jpht

Research Article

Journal of Postharvest Technology
01 (01): 060-068, October' 2013
www.jpht.info

Effect of Parboiling Treatment on the Milling Quality of Selected Rice Varieties

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Received : 10 Aug. 2013
Revised : 15 Sep. 2013
Accepted : 21 Sep. 2013

Keywords

Rice quality
Milling
Parboiling
Drying
Steaming

Abstract

Based on previous results indicating excessive milling loss inherent in rice milling process in Ethiopia, a study was conducted to evaluate the effects of parboiling treatment on three released (Gumara, Kokit, and Tigabe) and one local (X-Jigna) rice varieties. Parboiled and un-parboiled rice samples were milled using small and portable Rice Whitener (SRW). The result has indicated that the response for Parboiling is variety specific. But, in general, parboiling resulted in improved milling quality in most of the studied varieties. An overall increase in Milling yield (from 62.70 to 65.83%), milling recovery (from 79.50 to 83.97%) and whole grain yield (from 27.83 to 37.68%), was observed while milling loss has reduced (from 16.50 to 12.50%) by this treatment. Likewise, parboiling reduced machine throughput and output. Milling qualities of Gumara and Tigabe and, to some extent, Kokit varieties had been improver and that of X-Jigna declined when milled parboiled. Tigabe and Kokit had shown more or less similar milling properties when milled raw but Tigabe had shown better milling qualities when milled after parboiling. Thus, from the overall results of the research it become clear that milling qualities of the three varieties (Gumara, Tigabe,and Kokit) can be improved by parboiling. But parboiling had undesirable consequences on milling qualities of X-Jigna variety. It is therefore recommended that, along with improving the design of SRW machine, use of parboiling for selected varieties should be encouraged. Besides, under raw paddy milling conditions varieties with better milling quality as X-Jigna should preferably be promoted than lower milling quality Gumara variety. Improving the milling quality of Gumara and Tigabe by parboiling may also be useful.

INTRODUCTION

Rice is one of the most important cereal crops having a significant impact in human civilization. It, together with wheat, provides about 95% of the total nourishment of the world population. It is comparatively high in calorific value and a fairly good balance of amino acids. The grains are not separated from the hull during threshing and hence require additional dehulling and polishing operations for human consumption. It is usually eaten as a whole grain. Although most of the pre and post harvest operations are similar to most of the other cereals, its dehulling and polishing requirements make it different from most others.

Anatomically, rice grain is covered with husk and different bran layers, which are indigestible. Consequently, it should pass through different levels of milling operations to remove these fibrous parts and make it suitable for consumption. The purpose of rice milling is hence to remove the hull and bran and produce white rice (Hui, 1992). Rice processing methods, especially those involving milling operations, vary considerably throughout the world. Nonetheless, the most important consideration during rice processing is prevention of breakage of the endosperm.

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This is because of the fact that broken rice kernel is worth about one half of head (whole) rice (Hui, 1992). To achieve the best whole rice grain utmost care is required at all the stages of processing.

Milling quality of a given rice variety is defined as the ability of the grain to withstand hulling and polishing forces without breakage (Cruz and Khush, 2000). Careful milling of grain leads to achievement of the highest amount of whole grains and total recovery. The percentage head rice together with total recovery is the major concerns in rice milling and quality. Other related milling quality parameters are percentage broken kernels, total milling yield, degree of milling, percent unmilled grain and milling loss (Farouk and Islam, 1995; Peter and Olutayo, 2000).

Chemical analyses made on rice grain indicated that most of the non-starch nutrients are concentrated in the outer layers (bran and polish) of rice kernel which could easily be removed and lost during milling. This loss can be reduced either by consuming brown rice or by making some of the nutrients in the outer layer to penetrate into the kernel so that they are prevented from being removed during milling. Studies indicated that the former is not advisable due to some digestion problems and people's preference for well-milled white rice. Thus, parboiling which is a process of soaking, steaming and drying of paddy before milling is recommend to alleviate problems of nutrient loss and excessive breakage during milling (Nawab and Panday, 1974; Gariboldi 1984).

Parboiling is a process of gelatinization of rice starch within the grain. It results in a translucent and shiny rice, improves cooking quality and swelling ability during cooking, and also improves nutritional composition due to diffusion of B vitamins and other minerals in to the inner layers (Grist, 1965; Gariboldi 1984). Nonetheless, the actual effect of parboiling on deferent milling conditions and rice varieties is expected to differ (Sandhna et al, 1999).

Different experiments were conducted to determine the optimum soaking, steaming and drying temperatures and duration. Hence different optimum soaking water and steaming temperature and duration were suggested in the literature (Chakraverty and DE, 1981; Velupillai, and Lalit, 1982; Abdur et al., 1996). According to Sesay and Lalit (1985) the temperature and time of soaking varies depending on the nature or variety. However, water temperature of 65-70 0C and soaking time of about 4 hours was indicated to have considerably good effect. These values are still considered to vary based on the variety under consideration.

Rice is recently introduced crop in Ethiopia. Postharvest losses specially milling losses are very high. Selection, evaluation and promotion of suitable technologies which minimize losses and improve grain quality are of paramount importance in the countries research system. To this effect Parboiling is considered to be one of these potentially useful technologies. Therefore, this study was conducted to investigate the effect of parboiling on the milling qualities of different rice varieties and to determine their response to parboiling treatment.

MATERIALS AND METHODS

Varieties used

Three commercial varieties, namely IAC-164 (Gumara), IRAT- 209 (Kokit), and IREM-194 (Tigabe)/ along with the local variety (X-Jigna) were used for the study.

Milling machine used

Selam made Friction type Huller Mill (Figure 1), with screw type drum as main milling component was used for milling the raw and parboiled samples. The machine has an overall dimension of 1100 x 730 x 1100 mm (length x width x height), and was equipped with a single cylinder gasoline engine (Robin EY 28 model). The engine rated power is 5.5 kW and its maximum speed 4000 rpm. Test runs were made using the engine delivered with the prototype machine while the weight on the pressure plate was reduced from 4 kg to 2.1 kg to prevent over loading.

Parboiled Rice Sample preparation

From each variety, about 7 kg of paddy was taken and parboiled in the following ways:

Hot Water Soaking

Soaking water was pre-heated in a metallic kettle to a temperature of 80-90oC. Sample paddy was then put in this water. When the temperature of the mix drops, to 60-650C, during the process the soaking kettle was further heated to raise the temperature to 700C. The intensity of the heat was slightly increased or decreased during the soaking time so as to keep the temperature more or less constant. Mercury thermometer was used to monitor the temperature. Soaking continued for 3.5 hours for Kokit and for 4 hours for the remaining three varieties. Husks of variety Kokit started to split excessively before the intended soaking hour and hence soaking ended half an hour earlier than others.

Steaming

The paddy passed through the hot water soaking process was placed on a perforated tray above boiling water. A batch of about 5 mm thick was steamed at a time for 15-20 minutes, depending on the thickness of the batch and the level of endosperm opening and gelatinization. Paddy was slightly agitated two to three times until steaming is completed uniformly.

Sun drying

Each batch of soaked and steamed rough rice was placed on metallic tray in a single layer and placed under direct sun for ten minutes. This enabled to quickly evaporate the moisture adhering to the surface of the paddy. The paddy under this condition was then transferred to woven straw drying mat and allowed to further dry under direct sunlight. Wooden spreader was pulled and pushed over the grain until a paddy layer is inverted, mixed and flattened again. Pressing the grain between fingers and teeth were used to subjectively monitor the level of grain drying. Drying was stopped when paddy developed a slight resistance for teeth breaking. The moisture was then determined by oven drying method. Thermostatic oven Model NR120 was used for moisture determination. Dried parboiled paddy was then placed in polyethylene bags when it attained 12-15 % moisture content and kept under dry and dark condition until milled.

Milling quality determination

About 2 kg of raw and parboiled rice samples were milled in a single pass using the friction type mill indicated above. Prior to actual milling experiment calibration trials were made to determine optimum settings for good machine operations during which speed of operation, load setting and feed rate were determined.

The following evaluation parameters were assessed and compared between the results of raw and parboiled rice milling:

Paddy throughput (Kg/hr) = $\frac{W_p \times 3600}{T_N}$ …… (1)

Milling Yield (MY) (%) = $\left(W_m / W_p \right) \times 100$ …… (2)

Percentage broken grain (PBG) = $\frac{W_b}{W_M} \times 100$ ..(3)

Thousand grain weight loss

(TGWL) = $\frac{(W1 - W2)}{W1} \times 10$ …………………..(4)

Percentage milling loss

$$(PML)=(100 - Milling\ Recovery - 4)\%..(5)$$

where

Wp = Total weight of sample paddy milled (Kg) adjusted to 14% moisture content (wb)

TN = Net time taken for milling (seconds)

Wm = Total weight of milled rice (kg)

Wb = Weight of brown rice

W1 = Mean 1000-grain weight of a variety at brown rice level (g)

W2 = Mean 1000-grain weight of whole milled grain (both at standard moisture content) (g)

Experimental design and analyses

To investigate the effect of parboiling up on milled rice grain quality, a two by four (2X4) factorial experiment in complete randomized design with two levels of treatments (parboiled and raw rice) and four varieties each replicated three times were used.

Data was analyzed with Microsoft Excel, SPSS, and MSTAT softwares and statistical significant test was carried out at 0.05 and 0.01probability levels.

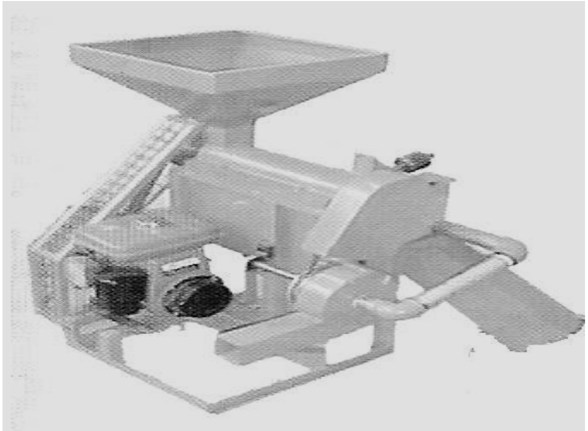

Figure 1. Selam made Rice Whitener (SRW)

was about 7.2%. This result in general agrees with that of Choudhury (1991) in that parboiling reduces relative easiness of a grain to be milled. This is due to the fact that bran of parboiled rice becomes more intact and hence needs more pressure for milling. Parboiling also increase hardness and brown rice becomes harder to whiten (Gariboldi, 1984).

Table 1a Paddy throughput (kg/h) as affected by parboiling and variety

Treatment	Variety				Mean [Y]
	Gumara	Kokit	Tigabe	X-Jigna	
Parboiled	134.17	177.83	172.47	191.27	167.28a
Raw rice	148.48	184.45	197.42	190.60	180.24b
Mean[Y]	141.33a	177.83b	184.95b	173.76b	
$LSD_{0.05}$	14.89				10.53

[Y-] In column means followed by common letters are not significantly different at 5% level.

Table1b ANOVA table of paddy throughput for parboiled and raw rice milling

Source of Variation	SS	df	MS	Fcomp.[b]	P-value	F crit
Variety	8930.494	3	2976.831	20.093**	0.000	3.238
Parboiling	1007.899	1	1007.899	6.803*	0.019	4.493
Interaction	496.912	3	165.637	1.118[ns]	0.371	3.238
Error	2370.378	16	148.148			
Total	12805.68	23				

CV=6.84% b-** Significant at 1% level * Significant at 5% level ns- not significant

Table 2a Effect of parboiling on percentage milling yield[X]

Heat treatment	**Variety**				**Mean[Y]**
	Gumara	**Kokit**	**Tigabe**	**X_Jigna**	
Parboiled	66.11bcd	65.06bc	69.13cd	63.02b	65.83a
Raw rice	54.67a	64.67bc	63.00b	68.33cd	62.67b
Mean[Y]	60.39a	64.86b	66.07b	65.68b	
$LSD_{0.05}$		2.76			1.95

[X]- average of three replications
[Y-] In row means followed by common letters are not significantly different at 5% level.
[Z –] In a row or column means followed by common letters are not significantly different at 5% level
LSD- List significant difference
LSD $_{0.05}$ of interaction is 3.9

Table 2 b ANOVA table of milling yield under parboiled and raw rice milling

Source of Variation	**SS**	**df**	**MS**	**Fcomp.[b]**	**P-value**	**F crit**
Variety	123.733	3	41.244	8.138**	0.002	3.239
Parboiling	60.040	1	60.040	11.847**	0.003	4.494
Interaction	235.389	3	78.462	15.482**	0.000	3.239
Error	81.085	16	5.0678			
Total	500.245	23				

CV=3.50% b-** Significant at 1% level ns- not significant

Table 3 Effect of parboiling on percentage milling recovery[X]

Heat treatment	**Variety**				Mean [Y]
	Gumara	*Kokit*	*Tigabe*	*X_Jigna*	
Parboiled	88.73c	81.83bc	87.51c	77.80ab	83.97b
Raw rice	72.67a	81.33bc	79.67bc	84.33c	79.50a
Mean	80.70	81.58	83.59	81.07	
$LSD_{0.05}$		5.12			2.57

[X]- average of three replications
[Y-] In column means followed by common letters are not significantly different at 5% level.
Z – In a row or column means followed by common letters are not significantly different at 5% level

Table 4a Percentage milling loss as affected by parboiling and variety[X]

Heat treatment	Variety				Mean[Y]
	Gumara	*Kokit*	*Tigabe*	*X_Jigna*	
Parboiled	7.33a	14.17bc	8.49a	18.20c	12.05a
Raw rice	23.33d	14.67bc	16.33bc	11.67ab	16.50b
Mean	15.33	14.42	12.41	14.93	
$LSD_{0.05}$		5.12			

[X]- average of three replications
[Y-] In column means followed by common letters are not significantly different at 5% level.
[Z –] In a row or column means followed by common letters are not significantly different at 5% level

Table 4b ANOVA table on % milling loss under parboiled and raw rice milling

Source of Variation	SS	df	MS	Fcomp.[b]	P-value	F crit
Variety	30.279	3	10.093	1.156[ns]	0.357	3.239
Parboiling	118.859	1	118.860	13.617**	0.002	4.494
Interaction	421.809	3	140.600	16.108**	0.000	3.239
Within	139.656	16	8.730			
Total	710.6036	23				

Cv=20.70% b-** Significant at 1% level ns- not significant

Table 5 Percentage whole grain of variety as affected by parboiling[X]

Heat treatment	Variety: *Gumara*	*Kokit*	*Tigabe*	*X_Jigna*	Mean[Y]
Parboiled	41.33c	31.03c	50.70f	27.63b	37.68b
Raw rice	31.67c	26.73b	20.63a	36.63d	28.93a
Mean[Y]	36.50c	28.88a	35.67c	32.13b	
					2.18
$LSD_{0.05}$		3.08			1.54

[X]- average of three replications
[Y]- In column means followed by common letters are not significantly different at 5% level.
[Z] – In a row or column means followed by common letters are not significantly different at 5% level

RESULTS AND DISCUSSION

Throughput

Throughput of Selam Rice Whitener (SRW) ranged from 134.17 to 191.27 kg/h when milling parboiled rice and from 141.33 to 184.95 kg/h for raw rice milling. Mean throughput using different varieties was 134.17 kg/h for Gumara, 177.83 kg/h for Kokit, 172.47 kg/h for Tigabe and 191.27 kg/h for X-Jigna (Table 1a). Similar values obtained during raw rice milling were 148.48, 184.45, 197.42, and 190.60 kg/h for Gumara, Kokit, Tigabe, and X-Jigna, respectively. The overall mean throughput was 167.28 kg/ h for parboiled and 180.24 kg/h for raw rice milling. This result showed that the overall throughput, which is mass of paddy processed per hour reduced when rice was milled after parboiling as compared with raw rice milling. The trend was the same for all varieties except for X-jigna in which throughput barely increased (0.35%) from 190.60 kg/h for raw to 191.27 kg/h for parboiled paddy milling.

Statistical analyses of the result indicated that the difference in throughput was significant both for the treatment and among varieties. But the interaction effect was not significant (Anova Table 1b). This result has shown that, as compared with raw rice milling, parboiling reduces machine throughput.

Percentage milling yield

Mean percentage-milling yield using parboiled and raw rice grains are shown in Table 2a. Overall mean percentage milling yield of the machine was 65.83% for parboiled and 62.67% for raw rice milling. This shows an overall 5.04% increase in milling yield due to parboiling treatment.

Percentage milling yield of Gumara increased from 54.67% to 66.11%, which was, in effect, a mean increment of 20.92%. This improvement is very high compared with the required 3.95% for statistically significant difference ($p<0.05$) (ANOVA Table2b). Kokit had shown a slight increment in percentage milling yield (64.67 to 65.06%), which was an increment of 0.60%. Regarding Tigabe, the mean percentage milling yield of the variety increased (63.00 to 69.13%) by 9.73%. The improvement made was statistically significant (p<0.05).

In the contrary, X-Jigna had shown reduced mean percentage milling yield due to parboiling. This reduced figure (from 68.33 to 63.02% on the average) was also statistically significant. This particular result contradicts earlier results and other findings obtained by many researches (Grist, 1965; Nawab and Pandya, 1974; Gariboldi, 1984). The reduction in percentage milling yield could be due to normal response of the variety to the effects of the treatment (parboiling) or due to the temperature and time combination used during the parboiling process. The first reason looks more likely because parboiling is considered effective for varieties which are more brittle due to the soft structure of their endosperm, and for those that give low output after milling. Long and slender varieties are usually parboiled because they are fragile compared with short or medium grains (Garboild, 1984). Therefore, it may not be useful practice for varieties like X-Jigna, which are short and have relatively better milling quality under raw milling conditions. On the other hand X-Jigna is short grain tropical Japonica variety (Sewagegne Tariku, personal communication), which may have lower gelatinization temperature than the other three varieties. Therefore the temperature of soaking water and the steaming duration could be different from that used during the experiment. This could have resulted in lower milling quality observed. Statistical analyses showed that statistically significance (p<0.01) variations exist due to the main effect of parboiling, variety, and their interaction (Table 2b).

Milling recovery (MR)

The results of the experiment (Table 3) show that MR of three

varieties had increased dramatically due to parboiling. When compared with raw rice milling, mean MR of Gumara increased by 22.10%, Kokit by 0.65%, and Tigabe by 9.84%. However, the milling recovery of X-Jigna reduced by 7.74% from that of raw milled rice. This shows that parboiling of Gumara and Tigabe under the stated conditions will increase their milling recovery. Besides, overall machine performance, as measured by milling recovery, was increased by 4.47%, which is considerable in the rice milling process. Statistical analyses made had shown that significant difference between means exist due to the effect of parboiling. The variety X treatment intraction was also significient (p<0.05). The lower improvement in the case of Kokit and reduced recovery in X-Jigna show that effect of parboiling is variety specific.

Percentage milling loss (PML)

The mean percentage milling loss of Gumara and Tigabe varieties had reduced from 23.33% to 7.33% and from 16.33 to 8.49%, respectively, when processed after parboiling (Table 4a). This was an achievement of considerable magnitude when it comes to minimization of processing losses. The mean percentage milling loses due to the main effect of parboiling also reduced from 16.50% to 12.05%. The reduction in loss observed when Kokit was milled was, however, lower (14.67 to 14.17%) and it loss increased (from 11.67 to 18.20%) when X-Jigna was milled after parboiling. As it can be seen from these tables parboiling treatment reduced the mean percentage milling loss figure from 16.50% during raw rice milling to 12.05%. Its effect was statistically significant (p<0.01) for treatment and Interaction (ANOVA table 4b).

Percentage whole grain (PWG)

Percentage whole grain of the four varieties, Gumara, Kokit Tigabe and X-Jigna was 31.67, 26.73, 20.63 and 36.63% when milled raw and 41.33, 31.03, 50.70 and 27.63%, respectively when milled after parboiling. This shows increment of 30.50, 16.09, and 145.76%, respectively, for the first three varieties and a reduction of about 24.57% for X-jigna. Generally, parboiling enabled to increase percentage whole grain (head rice yield) of Gumara, Kokit, and Tigabe while it reduced that of X-Jigna. The result also showed that the PWG recovery results of Selam Rice Whitening machine increased from 28.93% (raw milling) to 37.68% (milling after parboiling), which was an increase in whole grain proportion by 30.24%. Statistical analyses made showed that parboiling had significant effect on PWG. Besides, there was significant variation among varieties in their response to conditioning treatment.

CONCLUSION

Parboiled rice milling resulted in mean throughputs of 134.17 kg/hr for Gumara, 177.83 kg/hr for Kokit, 172.47 kg/hr for Tigabe and 191.27 kg/hr for X-Jigna. When the paddy was raw milled the mean throughputs were 148.48, 184.45, and 197.42, and 190.60 kg/hr for Gumara, Kokit, Tigabe and X-Jigna, respectively. This finding indicated that parboiling resulted in reduced throughput when compared with raw rice milling.

Percentage milling yield of Gumara increased from 54.67 to 66.11%, Tigabe, from 63.00 to 69.13%, and Kokit from 64.67 to 65.06% due to parboiling. The improvement made in milling yield was very high and statistically significant at $p<0.05$.

The percent milling recovery also increased due to parboiling, especially for three varieties. Mean recovery of Gumara increased from 72.67 to 88.73%, Kokit from 81.33 to 81.83 and Tigabe 79.67 to 87.51 % while that of X-Jigna reduced from 84.33 to 77.8%. This shows that the effect of parboiling on performance and quality parameters is dependent on variety. The percent milling recovery, in general, was increased by 5.62%.

Parboiling also increased percent whole grain of Gumara, Kokit, and Tigabe while it reduced that of X-Jigna variety. The percentage whole grain of Gumara, Kokit and Tigabe increased from raw rice milled values of 31.67, 26.73, and 20.63% to 41.33, 31.03, and 50.70%, respectively while the percentage whole grain was reduced from 36.63 to 27.63% for X-Jigna.

Percentage broken grains of Gumara, Kokit, and Tigabe were reduced due to parboiling from 68.33, 73.27, and 79.37% to 58.7, 68.97, and 49.30%, respectively, while the mean percentage broken grain of X-Jigna increased from 63.37 to 72.37%. Overall mean percentage of broken grain of Gumara and Tigabe was significantly lower than that of X-Jigna and Kokit.

Parboiling, in general improved milling quality three of the four rice varieties used in the study. It can thus be adopted or used for Gumara, Kokit, and Tigabe. It generally has an adverse effect on the local X-Jigna Variety. Besides, as the practice of parboiling requires skill, facilities and adequate energy sources, care must be taken and more research has to be done to suggest or recommend parboiling as an alternative to improve machine performance and milling quality of varieties.

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