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Performance evaluation of pressure parboiling system for paddy

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Abstract : Pressure parboiling is one of the developing methods, in which penetration of moisture into the paddy is in the form of water vapour under pressure, which gelatinizes the starch in the kernel. In the present study a pressure parboiling tank with uniform steam distribution assembly has been designed and developed. CO 45 paddy was selected for conducting the experiments. Three levels of soaking time (30, 75 and 12 min), steaming pressure (49, 122.6 and 196 kPa) and steaming time (10, 25 and 40 min.) were selected to study their effect on milling and cooking qualities. Maximum head rice yield. Breaking Hardness Value (BHV), transluence index and minimum cooking time were achieved, when paddy was soaked for 30 minutes and then steamed under 123.6kPa pressure for 22 minutes. *(**Key words** : Pressure parboiling, Gelatinization of paddy).*

Rice has been used as staple food since ancient times and today more than half of world's population consumes rice as main food in their diet. Rice provides more calories per hectare than any other cereal crop. Parboiling is one of the premilling treatments given to paddy to improve its quality (Pillaiyar and Mohandas, 1988). There are many methods of parboiling practiced at various regions / states. The various methods / technologies include traditional methods and modern. In the conventional /traditional methods, the soak water and rice invariably emit a bad smell, which is ascribed to microbial fermentation during soaking (Pillaiyar *et al.*, 1980). Also prolonged soaking of paddy resulted in loss of nutrients, development of foul odour and discolourisation of rice (Anthoniraj and Singaravadivel, 1980).

In the modern methods, soaking duration has been reduced by hot soaking and steaming paddy, thereby reducing the total duration and improving quality of the product (Bandopadhyay and Roy, 1977). Also to overcome the losses occurring during soaking (leaching losses) process, water was replaced by hot humid air (Ramalingam *et al.*, 1976). In one recent development of a slightly different nature, paddy is only partially soaked and then cooked by steaming under high pressure (Ali and Battacharya, 1982). In another process, soaked paddy is gelatinized by brief conduction heating with very hot sand or air, instead of steam (Iyengar *et al.*, 1971).

Pressure parboiling is one of the modern methods in which penetration of moisture into the paddy is in the form of water vapour under pressure, which gelatinizes the starch in the kernel (Shivanna, 1974). Paddy is soaked in cold or warm water for required period and then water is drained out. The air entrapped inside the rice kernel is driven out by the penetration of water vapour, therefore the presence of bellies in the parboiled rice is avoided. The rice obtained by this method has pleasing, slightly yellowish and uniform colour.

Materials and Methods

The parboiling unit is a leak proof tank made of mild steel sheet as shown in Fig 1. The tank is provided with a raw paddy inlet opening and paddy outlet opening. These openings are closed with suitable lids with gaskets. There is central opening to let steam into parboiling tank. On the lid of the tank, a safety valve has been fitted to release the excess pressure.

Paddy variety Co 45 was selected for conducting experiments at various levels of independent variables. Soaking paddy in water for a prolonged period causes leachate loss (Anthoniraj and Singaravadivel, 1980). Hence the range of soaking period was selected as 30 to 120 minutes. Steaming at low pressure and short duration cause incomplete parboiling, whereas high pressure and long duration causes over parboiling of rice (Zakiuddin and Bhattacharya, 1982). Therefore, steaming was done in the range of 49 to 196 kPa pressure and duration of steaming was selected as 10 to 40 minutes. Slow drying of parboiled paddy in shade leads to excellent milling results (Bhattacharya and Indhudharaswamy 1967). Hence parboiled paddy was dried in shade to a moisture level of 12 to 14 per cent (wb).

The transluence index of the parboiled paddy was calculated by using the chalky grain detector. It is a metallic box consisting of an electrical bulb with a reflector for uniform distribution of light. An indented plantform is provided above the bulb for placing the rice in correct position. The top cover of the box is made of ground glass plate in an oval shape. A sample of 100 polished grains was taken and placed in the indents of the black platform and the light beam was passed over the kernels from the

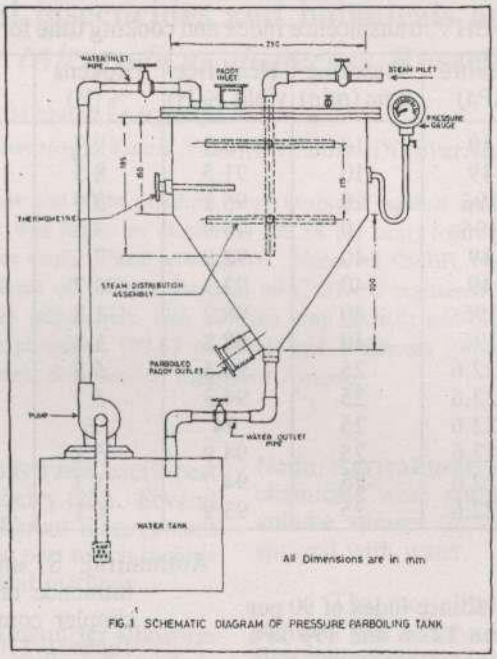

Fig. 1. Schematic diagram of pressure parboiling tank

bottom. In the transmitted light translucent and opaque grains were counted. The translucence index was determined as per (Bandopadhyay and Roy, 1977).

$$\text{Translucent Index} = \frac{\text{Number of translucent grains}}{\text{Number of grains taken}} \times 100$$

The breaking hardness value (BHV) was determined for rice samples using KIYA hardness tester. For determination of hardness 5 whole grains of polished rice were randomly selected. Before each test the black indicator was adjusted to zero and the red indicator was slowly positioned against it without disturbing the black one. The grain was placed on the loading platform in such a way that indenter can press it. The hand wheel was rotated slowly in clockwise direction that enabled the indentor to lower down until the grain was cracked. The cracking of grain was indicated by the separation of the black indicator from the red one and with cracking sound also. The hardness of grain was recorded in kgf required to crack the grain in compression. An average of 5 readings was taken for each sample.

Distilled water was boiled in a 250 ml beaker and about 5 g of whole polished rice was added. After ten minutes of boiling, grains were withdrawn at 1-minute interval by a perforated ladle, placed in between two glass plates, pressed and observed for the presence of opaque-core in pressed area. The cooking and pressing were continued till the disappearance of opaque-core. The time taken in minute for this stage was taken as optimal cooking time.

Results and Discussion

The Head rice yield, percentage of broken, breaking hardness value, translucence index and cooking time for various combinations of treatments required is presented in Table 1.

The minimum value of broken / maximum head rice yield at 30 minutes soaking time was 1.9 per cent 98.1 per cent when the pressure and soaking time were 196kPa and 40 minutes respectively, while the maximum value of broken/minimum head rice yield was 9.6 per cent and 90.4 per cent at 49 kPa and 10 minutes. It inferred that higher head rice yield and minimum broken may be achieved if the operating pressure and steaming time were high.

The minimum value of BHV for 30 minutes soaking time 49 kPa steaming pressure and 10 minutes steaming time was 7.1 kg, while a maximum value of 9.9 kg was obtained at 196 kPa pressure and 40 minutes at the same period of soaking. It is observed that the effect of pressure on hardness values is very much pronounced followed by steaming time. Soaking time has little effect on hardness value compared to other treatments within the ranges

Table 1. Percentage brokens, BHV, translucence index and cooking time for various treatment combainations

Treatment number	Soaking time (min)	Pressure (kPa)	Steaming time (min)	Head rice yield %(H)	Brokens % (B)	BHV kg(f)	Translucence Index %(TI)	Cooking time (min)
1	30	49	10	90.3	9.7	7.1	66	30
2	120	49	10	91.5	8.5	7.3	71	33
3	30	196	10	96.1	3.9	9.1	80	41
4	120	196	10	96.9	3.1	9.4	82	45
5	30	49	40	92.9	7.1	8	88	36
6	120	49	40	93.3	6.7	8.5	95	38
7	30	196	40	98.2	1.8	10.1	98	50
8	120	196	40	98.8	1.2	10.5	100	59
9	75	122.6	25	94.5	5.5	8.8	88	45
10	75	122.6	25	94.3	5.7	8.5	81	47
11	75	122.6	25	94	6	9.1	85	43
12	75	122.6	25	94.9	5.1	8.8	80	45
13	75	122.6	25	94.7	5.3	8.7	86	48
14	75	122.6	25	93.9	6.1	8.9	83	42

specified above.

It was found that translucence index of 90 per cent lie approximately between 122.6 and 196 kPa pressure, 30 and 40 minutes of steaming time respectively. Translucence index of 100 per cent may be obtained at 196 kPa pressure when steamed for 40 minutes. The effect of pressure parboiled rice. This is due to the penetration of moisture in the form of water vapour under pressure, which makes the kernel translucent. Further increase in pressure or duration of steaming time may result in cooking of rice rather than parboiling.

Pressure and steaming time are the dominant factors, which influences the cooking time followed by soaking time. At higher steaming pressure, the kernel hardness increases, which in turn increases the optimal cooking time. Pressure and steaming time were selected, such that a maximum hardness is obtained with minimum cooking time. Therefore, optimum pressure of 122.6 to 196 kPa and steaming time of 20 to 30 minutes may be selected for parboiling so that the product has an acceptable cooking time.

Considering various quality factors, the treatments namely soaking time, steaming pressure and steaming time were optimized as 30 minutes, 123.6 kPa and 22 minutes respectively, in order to obtain 94 per cent head rice yield, 8.5 kg breaking hardness value, 40 minutes optimal cooking time and 80 per cent translucence index.

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