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Impact of Parboiling conditions on Milling Quality and the Nutritional Value of Popular Rice varieties of Telangana

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ABSTRACT: The practice of parboiling rice is not new and has been done for a long time in India. However, the procedure of parboiling is not uniformly carried out and the method used varies with the area as well as the knowledge of the processor, resulting in variation in the quality of grain received after the process. This necessitated the need for optimization of the parboiling conditions. So, in the present study locally most cultivated rice varieties (BPT 5204, MTU 1010, RNR 15048, KNM 118 and JGL 18047) in Telangana were subjected to parboiling treatment at three different temperatures (90°C, 100°C, 110°C) and durations (15, 20, 25 minutes). The treatment results indicated that parboiling at 90^0C temperature for 15 min found to have better head rice recovery (72.29 %) compared to the other two temperatures (65.60 % @100°C and 62.00 % @ 110°C) and durations (64.20 % @ 20 min & 63.20 % @ 25 min). The result of the present study clearly showed that parboiling with high steaming temperature and steaming time decreased the head rice yield, as it resulted in breakage of pericarp of paddy seed while parboiling process. The present study also investigated the effect of parboiling on milling quality and nutritional parameters of these five varieties. Milling quality parameters like percent milling recovery and Head Rice Recovery increased with parboiling and brokens percent decreased significantly. Parboiling reduced the nutritional parameters like crude protein content and crude fat content and increased the other parameters like ash and crude fiber content. Parboiling had significant effect on the grain breadth but its effect on grain length was not significant. Parboiling also recorded less L/B ratio (3.25) compared to non-parboiled rice (3.35). Therefore, it can be concluded that parboiling process at a steaming temperature of 90^0C and duration of 15 minutes significantly increases the milling yield, HRR and reduces the breakages while retaining the minerals and crude fiber content which aid in the health of consumers.

Keywords: Rice, Parboiling, Steaming, Head rice recovery, Nutritional parameters.

INTRODUCTION

A little over fifty-five percent of the total rice exported from India is basmati and parboiled rice. Parboiled rice typically sells at a premium to non-parboiled rice. Thailand, India, and the United States are the top exporters of parboiled rice. Not only in exports but also parboiled rice has 20 Lakh Metric Tons per year of domestic consumption (Minhas, 2023). Improved quality and increased milling outputs are the main goals of parboiling. There are several processes through which rice is parboiled. But all these procedures have three basic steps, i.e., soaking, heating, and drying. However, parboiling produces some undesirable effects if not done in a proper way, for example, parboiling of rough rice at elevated temperatures and long steaming durations produces harder and darker product, which has a lower market value (Kimura *et al.*, 1993). The quality of parboiled rice is affected by the severity of the parboiling treatment; severely treated rough rice produces a product of lesser quality. After boiling gelatinization happens solely in the outer layers of the aleurone, sealing the grain and increasing the head rice yield (Boers *et al.*, 2015). Different conditions of parboiling have been observed to have different effects on the outcome of parboiling. Soaking temperature of water (40°C, 50°C and 60°C) was reported to have effect on physicochemical properties, milling and cooking of parboiled rice (Sareepuang *et al.*, 2008). Physical qualities of grain like hardness, milling yield, lightness, and colour values of parboiled rice produced at lower temperatures of 80, 90, and 100°C were reported to be better than those produced at higher temperatures of 110 and 120°C (Islam *et al.*, 2002). Ogunbiyi (2018) reported that initial soaking temperature of 67.7°C, Soaking time of 13hrs 18 minutes and final moisture content of 12.7% are the best paddy parboiling conditions for improved quality of milled rice in Nigeria.

Furthermore, the parboiling process was reported to cause significant increase in nutritional content such as ash, protein, and fat and this increase decreased the carbohydrate content correspondingly, affecting rice's glycemic index (Fonseca *et al*., 2014). Compared to non-parboiled rice, parboiled rice has several benefits, including improved kernel strength, increased milling recovery and prevention of milling-related nutritional loss, and improved shelf life. Vitamins and minerals that normally exist in the bran and aleurone layer flow into the endosperm during the parboiling process. Thus, post-milling parboiled rice contains much greater amounts of B vitamins, minerals and free amino acids than raw rice (Bhattacharya, 2004). Additionally, the loss of nutrients during washing is also greatly reduced. In terms of technology, parboiled grains remain intact after cooking rather than mashing together, which makes rice acceptable for products that are canned, expanded, or flaked (Arendt and Zannini 2013). Rice parboiling, or the hydrothermal treatment of rice prior to processing, has also been investigated to improve the physicochemical and nutritional quality of rice, as well as its digestibility (Zohoun *et al*., 2018; Kongkachuichai *et al*., 2020). Hence, the current study was conducted with an objective to check the effect of steaming temperature and duration on milling yield of parboiled rice and to evaluate the effect of parboiling on the nutritional and physical parameters in five popular rice cultivars of Telangana.

MATERIAL AND METHODS

Freshly harvested seed of selected varieties *i.e*., BPT 5204, MTU 1010, RNR 15048, KNM 118 and JGL 18047 was obtained from the farmer's field. Samples were cleaned and dried properly before subjecting them to the parboiling process.

Parboiling Process. 3 kg of paddy sample was soaked in water (1:2.5 ratio) at a temperature of 70°C for 3 hours followed by steaming at three different temperatures (90°C, 100°C, 110°C) and durations (15, 20, 25 minutes), for each rice variety individually. After the steaming process, the moisture content was reduced by drying the samples at 40^0C in hot air oven, until it reached a moisture content of 13%. The dried samples were then milled using a lab model (Indosaw, Rice Sheller & Polisher) milling and polishing equipment.

Milling quality parameters. One kilogram of rough rice of each variety was fed to the dehulling and polishing equipment and from the output, milling recovery percent, head rice recovery percent and percent brokens were calculated as per the procedures given by Azam *et al*. (2017). All the treated grain samples were subjected to further nutritional quality analysis, along with an untreated sample that served as control.

Physical parameters of the grain. Physical parameters like grain dimensions (length & breadth), L/B ratios of raw and cooked rice were measured. A grain micrometer was used to measure grain dimensions with accuracy of 0.001 mm, where ten rice grains which were uniform were randomly selected and their length and width were measured in triplicates. After cooking the elongation ratio of the grain was also measured (Suwansri and Meullenet 2004).

Colour Values: L*, a*, b* values of the milled and polished rice grain were measured with Hunter lab (Color flex with a measuring aperture of 36 mm, Firmware versions 1.1, Reston, Virginia) as per AOAC (2005) procedure.

Nutritive content. Moisture content of control and experimental rice samples were determined by IS1155:1968/4333(2):2002 method. Protein content was estimated as per AOAC 992.23. - Generic Combustion method, 20^{th} Edition, using Leco FP-528 Nitrogen Analyzer. Fat content was estimated as crude hexane extract of control and parboiled samples using automatic Gerhardt Soxtherm extraction unit (AOAC 2003.06). Crude fiber content of the samples was determined by the procedure given by Association of Official Analytical Chemists (AOAC 962.09). Total ash was determined using IS 1155:1968 (Reaffirmed 2010) procedure.

Amylose content. Amylose content of the sample was determined by the method given by Juliano (1971). 100 mg of sample was taken in a beaker and 1 ml 95% ethanol and 9 ml of 1N NaOH was added to the sample and the sample was kept in boiling water bath for 15 minutes. Then the sample was cooled, and volume was made upto100 ml 5ml of sample was drawn to another conical flask and to that 1ml of 1N acetic acid and 2ml iodine solutions were added and the volume was made up to 100 ml and the samples were kept in dark for 20 minutes. The absorbance of the samples was read at 620 nm in a spectrophotometer and the value of amylose was calculated from the standard graph.

Amylopectin content. Calculated following the equation explained by Torruco-Uco *et al.* (2006). For the calculation, the average amylose content was considered.

Amylopectin % = (100-Amylose%)

Statistical analysis. Data on the above-mentioned parameters was analyzed in two-factor analysis in Complete randomized design (CRD) with OPSTAT software. The significance of the differences between the averages were tested at the probability level of 5%.

RESULTS AND DISCUSSION

Milling Quality Parameters. The process of milling is crucial in rice production because it impacts the nutritional, cooking, and sensory properties of raw rice. Millers always want a technique that provides the best milling recovery percentage in parboiled rice while remaining economically viable. In the present study the milling recovery percent improved significantly with the parboiling procedure, regardless of the variety, the best recovery was obtained with a temperature of 90°C and a period of 15 minutes (Fig. 1). However, the increase was highest in the case of MTU 1010 and lowest in the case of RNR 15048 and KNM 118, even though the control sample of RNR 15048 had the highest percentage of milling recovery (73.72 %). This finding also agrees with Sareepuang *et al*. (2008) explanation that parboiling increases milling yield in comparison to non-parboiled rice. The reason for this result could be grain gelatinization and expansion during the parboiling process, and their restoration to their previous state following drying by cementing the internal fissures and becomes harder. These findings are consistent with those of Jagtap *et al*. (2008); Chavan *et al*. (2018); Gewaily *et al*. (2019).

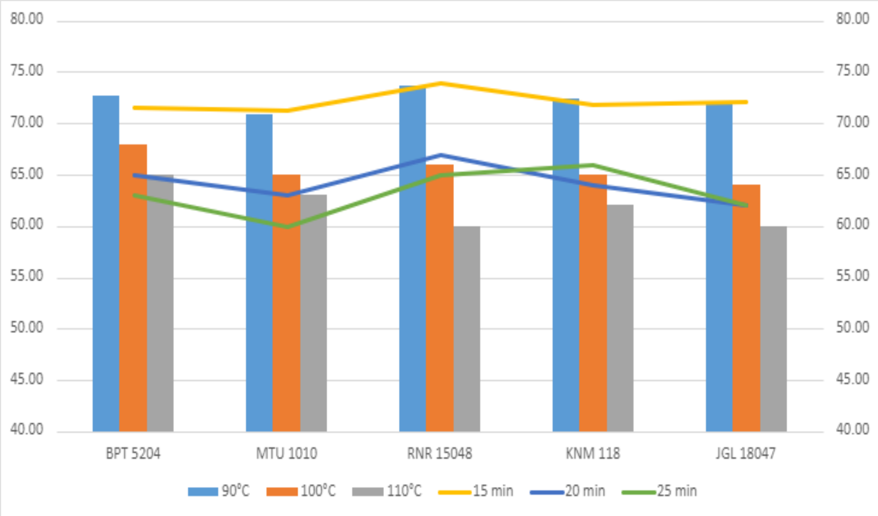

Fig. 1. Effect of steaming temperature and duration on Milling Recovery (%).

Table 1: Parboiling effect on the milling Parameters of Rice.

Variety	**HRR (%)**		**Brokens (%)**	
	Control	**Parboiled**	**Control**	**Parboiled**
BPT 5204	68.03	72.54	7.69	5.48
MTU 1010	65.01	69.88	8.53	6.57
RNR 15048	68.70	72.95	8.01	5.50
KNM 118	66.38	69.57	8.96	6.61
JGL 18047	66.12	70.65	9.36	6.27
Mean	**66.85**	**71.12**	**8.51**	**6.09**
CD (V)	0.75 *		0.33 *	
CD (T)	0.47 *		0.21 *	
CD (V × T)	NS		0.47*	

*Level of significance P < 0.05

Head rice recovery (%) in control samples varied from 65.01 to 68.70 %, whereas in case of parboiled rice it varied from 69.57 to 72.95 %. Parboiling significantly increased the HRR in all the five varieties tested. The interaction effect between variety and treatment was also significant for brokens (%). Parboiling not only increased the HRR but also contributed to the reduction of broken rice percentage in the tested rice varieties. This may be attributed to the increase in hardness of the rice grain that occurred following parboiling process, which play an active role in improving the head rice yields and hardness values. These results agree with those found by Ibukun (2008); Zohoun *et al*. (2018).

Physical Properties of the grain. Grain dimensions of the selected varieties varied significantly, and the length of non-parboiled rice ranged from 5.10 to 6.72 mm and the breadth was in the range of 1.50 to 1.83 mm (Table 2). Parboiling did not show any significant effect on the length of the grain however significant difference in the breadth was observed in case of the variety MTU 1010. Upon cooking there was significant differences in the length of the grain of KNM 118 and JGL 18047. The overall effect of the parboiling on grain length was significant after cooking. L/B ratio of cooked rice was significantly high in non-parboiled rice (3.35) than the parboiled rice (3.25) as the parboiled rice recorded higher width wise expansion (2.64 mm) than the non-parboiled rice (2.74 mm). The interaction between the variety and parboiling treatment for grain physical properties was non-significant. These results agree with the reports of El-Bana *et al*. (2020) who also reported no significant variation in the length of parboiled and non-parboiled rice before cooking.

Table 2: Parboiling effect on physical properties of rice grain before and after cooking.

Variety	Before Cooking						After Cooking							
	Grain length (mm)		Grain Breadth (mm)		L/B Ratio		Grain length (mm)		Grain Breadth (mm)		L/B ratio		Elongation ratio	
	Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled
BPT 5204	5.10	5.09	1.68	1.70	3.03	3.00	9.10	9.14	2.57	2.61	3.55	3.50	1.79	1.79
MTU 1010	6.72	6.74	1.80	1.87	3.74	3.60	8.73	8.78	2.80	2.87	3.12	3.06	1.30	1.30
RNR 15048	5.30	5.37	1.50	1.53	3.53	3.51	8.71	8.69	2.55	2.65	3.41	3.28	1.64	1.62
KNM 118	5.94	6.05	1.63	1.64	3.64	3.70	9.03	9.17	2.56	2.69	3.53	3.40	1.52	1.51
JGL 18047	6.49	6.47	1.83	1.86	3.56	3.48	8.49	8.58	2.71	2.89	3.13	2.98	1.31	1.33
Mean	**5.91**	**5.95**	**1.69**	**1.72**	**3.50**	**3.46**	**8.81**	**8.87**	**2.64**	**2.74**	**3.35**	**3.25**	**1.51**	**1.51**
CD (V)	0.062*		0.05*		0.09*		0.09*		0.06*		0.09*		0.03*	
CD (T)	NS		0.03*		NS		0.06*		0.04*		0.06*		NS	

*Level of significance P < 0.05

Table 3: Effect of parboiling on the colour of rice grains.

Variety	L*	a*	b*	DE*
Control				
BPT 5204	69.44±0.007	4.12±0.028	22.44±0.028	35.37±0.021
MTU 1010	72.25±0.035	3.18±0.021	19.15±0.049	34.01±0.007
RNR 15048	71.65±0.042	3.67±0.035	20.77±0.000	35.27±0.035
KNM 118	73.48±0.021	5.03±0.014	20.62±0.007	33.16±0.049
JGL 18047	70.23±0.037	3.46±0.018	18.63±0.004	34.05±0.006
Parboiled				
BPT 5204	67.98±0.000	5.25±0.000	24.75±0.028	36.54±0.028
MTU 1010	70.52±0.000	5.02±0.014	19.63±0.014	35.36±0.000
RNR 15048	66.36±0.014	6.32±0.014	24.85±0.021	36.82±0.028
KNM 118	70.94±0.021	7.45±0.049	19.62±0.021	34.76±0.014
JGL 18047	68.35±0.012	4.58±0.013	20.56±0.025	35.56±0.012

* Values in the table indicates Mean ±Standard deviation

Table 4: Parboiling effect on nutritive value of rice grain.

Sr. No.	Variety Name	Crude Protein (%)		Ash (%)		Crude Fat (%)		Crude Fiber (%)		Amylose Content (%)		Amylopectin Content (%)	
		Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled	Control	Parboiled
1.	BPT 5204	8.15	8.06	0.87	1.03	0.91	0.83	0.96	1.03	21.82	20.71	78.18	79.29
2.	MTU 1010	8.36	8.31	0.85	0.96	0.87	0.78	1.02	1.14	23.45	22.93	76.55	77.07
3.	RNR 15048	8.44	8.22	0.94	0.98	0.98	0.87	0.95	1.06	22.76	21.02	77.24	78.98
4.	KNM 118	8.41	8.30	0.73	0.85	0.94	0.82	1.08	1.21	21.45	20.06	78.55	79.94
5.	JGL 18047	8.07	7.97	0.74	0.97	0.82	0.78	0.99	1.24	23.37	22.46	76.63	77.54
	Mean	**8.29**	**8.17**	**0.83**	**0.96**	**0.90**	**0.82**	**1.00**	**1.14**	**22.57**	**21.44**	**77.43**	**78.56**
	CD (V)	0.14*		0.02*		0.01*		0.03 *		0.246*		0.245*	
	CD (T)	0.09*		0.01*		0.01*		0.02 *		0.156*		0.155*	

*Level of significance P < 0.05

According to the findings of the colour experiments, there was a noticeable shift in the rice grain's colour with parboiling (Table 3). Luminosity is measured by the unit L*. The L* readings significantly decreased, showing that the rice samples had become darker after parboiling. Values of a* & b* rose after parboiling indicating increasing intensity of hue for redness and yellowness. Similar results of increased a* & b* and decreased values of L* after parboiling was also reported by Balbinoti *et al*. (2018). While the increase in redness could only be explained by the diffusion of red pigments from the interior bran to the endosperm, the increase in yellowness during soaking could be attributed to the diffusion of yellow pigments from the exterior and interior bran layers towards the endosperm (Lamberts *et al*., 2006). Oli *et al*. (2016) reported that milled parboiled rice has yellow colour while its non-parboiled counterpart is white, which could be due to diffusion of bran and hull pigments, and enzymatic and non-enzymatic browning that are the major causes of colour change in parboiled rice. There are a few possible compounds such as phenolic acids and carotenoids associated with hull and bran layer of rice that could contribute to colour change in parboiled rice. The paddy hull is rich in phenolic acids (ferulic, chlorogenic and p-coumaric acids) (Butsat and Siriamornpun 2010) which may diffuse into endosperm during parboiling process.

Nutrient content of the grain: Data on chemical composition of parboiled and non- parboiled rice showed that the crude protein content in the non-parboiled rice ranged from 8.07 to 8.44 % whereas that of parboiled rice was in the range of 7.97 to 8.30 % (Table 4). Except for MTU 1010 the difference in the crude protein content of parboiled and control rice samples was significant ($P \leq 0.05$). Parboiling significantly reduced the crude protein content. This could be due to the leaching of nitrogen and albumin due to rupturing of the grain during the process of steaming as reported by Chavan *et al*. (2018). Another report of Chukwu and Oseh (2009) suggested the cause for loss in protein content due to dissolution of soluble nitrogen in the soaking step of parboiling process. Not only protein content but crude fat content was also decreased with the parboiling process. Five varieties of rice significantly differed for the crude fat content. As there is movement of oil globules from the kernel endosperm to the surface during parboiling there is an increase in the oil content of rice bran and decrease in the crude fat content of kernel endosperm (Ibukun, 2008).

Ash content which is indicative of mineral content of sample varied significantly among the varieties analysed. The ash content in non -parboiled rice ranged from 0.74 to 0.94 %. A significant increase in the ash content was observed with the parboiling. Penetration of water-soluble minerals from pericarp to the endosperm layer throughout the soaking and steaming steps in parboiling can be attributed to the increase in ash content after parboiling (Chavan *et al*., 2018; Isnaini *et al*., 2019). In contrast to the trend of ash content a significant reduction in the crude fiber content was observed after parboiling. Among the varieties, KNM 118 recorded the highest crude fiber content before and after parboiling. Similar increase in the crude fiber content after parboiling was also reported by Otegbayo *et al*. (2001).

Rice cooking and pasting qualities are very much influenced by its amylose content. MTU 1010 and JGL 18047 had the highest amylose levels among the five rice varieties examined (Table 4). The parboiling process reduced the amylose concentration of all samples. Amylose content drops due to starch solubilisation and leaching of amylose molecules into the surrounding water during soaking and subsequent steaming during parboiling. The results obtained are consistent with those reported by Kale *et al*. (2015); Yenrina *et al*. (2017). Because amylose and amylopectin content are inversely related, a decrease in amylose content resulted in an increase in amylopectin content.

CONCLUSIONS

Based on the findings of this study, increasing the temperature of steaming beyond 90°C and increasing the steaming duration beyond 15 minutes during the parboiling process had a negative impact on milling quality parameters such as milling recovery percent and head rice recovery. Among the five varieties evaluated, BPT 5204 and RNR 15048 had higher HRR values than the others. Regardless of the type, parboiling raised the HRR and decreased the brokens %. The parboiling procedure enhanced not only the milling qualities of the grain but also the total mineral content, i.e., the ash content of the grain. However, parboiled grain had a lower fat level than unparboiled grain. It can be concluded that parboiling treatment can be effectively used to these five popular Telangana varieties to improve milling yield and nutritional content.

FUTURE SCOPE

Previous research found that varying parboiling parameters and milling intensity resulted in significantly variable zinc and iron retention in parboiled rice. Because of the range of parboiling processes employed in South Asia, it is expected that zinc and iron losses during parboiling will vary greatly. It is crucial to identify the parboiling parameters that result in enhanced zinc and iron concentrations in biofortified and non-biofortified rice. Since this component was not explored in this study, it can be regarded as a potential scope of extension.

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Conflict of Interest. None.

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