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EFFECT OF SOAKING AND STEAMING PARAMETERS ON MILLING QUALITY OF PADDY (CV. *MTU 1075*)

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Abstract: The effect of soaking and steaming parameters on the milling characteristics of paddy (Cv. *MTU 1075*) was studied at different initial moisture contents. Soaking was carried out at different temperatures of 40 to 80°C. Soaking was also carried out at three elevated pressures viz. 2.0, 4.0 and 6.0 $kg \cdot cm^{-2}$ absolute pressure at the soak water temperature of 70°C. Steaming was carried out at 0.5, 1.0, 1.5, 2.0 and 2.5 $kg \cdot cm^{-2}$ absolute pressures. It was observed that the increase in the soak water temperature as well as the pressure of soaking improved the milling quality of paddy with higher head rice yield ratios and reduced white bellies. Soaking at 80°C however reduced the head rice yield when soaked beyond 120 min. During soaking under pressure, there was difference in the head rice yield initially up to about 10 min of soaking, the difference diminished as the soaking time was increased beyond that. The maximum head rice yield was obtained with the processing at steam pressure of 1.5 $kg \cdot cm^{-2}$ for 12.5 to15 min. Only soaking under hydrostatic pressure also improved the yield of rice for all the conditions.

Key words*: soaking, steaming, white belly, head rice yield, milling quality, hydrostatic pressure*

INTRODUCTION

Parboiling is defined as the hydrothermal treatment to paddy grain to improve its quality. The usual parboiling method involves three steps as soaking of paddy in water,

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steaming the saturated and soft paddy and then drying the steamed paddy [1]. The time for soaking and steaming has been standardized for quality product. Among other advantages, one major benefit obtained by parboiling is the gelatinization of starch and improvement in the milling yield. The different common parboiling methods as the CFTRI method involves a processing time of 6 to 8 hours. The amount of steam consumption is also about 200 kg per tonne of paddy [2]. Alternate paddy parboiling methods without the use of steaming have also been studied with the objective to reduce the energy consumption and initial investment [3-7]. A recent development involves double steaming; the first steaming is used to heat the paddy, second steaming is used for gelatinization of paddy [2]. However, the temperature of gelatinization and the duration of parboiling depend on the variety of paddy. It could be possible to eliminate the steaming method and cause gelatinization of starch by hydrostatic pressure soaking only.

It was observed that the pneumatic pressure parboiling method could eliminate the white bellies and reduced the milling yield for paddy Cv. Parijata[6]. However, the effects would be different for different varieties of paddy. Hence, it was planned to study the extent of gelatinization during soaking at atmospheric pressure and at elevated pressures of paddy (Cv. *MTU 1075*) to assess the feasibility of eliminating the steaming process during parboiling. Only steaming was also carried out at different moisture contents of the grain to observe the degree of gelatinization at different pressures. The effectiveness of the above conditions on milling quality of paddy was also studied to decide the optimum processing conditions for the tested variety. The results of the study could help in developing alternative parboiling techniques for paddy involving less process time, energy and with acceptable milling quality. The diffusion coefficient of the paddy variety MTU 1075was also studied and observed to follow Arrhenius type relationship. The diffusion constant and activation energy were found out to be 0.01345 m^2/min and 35.19 kJ/g-mole, respectively [8].

MATERIALS AND METHODS

The paddy variety *MTU 1075*, which is a widely cultivated variety of the region, was used for the study. It is a slender variety of paddy and the average length, breadth and thickness were found out to be 5.74±0.084 cm, 2.1±0.224 cm and 1.84±0.089 cm. The effect on gelatinization and milling quality of paddy was observed as affected by soaking at different temperatures and pressure levels, and steaming at different pressure levels.

For the soaking experiments, paddy was soaked at water temperatures of 40°, 50°, 60°, 70° and 80°C at three initial moisture levels. Freshly harvested paddy was dried under shade for different times to attain the desired moisture levels. The actual moisture contents were determined just before the start of the experiments. The change in moisture content of paddy during soaking was recorded to determine the rate of moisture absorption and final moisture contents. The hydrostatic soaking of paddy was continued for 6 h at 2.0, 4.0 and 6.0 $kg \cdot cm^{-2}$ hydrostatic pressure levels and at a constant temperature of 70°C at three initial moisture levels. The samples were then shade dried till the final moisture content of 16 g per 100 g dry matter for subsequent studies on the degree of gelatinization and milling quality. Similarly the extent of parboiling by steaming was observed by employing five levels of steam pressure, viz. 0.5, 1.0, 1.5, 2.0

and 2.5 kg·cm^{-2} and the duration of steaming was kept as 25 min. In this case also the initial moisture was maintained at three levels.

To analyze the extent of gelatinization, the percentage of white bellies in rice for different durations of soaking, steaming and hydrostatic treatments were experimentally determined by the principle of refraction of light by keeping samples on an illuminated work board [6]. One hundred rice grains were collected randomly after polishing the samples and were used for the analysis. The raw rice grains and grains containing opaque centre were considered to be having white bellies. Only fully translucent kernels with no white core were considered to have been properly gelatinized.

The milling studies were conducted with the help of laboratory model Satake rice sheller, polisher and length grader. The clearance between the rollers in the sheller was so adjusted that not more than 5% remained unshelled after two passes. The brown rice was then polished for one minute in the polisher and then graded. Percent head rice was calculated on the basis of initial paddy weight. Head yield ratios were calculated relative to raw paddy sample. The milling quality was presented as head yield ratio, which was defined as:

$$\text{Head yield ratio} = \frac{\text{Head rice yield obtained from the sample}}{\text{Head rice yield obtain from control (raw paddy)}} \tag{1}$$

RESULTS AND DISCUSSION

White bellied kernels. Proper gelatinization of the grain indicates the absence of white bellies. Thus the presence of white bellies in the grain kernels after the soaking and steaming operations were determined. Fig. 1 shows the percent of white-bellied kernels obtained after soaking at different temperatures under atmospheric pressure. The amount of white bellies reduced with increase in soaking temperature as well as the duration of soaking. The initial moisture content did not affect the final extent of gelatinization. However, it was observed that the white bellies could not be completely eliminated even after soaking up to 6 hours at temperatures at or below 70°C. It was attributed to the reason that the gelatinization temperature was not achieved. The white bellies were completely eliminated after 5 hours of soaking at a temperature of 80°C.

Fig. 2 shows the percent white bellies-vs-soaking time at different hydrostatic pressures. In this situation, the duration of soaking, initial moisture content and hydrostatic pressure, all affected the extent of white bellies. The increase in hydrostatic pressure resulted in more elimination of white bellies. It was possible to eliminate the white bellies completely by soaking paddy in 70°C soak water under hydrostatic pressure of 6.0 kg·cm^{-2} for 6 hours.

The steaming operation effectively reduced the white bellies and the extent of reduction was affected by initial moisture content, duration of steaming as well as pressure of steaming (Fig. 3). White bellies could not be completely eliminated at steaming pressure of 0.5 kg·cm^{-2} even by increasing duration of steaming up to 30 minutes and with increase of initial moisture content. As the presence of white bellies decreased with increase in initial moisture content and steaming pressure, paddy with higher initial moisture contents (say more than 24 g per 100 g dry matter) could be parboiled successfully by exposing it to steam pressure of 1.5 kg·cm^{-2} for only 15 min.

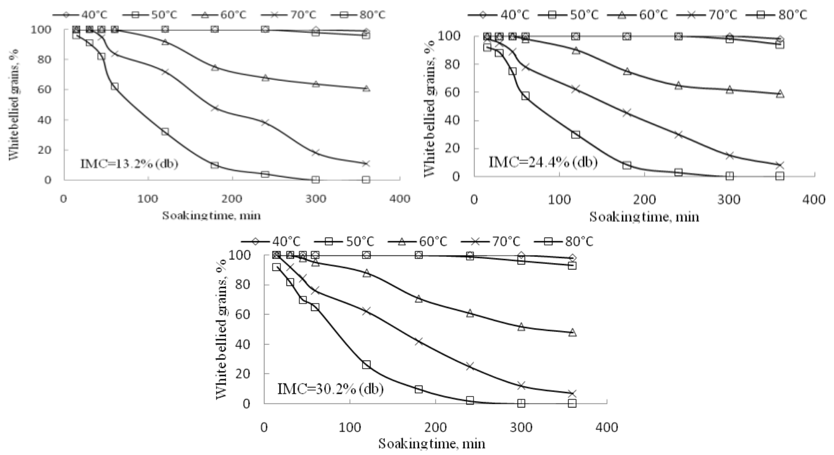


Figure. 1 Effect of soaking paddy at different temperatures on the presence of white bellies (IMC: initial moisture content)

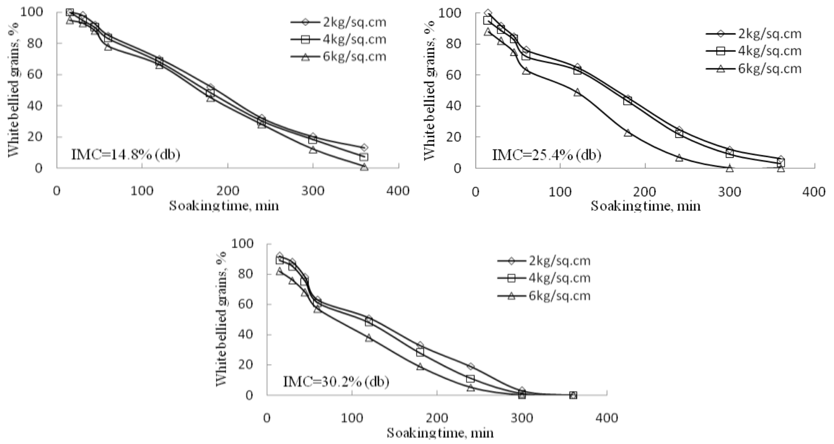


Figure. 2 Effect of hydrostatic pressure on the presence of white bellies (IMC: initial moisture content)

Head rice yield. Figure 4 shows the head yield ratios obtained for different soaking treatments. The average head rice yield obtained for the raw sample (control) under similar milling conditions was 62.4±1.6%. The head yield of rice simply soaked at atmospheric pressure was lower than that for the control sample for short durations of soaking. The head rice yield increased with increase in initial moisture content as well as the temperature of soaking. Soaking at 70°C for more than 60 min yielded higher head rice yield as compared to other low temperature soaking treatments. The head rice yield also increased for paddy soaked at 80°C for short duration; however, prolonged soaking at 80°C resulted in more breakage, which could be attributed to more softening of granules.

Fig. 5 shows the yield of rice obtained under pressure soaking, which signify that the head rice yield increased with increase in initial moisture content, duration of soaking and increase of soaking pressure. In general soaking under pressure resulted in more head rice yield as compared to soaking at atmospheric pressures. Thus pressure soaking caused gelatinization of the starch.

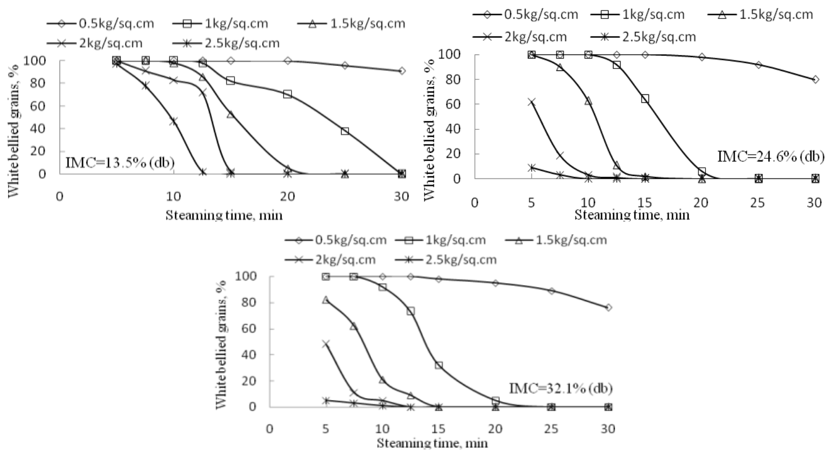


Figure 3. Effect of steaming at different pressures on white bellies (IMC: initial moisture content)

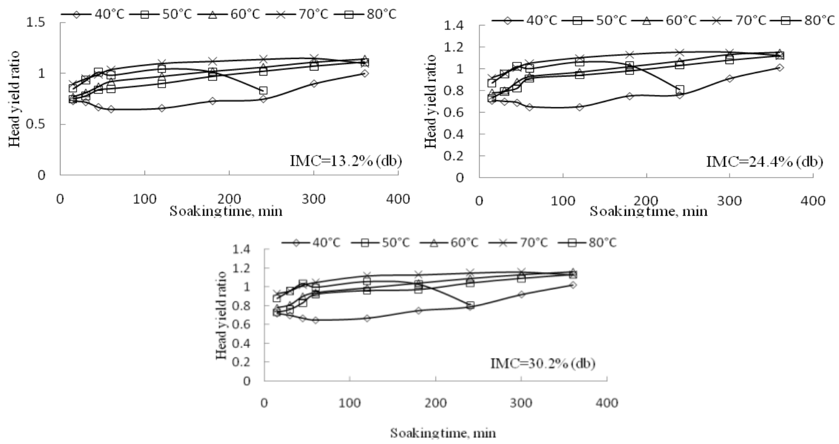
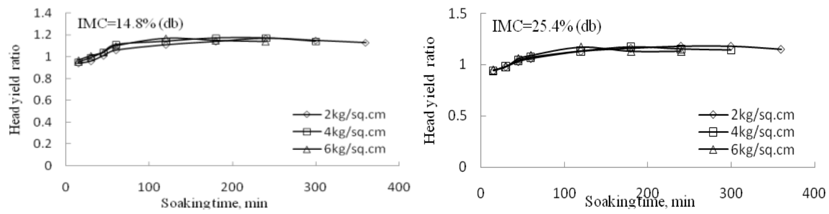


Figure 4. Head yield ratio of rice as affected by soaking temperature



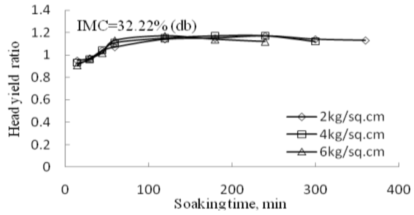
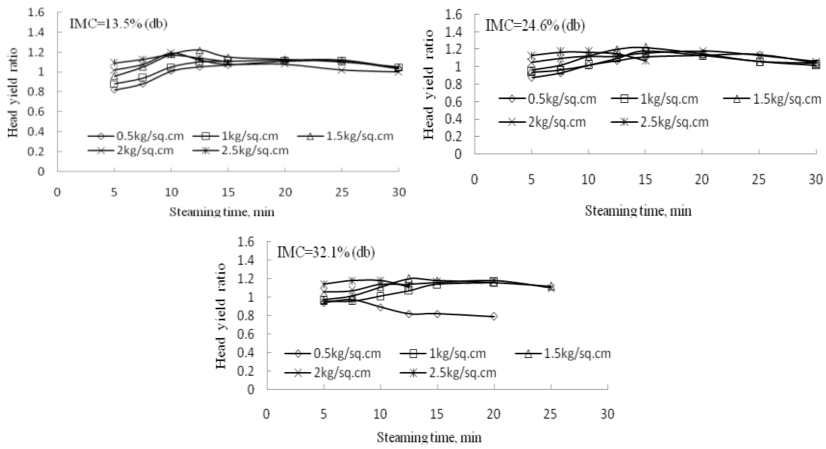


Figure 5. Effect on head rice yield by hydrostatic pressure soaking



Fiure 6. Effect on head rice yield by steaming at different pressures
(IMC = initial moisture content)

The head rice yield increased with increase in steaming pressure, initial moisture content, and the duration of steaming (Fig. 6). The maximum head rice yield was obtained under the conditions of a steam pressure of 1.5 kg·cm^{-2} for 12.5-15 min. However, it was observed that the maximum head rice yield was obtained under the conditions of a steam pressure of 1.5 kg·cm^{-2} for 30 min or 2.0 kg·cm^{-2} for 20 min, respectively [6]. The initial grain moisture content did not remarkably affect the head yield though the time of the treatment varied a little with that.

The study suggests that it is possible to achieve complete gelatinization and improve the head rice yield by employing only soaking or steaming under pressure with suitable initial moisture content. The pressure during soaking or steaming is important for the degree of gelatinization.

CONCLUSIONS

The effects of only soaking paddy at different temperatures under atmospheric pressure, soaking at different pressures at a constant temperature (70°C) and steaming under different pressures on the gelatinization of the grain and milling qualities were studied. It was observed that the steaming operation was quite effective in reducing the white bellies and the extent of reduction was affected by initial moisture content, duration of steaming as well as pressure of steaming. Soaking at 70°C for more than 60 min yielded higher head rice yield as compared to other low temperature soaking treatments. The head rice yield also increased for paddy soaked at 80°C for short duration; however, prolonged soaking at 80°C resulted in more breakage. Soaking under pressure resulted in more head rive yield as compared to soaking at atmospheric pressures. The maximum head rice yield was obtained under the conditions as initial grain moisture content of about 25 g per g dry matter at a steam pressure of 1.5 or 2.0 $kg \cdot cm^{-2}$ for a period of 30 and 20 min, respectively. The study suggests that it is possible to achieve complete gelatinization and improve the head rice yield by employing only soaking or steaming.

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UTICAJ PARAMETARA KVAŠENJA I PARENJA NA KVALITET MLEVENJA PIRINČA (CV. *MTU 1075*)

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Sažetak: Uticaj parametara kvašenja i parenja na kvalitet mlevenja pirinča (Cv. *MTU 1075*) je proučavan pri različitim inicijalnim sadržajima vlage. Kvašenje je izvođeno pri različitim temperaturama od 40 do 80°C. Tako đe je kvašeno i pri tri apsolutna pritiska od 2.0, 4.0 i 6.0 kg·cm^{-2} pri temperaturi vode za kvašenje od 70°C. Parenje je izvođeno pri apsolutnim pritiscima od 0.5, 1.0, 1.5, 2.0 i 2.5 kg·cm^{-2}. Uočeno je da je povećanje temperature vode za kvašenje kao i pritiska kvašenja pvećalo kvalitet mlevenja pirinča sa većim prinosom i smanjilo gubitke. Parenje na 80°C smanjilo je prinos kada je trajalo više od 120 min. Tokom kvašenja pod pritiskom je postojala razlika u početnom prinosu do oko 10 min kvašenja, a razlika se smanjila kako se vreme kvašenja povećavalo preko toga. Maksimalan prinos bio je postignut obradom sa pritiskom pare od 1.5 kg·cm^{-2} od 12.5 do 15 min. Samo kvašenje pri hidrostatičkom pritisku takođe je povećalo prinos u svim uslovima.

Ključne reči*: kvašenje, parenje, prinos, kvalitet mlevenja, hidrostatički pritisak*

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