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Paddy Parboiling for Improved Milling, Better Cooking and Higher Recovery of Rice Bran Oil

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The milling and cooking qualities of rice depend mainly on the variety of paddy and its parboiling characteristics. Therefore, paddy varieties Mahamaya and Swarna were evaluated for their parboiling characteristics. An experiment was conducted by soaking paddy at 60°C for 4 h, steaming for 15 min and drying under shade for 24 h. Degree of parboiling was evaluated in terms of equilibrium moisture content at saturation, alkali spreading value, sedimentation and water uptake ratio. The parboiled sample had shown better milling quality in terms of more head yield, lower breakage and higher milling efficiency. In addition, it acquired better cooking quality as shown by lower water uptake at 97°C and minimum leaching loss during cooking. The bran oil quality was also found to be more in parboiled rice.

Key words: Cooking quality, Milling quality, Oil content in bran, Parboiled rice, Parboiling

Rice (*Oryza sativa* L.) is the staple food of more than half of the world's population. Nearly, half to two third of world population has partially or totally adopted rice as their main food. It has been reported that the production of rice in the world is about 470 million tones in the year 2012-13 (IGC, 2014). The composition of paddy is approximately 72% rice, 5% rice bran and 23% husk. People of some Asian countries prefer parboiled rice instead of raw rice because of its peculiar appearance, aroma, taste and digestibility. Parboiling is a pre-milling treatment (optional) given to paddy to achieve the maximum recovery of head rice, and to minimize breakage. The quality of parboiled rice dependes mainly on the variety and its parboiling characteristics. Therefore, investigations on the parboiling characteristics of local rice varieties and standardization of easy methods of parboiling become absolutely essential for better market quality of the final produce.

Materials and Methods

Two varieties of paddy, Mahamaya and Swarna were procured from Research Farm of Indira Gandhi Agricultural University, Raipur, India. Paddy cleaning was done manually to remove foreign matter, stones, immature, damaged and discoloured grains.

Soaking

The main purpose of soaking is to raise moisture content to facilitate gelatinization during steaming. Also to understand the hydration characteristics of paddy, preliminary soaking experiments were conducted at ambient and at 60°C for 4 h dipping.

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Experimental set up and procedure

The laboratory experimental set up consisted of glass beakers of 500 ml capacity, a water bath with heating capacity of 110°C along with temperature control arrangement. Paddy grains (100 g) were taken in glass beaker and 300 ml of water was added. The beaker was placed in the hot water-bath and after every 30 min samples were taken out and the moisture content was determined by standard method (*Oko et al.,* 2012). While soaking, grains were stirred at regular interval for uniform exposure of outer surface.

The prototype experimental set up for soaking of paddy grains consisted of cylindrical containers made of stainless steel. Cleaned paddy grains (2 kg) were taken in the containers. Grain to water ratio was kept 1:3. In order to attain the desired temperature, 6 L of hot water at predetermined temperature was added to the container, covered with a lid before placing in the hot water bath. The temperature of water bath was maintained at 2°C higher than the desired. Stirring was done at regular interval by using an iron ladle. After desired soaking duration, the container was removed from water bath to drain excess water.

Steaming

Steaming is the process of application of heat to the soaked grain to complete the gelatinization process. Steaming was given at fixed pressure (1 kg/cm^2) for a predetermined time (15 min) in an autoclave.

Drying

The samples after soaking and steaming were spread in stainless steel trays of size 60 × 45 cm and frequently stirred for uniform drying. The steamed paddy samples were shade dried for 24 h. The dried samples were then placed in polythene bags for tempering (24 h), and used for milling experiment.

Degree of parboiling determination

Equilibrium moisture content at saturation

Small sample of rice (2 g) from each treatment including raw rice were taken separately, in test tubes containing 10 ml of distilled water and kept undisturbed for 24 h at room temperature (25°C). After 24 h, the contents of test tubes were emptied into a perforated tray and surface moisture of soaked grains was removed by using blotting paper. Then the samples were weighed quickly and moisture content was determined by gravimetric method.

Alkali dispersion test

A solution of KOH (10 ml, 1.7% conc.) was taken in glass Petri dishes. The dishes were placed on a hard paper having black surface. Six whole kernels of each parboiled and raw rice were dropped in separate Petri dishes, covered and kept undisturbed for 24 h at room temperature (25°C). After 24 h, the samples were observed and rated for spreading value following 7 point scale.

Sedimentation test

For this test, samples from each treatment including raw rice were ground manually in a stone mortar and pestle. A definite quantity of ground samples (2 g, 80 mesh) were taken in a measuring cylinder (25 ml) and initial volume was noted. Then the volume was made up to 15 ml by adding 0.05 N hydrochloric acid. Measuring cylinder was kept undisturbed for 4 h at room temperature. The volumes of sediments were measured and the difference in initial volume and final volume in each sample gave the sedimentation volume.

Water uptake ratio (W_{62} /W_{97})

The method described for water uptake at 97°C was repeated. Then, 2 g of each sample was taken and cooked in 15 ml distilled water bath at 62±1°C for 45 min. The moisture content of cooked samples was determined by gravimetric method (*Oko et al.,* 2012).

Milling experiment

The milling operations like cleaning, shelling, separation, polishing and grading were adopted for both raw and parboiled paddy samples and the estimation of various milling properties for each sample was done. The milling efficiency, head yield and broken rice were calculated as suggested by Mandhyan and Sharma (1992).

$$\eta_{me}\ (\%) = \frac{W_{tr}}{W_{tp}} \times 100 \quad (1)$$

Where, η_{me} = Milling efficiency (%)

W_{tr} = Weight of total rice, (head + brokens) in g

W_{tp} = Total weight of paddy in g

$$Y_h(\%) = \frac{W_{hr}}{W_{mr}} \times 100 \quad (2)$$

Where, Y_h = Head yield (%)

W_{hr} = Weight of head rice in g

W_{mr} = Weight of milled rice in g

$$Y_b(\%) = \frac{W_{bpr}}{W_{tpr}} \times 100 \quad (3)$$

Where, Y_b =Broken (%)

W_{bpr} = Weight of broken polished rice in g

W_{tpr} = Weight of total polished rice in g

After milling, representative sample of rice were drawn and subjected to further tests like evaluation of cooking quality and determination of degree of parboiling.

Cooking quality evaluation

Water uptake at 97°C

Cooking tests were carried out by using a boiling water bath. Two g of rice samples from each treatment including raw rice were taken in test tubes separately, to which 15 ml of distilled water was added. The test tubes were then placed in boiling water bath for 30 min. After cooking, the contents of the tubes were emptied into a small perforated tray. The cooked grains were spread on a filer paper, gently wiped to remove surface moisture and quickly weighed. Moisture content of the sample was determined by oven drying method (*Oko et al.,* 2012).

Leaching loss of solids in gruel during cooking

For determining leaching loss of solids, 2 g of rice from each treatment were taken, separately in test tubes to which 15 ml of distilled water was added. The test tubes were then placed in boiling water bath for 30 min. After cooking, the gruel along with one or two rinses of the test tube was collected in moisture box, and dried in a hot air oven at 110°C. The solid loss was expressed in term of per cent dry material of the particular sample Yadav *et al.(*2007).

Oil content of bran

The oil content of bran was estimated as a crude petroleum ether extract. Sample of bran was ground and then 2-3 g was taken in a thimble which was then plugged with cotton. The thimble was then placed in a Soxhlet apparatus and extracted with ether for 6 h. The extract was filtered into a conical flask. With 4-5 washings, remaining extract was also transferred to conical flask. The ether was then removed by evaporation leaving behind bran oil. The flask with the residue is dried at 60-70°C in an oven and after cooling in a desiccator it weighed accurately. The percentage of oil in raw and parboiled bran was calculated using the following formula:

$$\text{oil (\%)} = \frac{W_o}{W_d} \times 100 \qquad (4)$$

Where, W_o= Weight of oil (g)

W_d = Weight of dry matter of bran (g)

Results and Discussion

In parboiling experiment, temperature, time of soaking and steaming were kept constant. MT-1 and MT-2 represent Mahamaya variety of paddy in raw and parboiled form, respectively, while ST-1 and ST-2 represent *Swarna* variety of paddy in raw and parboiled form, respectively.

Effect of soaking temperature on moisture content

Preliminary soaking was done at ambient (32^{o}C) and at 60^{o}C to understand the hydration characteristics of paddy. The main purpose of soaking was to raise the moisture content to steaming to facilitate gelatinization of starch. The results with respect to Mahamaya and Swarna varieties are presented in Fig. 1.

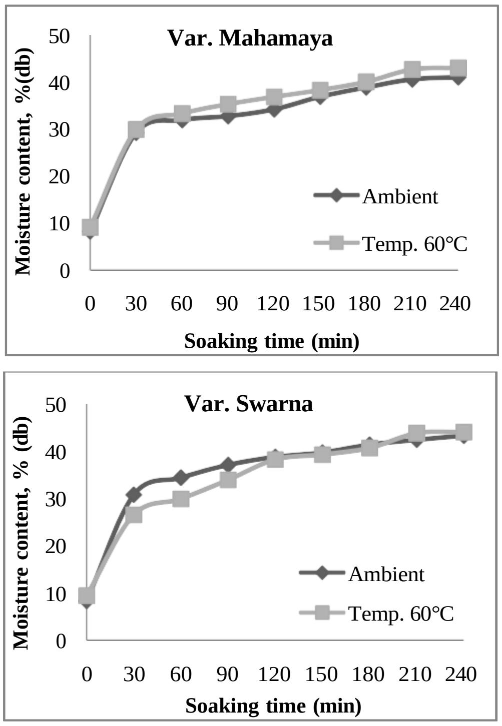
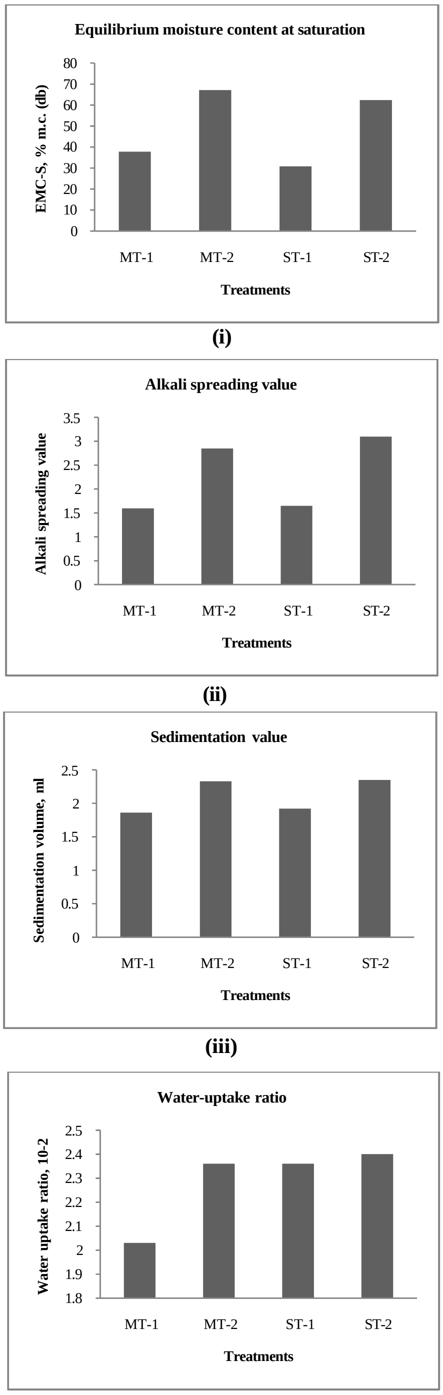


Fig. 1. Effect of soaking time on moisture content

There was a sudden increase in moisture content at initial stages of soaking. Chakraverty (1981) stated that initial high moisture gain was due to the presence of air gap between hull and kernel. It was further observed that this phase of sudden rise in moisture content lasted for 1 h only and after that the moisture content of paddy increased much slowly.



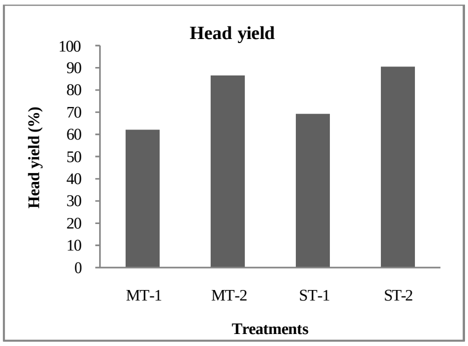
(iv)

Fig. 2.Evaluation of degree of parboiling

Evaluation of degree of parboiling

Equilibrium moisture content at saturation

For parboiled grains, equilibrium moisture content at saturation gives an indication of the gelatinization of starch. The results of this experiment are presented in Fig.2 (i). The EMC-S value of parboiled samples were found to be higher (67.07 and 62.28% in cases of Mahamaya and Swarna) and that of raw samples lower (37.73 and 30.76% in cases of Mahamaya and Swarna). The possible reason for lower value of EMC-S of raw rice sample



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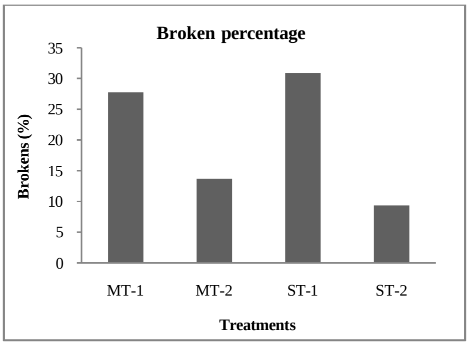

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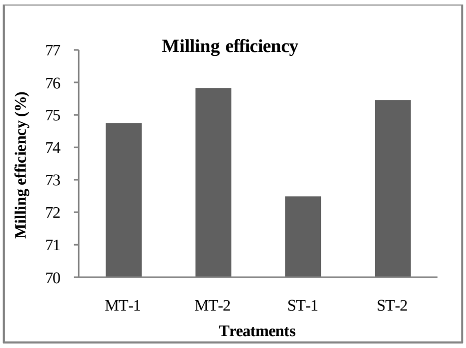


(iii)

Fig. 3. Effect of parboiling on milling quality

may be due to no gelatinization of starch in them; therefore, the samples might have absorbed less moisture even after exposing for 24 h.

Alkali spreading value

Alkali spreading value also gives the extent of gelatinization in parboiled samples. The result of alkali dispersion test is depicted in Fig. 2 (ii). It can be observed that raw samples of rice were almost unaffected and showed lower values (1.60 and 1.65 in cases of Mahamaya and Swarna respectively). Parboiled rice sample showed higher spreading values (2.85 and 3.10 in cases of Mahamaya and Swarna, respectively). This higher value of spreading was due to higher gelatinization of starch, which reacted with alkali solution. These finding are in agreement with the findings of Guha and Ali (1998).

The alkali spreading values were manually given in ascending order (1 -7) after looking to the extent of distortion in the grain caused by alkali. These were, kernel not affected (1), kernel swollen (2), kernel swollen or periphery narrow (3), kernel swollen, periphery complete and wide (4), kernel split (5), kernel dispersed merging (6) and kernel completely dispersed and intermingled (7).

Sedimentation test

Increase in sedimentation volume of parboiled rice sample was also taken as the measure of degree of parboiling. The results of sedimentation test are given in Fig. 2 (iii). It can be observed that the increase in sedimentation volume was lower (1.86 and 1.92 ml in cases of Mahamaya and Swarna respectively) for raw rice grain and higher (2.33 ml and 2.35 ml in cases of Mahamaya and Swarna respectively) for parboiled rice samples. Increase in volume for raw grain was less owing to ungelatinized starch, which would have resulted in less absorption of HCl.Gelatinized starch of parboiled grains absorbed more HCl and therefore, attained higher sedimentation value. These finding are agreement with the finding of Mahadevappa and Desikachar (1968).

Water uptake ratio (W_{62}/W_{97})

From the Fig. 2 (iv), it can be concluded that raw rice sample attained lower value (2.03 x 10^{-2}, 2.36 x 10^{-2}), while parboiled rice showed higher value (2.36x10^{-2}, 2.40 x 10^{-2}). Thus, water uptake ratio of raw sample of rice was low in comparison to parboiled rice in both varieties. This is because raw sample at 62°C absorbed less moisture in 45 min, while it absorbed more moisture at 97°C in 30 min owing to its un-gelatinized starch. Das *et al.* (1989) also reported that water uptake ratio of parboiled rice was higher with severity of parboiling.

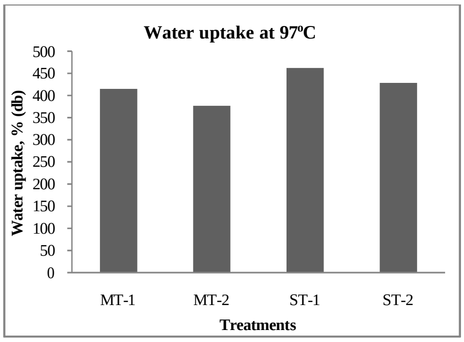
Effect of parboiling on milling quality

Raw and parboiled samples of paddy (100 g) were dehulled on rubber roll sheller and various fractions were separated and milling quality was evaluated. Results of milling experiment are presented in Fig. 3 (i), (ii) and (iii). The milling quality of Mahamaya was found to be almost same as that of Swarna. It can be observed that head yield and milling efficiency of parboiled sample were higher while, broken content was lower than that of raw sample.

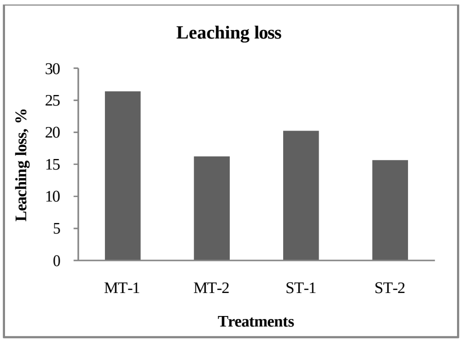
This is because parboiled grains being comparatively very hard, were able to sustain the stress applied on them during milling without breakage. But raw grains being comparatively soft were not able to withstand milling, which resulted in more breakage and lesser head yield.

Effect of parboiling on cooking quality

Cooking quality of raw and parboiled grain was evaluated on the basis of water uptake at 97°C and loss of solids in gruel during cooking.



(i)



(ii)

Fig. 4 Effect of parboiling on cooking quality

Water uptake at 97ºC

The results of water uptake are presented in Fig. 4 (i). It can be observed that water uptake was higher for raw sample of rice than that of parboiled rice sample in both Mahamaya and Swarna varieties. This is mainly because parboiling imparted hardness to the grain, which had resulted in lesser water uptake than raw grain for same cooking time. The possible reason may be lower penetration of water in harder grains as the moisture diffusion rate might have reduced with excessive hardness of grain.

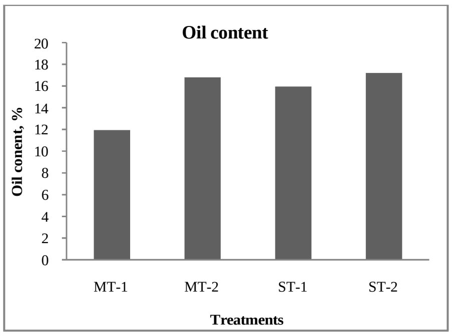


Fig. 5 Oil content of bran obtained from raw and parboiled brown rice

Leaching of solids during cooking

The results of loss of solids during cooking are represented in Fig. 4 (ii). It can be seen that loss of solids in gruel were higher (26.38 and 20.22% in cases of Mahamaya and Swarna respectively) for raw samples of rice and lower (16.21 and 15.66% in cases of Mahamaya and Swarna respectively) for parboiled sample of rice. This was due to the gelatinization of starch reducing pore spaces in grains. So, hard outer surface imparted resistance to leaching during cooking.

Oil content of bran

The results of bran oil content are presented in Fig. 5. It can be seen that the oil content in bran obtained during polishing of raw brown rice were lower (11.93 and15.94% in cases of Mahamaya and Swarna, respectively) and higher (16.79 and 17.19% in cases of Mahamaya and Swarna, respectively) for bran obtained during polishing of brown rice. This is because during soaking useful ingredients including fatty substances migrate from paddy husk to rice aleuronic layer.These results are corroborating the outcome of Abroal (1983).

Conclusion

The Mahamaya and Swarna varieties have conformed potential for parboiling as both have acquired higher hardness due to parboiling. Both the varieties attained almost same degree of parboiling as evidenced by factors of equilibrium moisture contained at saturation, alkali spreading, sedimentation and water uptake ratio. For both varieties, capability of parboiling is also reflected by cooking tests with lower water uptake and leaching loss. Most notable characteristics of grain for parboiling is increased head yield and milling efficiency with decreased broken percentage.

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