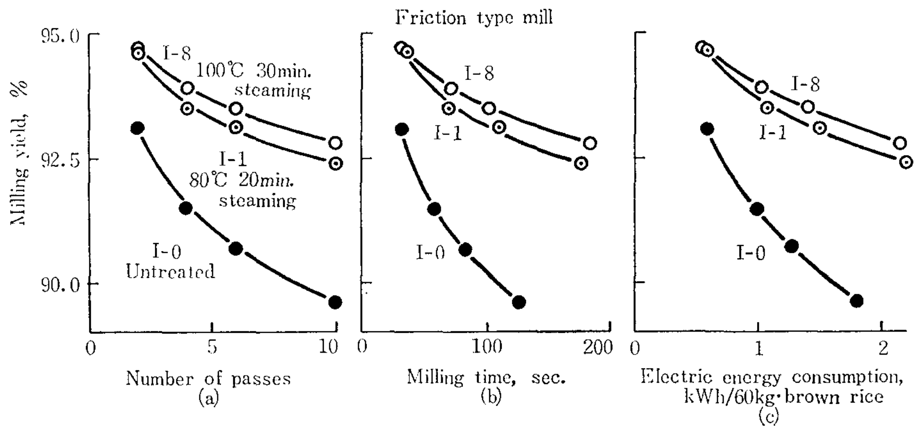

Fig. 10. Milling characteristics of parboiled rice milled by the friction type milling machine.

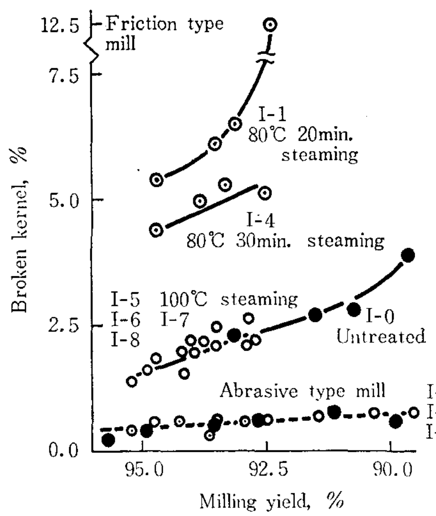

Fig. 11. Effect of parboiling conditions on breakage of parboiled rice milled by the friction type milling machine or the abrasive type milling machine.

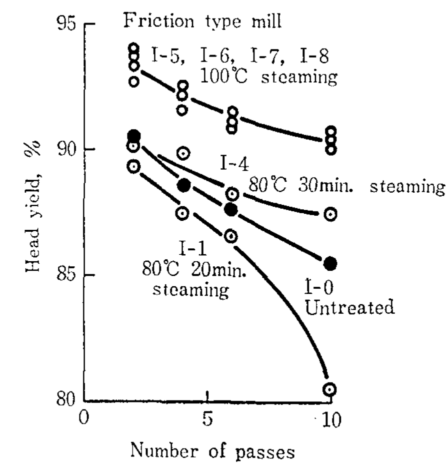

Fig. 12. Effect of parboiling conditions on head yield of parboiled rice milled by the friction type milling machine.

parboiled brown rice is difficult to realize because the parboiling process hardens the rice kernel. This phenomenon occurred when the abrasive type milling machine was used too.

However, the hardening effect of the parboiling process was more attenuated when the abrasive type milling machine was used.

Fig. 11 shows the relationship between the milling yield and the rate of broken kernels. Proper parboiling process gives hardness and viscoelasticity to rice kernels. The rate of broken kernels increased with the increase of the milling yield. Especially many borken kernel were observed at the steaming temperature of 80°C with a percentage ranging from 5 to 12.5% of total. The occurrence of broken kernels in milled rice with the abrasive type milling machine was less frequent than that with the friction type milling machine. This finding suggests that the breakage was caused by the mechanical action of the friction type milling machine. It is necessary to pass at first the parboiled rice through an abrasive type milling machine to remove the parboiled rice bran. Thereafter polishing can be done in a friction type milling machine.

Fig. 12 shows the relationship between the number of passes and head yield determined by the weight percentage of milled rice without broken kernels and brown rice, As the parboiled rice that had been steamed at 80°C contained many broken kernels, the head yield was lower than that of untreated rice.

Summary

This study was carried out in order to obtain fundamental data for the parboiling process and milling of rice.

The results obtained were as follows ;

1. The water absorption rate during soaking increased with the increase of water temperature. The time of equilibration of the moisture content after soaking was different between long grain rice and short grain rice. Soaking temperature and time required to obtain proper grain moisture level after soaking were 60°C and 2 hours, respectively.
2. The typical change in the appearance of parboiled rice seemed to be caused by discoloration of the chlorophyll in the pericarp, the organic modification of the starch structure in the endosperm and the browning of the rice kernel.
3. The fissure of the rice kernel are developed as a result of soaking. The cracking hardness of parboiled rice was reduced as compared to that of raw rice owing to the fissures, at a steaming temperature of 80°C. How-

ever, it increased due to the viscoelasticity of the kernel resulting from gelatinization, at a steaming temperature of 100°C.
4. Compared with untreated rice, milling yield of parboiled rice was much higher under the same conditions.
5. The percentage of broken kernels at a steaming temperature of 80°C ranged from 5 to 12.5%.

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