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CHANGES IN PHYSICO-CHEMICAL PROPERTIES OF SOME PROMISING LINES / VARIETIES OF RICE (*Oryza sativa* L.) AFTER PARBOILING

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ABSTRACT

Some of the promising lines/ varieties of Rice Research Institute, Kala Shah Kaku, including approved fragrant (Basmati) rice variety i.e. Shaheen Basmati and NIAB-IR9, were used to assess interactive efficacy of parboiling on these varieties/lines and practical expediency of using standardized parboiling technique for improving nutritional, milling and cooking qualities of these lines/ varieties. For the purpose, white milled and parboiled rice samples often lines/ varieties were analyzed for nutritional quality parameters such as ash, dry matter, crude fat, crude protein, crude fiber, vitamin B-6; milling quality parameters such as brown rice, total milling recovery, head rice recovery, ratio of broken grains; and cooking quality parameters such as curling and bursting. The study showed significant variation in efficacy of parboiling to different varieties/lines. The results clearly showed average increase in mineral contents in terms of ash% increase, dry matter, longer cooked grain length and considerable rise in vitamin B-6 contents, higher total milling recovery and head rice recovery in almost all the samples. While crude fiber, crude protein and crude fat was decreased non-significantly. Furthermore, quality reducing factors such as number of broken grains, bursting and curling percentage of cooked rice were also found reduced significantly in parboiled samples. It may, therefore, be suggested that parboiling offers a better alternative to conserve and increase nutritional, milling and cooking quality values of rice varieties/ lines. Less percentage of broken, burst and curled grains may result in augmented net income.

INTRODUCTION

Rice is utilized as a basic source of sustenance for more than half of the world's population, thus, making it a second most important cereal grain after wheat (Ghadge and Prasad, 2012; Bhatia *et al*., 2009; Prasad *et al*., 2010a, b, c). About 50% of the world's paddy production is parboiled. Parboiled rice, sometimes also called as converted rice, is a partially boiled un-husk rice. The three basic steps of parboiling are soaking, steaming and drying (Miah, *et al*., 2002). The treatment is practiced in Pakistan as well as many other parts of the world such as India, Bangladesh, Myanmar, Malaysia, Nepal, Sri Lanka, Guinea, South Africa, Italy, Spain, Nigeria, Thailand, Switzerland, USA and France (Pillaiyar, 1981). Parboiling drives nutrients, especially thiamine, from the bran to endosperm (Kyritsi, *et al*., 2011), hence parboiled white rice is 80% nutritionally similar to brown rice. Because of this, parboiling is now being adopted by more than 80% countries of the world. Parboiled rice takes less time to cook and is firmer and less sticky. In most of the countries, parboiled rice is either partially or fully precooked before sale. The major reasons for parboiling rice include higher milling yields, higher nutritional value and resistance to spoilage by insects and mold (Bhattacharya and subbarao, 1966; Elbert *et al.,* 2000).However, the suitability and efficacy of parboiling for Pakistani local varieties and lines is still needed to be determined. Therefore, a study was conducted whereby ten promising lines having average grain length (AGL) more than 8.0 mm with very good milling and cooking qualities, developed by Rice Research Institute, Kala Shah Kaku, along with approved basmati varieties of Pakistan, were analyzed for their suitability to be used for parboiling and improvement in physic-chemical properties were also studied to ascertain the

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effectiveness of parboiling with special reference to these varieties and lines.

MATERIALS AND METHODS

The study was conducted during 2012 in which nutritional, milling and cooking quality analysis of white milled raw and parboiled rice samples of 11 rice lines/varieties i.e. PK8685, PK8892, PK7274, PK8649, PK7899, PK8809, PK8650, PK8431, Shaheen Basmati, PK8647 and NIAB-IR9 was conducted.

Parboiling Treatment

The rough rice samples (5-6 kg.) of ten selected lines/ varieties were treated according to the treatment matrix that included two drying cycles. The most suitable soaking temperatures and soaking durations for all the ten lines/ varieties were predetermined in the laboratory of Rice Research Institute using Lab Scale Parboiling Unit. The drying temperature during 1st pass is 95°C and during 2nd pass was 75°C. The steamed paddy was dried at a temperature of 95°C during first pass, below the starch gelatinization Temperatures (GT), till moisture content of treated paddy reaches 18%.GT helps in determining the optimum soaking temperature for a particular rice line/ variety. After 1st pass, the partially dried paddy was tempered at room temperature for a minimum period of 2-3 hours. Presoaking below the GT minimizes the splitting of grains. After tempering, drying temperature during the second drying cycle was 75°C, till the treated paddy reaches 11% moisture content. The treated and dried paddy samples were milled to determine various grain nutritional, milling and cooking quality parameters as described below.

Nutritional Quality Parameters

Parameters for nutritional quality such as Ash Percentage (%), Dry Matter (DM%), Crude Fat (CF%), Crude Protein (CP%), Crude Fiber (CFi%) and Vitamin B-6 (B-6) contents were analyzed using lab scale parboiling unit (LSPU) in order to determine the effects of parboiling on these nutritional quality parameters. Specifications for LSPU were developed and the unit was procured and installed accordingly.

Milling and cooking characteristics

Parboiled and un-parboiled samples of each variety/ line was cleaned with a seed blower. 1kg of each treated and raw dried (less than 12% moisture content) paddy samples of each line/ variety were hulled with a testing husker (THU, 35H, Satake Engineering Co. Ltd., Japan). The moisture content of each sample was predetermined using a Steinlite Model 500 RC Electronic moisture tester. Then 500 g of brown rice of each sample obtained was then whitened in a single pass friction rice pearler (BS08A, Satake Engineering Co. Ltd., Japan) with the degree of whiteness set between 'Low' and 'Medium' on the equipment. After milling, rice bran was removed with a 1.7 mm sieve. A cleaned sample of milled rice was weighed and was used to determine milling recovery parameters such as Total Milling Recovery Percentage (TMR %), Head Rice Recovery (HRR) and percentage of Brokens. Head rice recovery (HRR %) was calculated as percentage of whole milled grains respect to the brown rice, then the average value was calculated (Bello *et al*., 2004). De-husked rice of both parboiled and un-parboiled samples of each variety/ line was cooked in excess water. Twenty grains of each sample were cooked with a colander in a boiler placed on an electric heater (98°C) at cooking time of respective variety/ line. Then cooking quality parameters such as Cooked Grain Length (CGL in millimeters), Percent Curling and Bursting Percentage of all the samples were measured.

RESULTS AND DISCUSSION

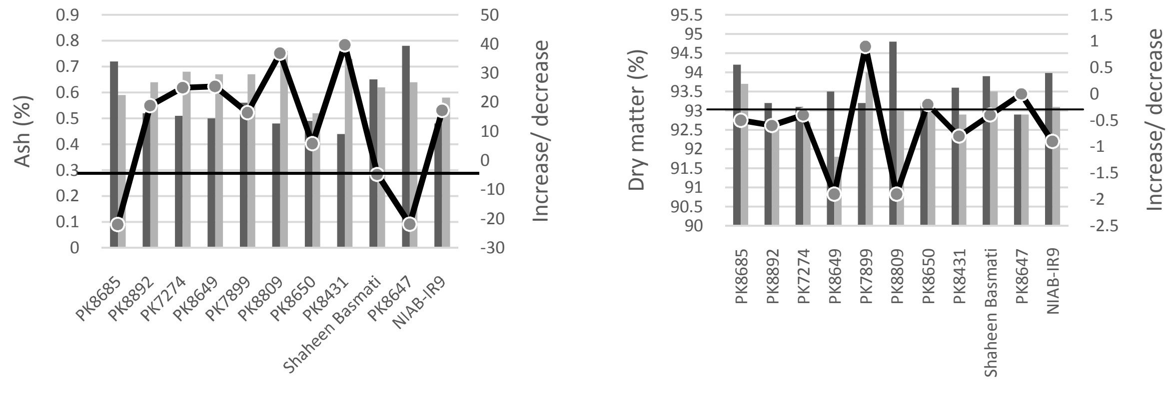
Results (Table 2) shows that almost all the genotypes were significantly different among themselves in respect to all the studied characters, showing remarkable diversity in these characters (Fig. 1 and 2). Table 1 clearly shows range and means of values for all the studied characters obtained from all the parboiled and un-parboiled milled rice samples of each genotype. By comparing the means of parboiled and un-parboiled rice samples, it becomes evident that there was increase in total milling recovery, head rice recovery, ash %, dry matter %, crude protein % and vitamin B6on average basis. While broken %, curling %, bursting % and crude fat % was found to decrease on average basis after parboiling. Average crude fiber % remained stable showing no significant influence of parboiling (Table 1).

Table 1. Range and means of studied physico-chemical parameters of raw and parboiled samples of all genotypes

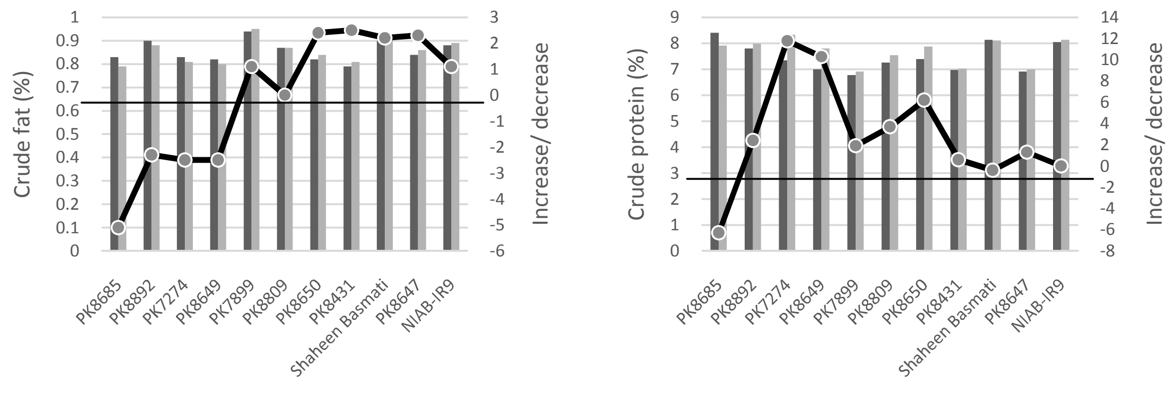
Parameters	Un-parboiled		Parboiled	
	Range	Mean	Range	Mean
Total Milling Recovery (%)	79.25-71	70.25	70.41-72.15	71.58
Head Rice Recovery (%)	43.5-51.4	48.84	54.04-64.5	58.51
Broken (%)	18.5-26.5	21.41	7.77-17.38	13.07
Curling (%)	2.0-8.0	4.55	0.6-2.55	1.28
Bursting (%)	2.0-10.0	4.09	0.38-2.54	1.20
Ash (%)	0.44-0.78	0.62	0.58-0.76	0.68
Dry Matter (%)	92.9-94.2	93.6	91.8-94.0	92.9
Crude Fat (%)	0.79-0.94	0.86	0.81-0.95	0.88
Crude Protein (%)	6.78-8.41	7.579	6.91-8.33	7.759
Crude Fiber (%)	0.37-0.45	0.426	0.34-0.44	0.394
Vitamin B-6 (ppm)	1.24-5.51	3.377	1.60-7.51	4.676

Ash and Dry matter percentage

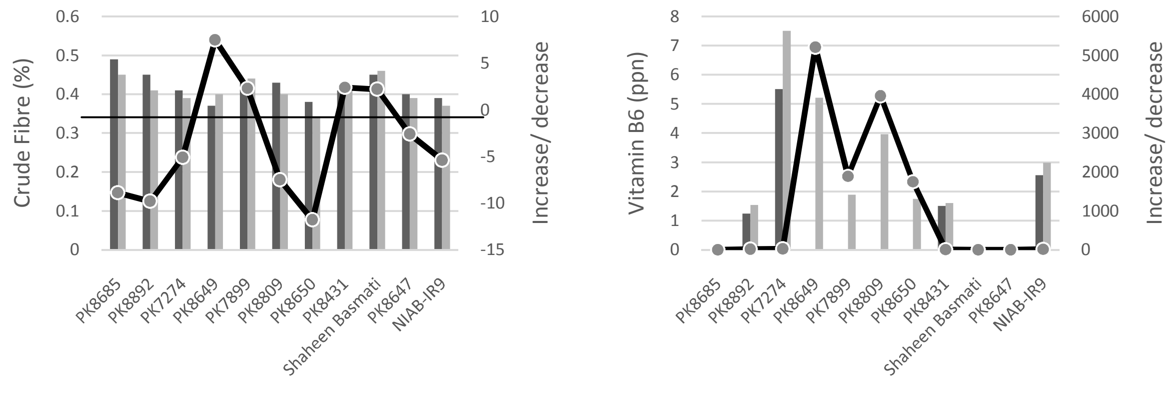
Table 1 clearly shows significant difference among all the genotypes for their ash and dry matter percentages. Results shows that ash increases in parboiled samples except for three varieties/ lines i.e., Shaheen Basmati, lines PK8685 and PK8647 as indicated by the line graph that is below the reference line at zero (Fig. 1a). Maximum increase in ash was recorded for line PK8431 (39.7%) followed by line PK8809 (36.8%) while minimum (5.8%) was recorded in case of line PK8650 as depicted in Fig. 1(a). As ash represents the mineral contents, so it showed that parboiling process increases the mineral content in rice kernel. The brown rice, produced by removing the hull only, contains most of the minerals in outer most layer. The complete milling and polishing removes more than 70% of minerals therein, resulting in reduced nutritional white rice. Contrary to this, parboiling pushes these minerals from outer layer of brown rice into the endosperm, by high temperature and pressure, thus maintaining the nutritional value of rice. However, the process that produces brown rice removes only the outermost layer, the hull, of the rice kernel



(a) (b)



(c) (d)



(e) (f)

Fig. 1. Nutritional quality parameters of parboiled and un-parboiled milled samples of all the studied lines/ varieties of rice. Line graph indicates increase or decrease in percentage. Points in graph line above and below the reference line at zero indicates increase and decrease respectively

and is the least damaging to its nutritional value. Ogbonnaya and Friday (2009) also demonstrated that temperature had significant influence on ash percentage. Dry matter percentage showed decrease in almost all parboiled samples with maximum (1.9%) recorded in PK8649 and PK8809graphically demonstrated in Fig. 1(b).

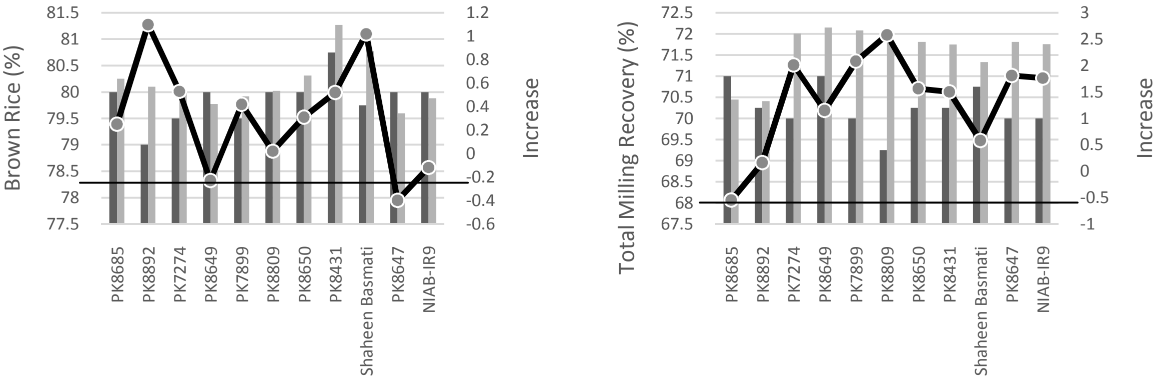
Crude Fat, Crude Protein and Crude Fiber

A significant difference was recorded in all the parboiled and un-parboiled samples (Table 2). The results given in Fig. 1 (c) clearly indicate that crude fat percentage was decreased in all parboiled samples except four, and in this context maximum decrease (5.1%) was recorded in PK8685 while minimum (0%) in PK8809. The decrease or loss of crude fat in parboiled samples may be due to the heating process and leaching of fat into the soaking water. Rao and Juliano (1970) also showed that fat content decreases during parboiling process. On the other hand, there were mixed results for crude protein percentage. For six rice genotypes, crude protein increases and in four it decreases (Fig 1d).

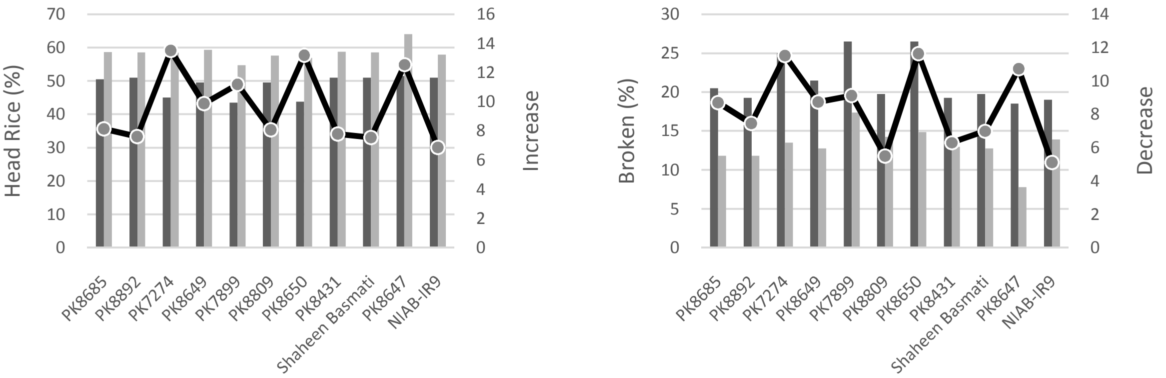
Table 2. Comparison of nutritional quality parameters among raw rice and parboiled rice samples of all the studied genotypes

Sr. #	Lines/ Varieties	Ash (%)		Dry matter (%)		Crude Fat (%)		Crude Protein (%)		Crude Fiber (%)		Vitamin B-6	
		WR	PBR	WR	PBR	WR	PBR	WR	PBR	WR	PBR	WR	PBR
1	PK8685	0.72	0.59	94.2	93.7	0.83	0.79	8.41	7.91	0.49	0.45	ND	ND
2	PK8892	0.52	0.64	93.2	92.6	0.9	0.88	7.8	7.99	0.45	0.41	1.24	1.54
3	PK7274	0.51	0.68	93.1	92.7	0.83	0.81	7.35	8.33	0.41	0.39	5.51	7.51
4	PK8649	0.5	0.67	93.5	91.8	0.82	0.8	7	7.8	0.37	0.4	ND	5.21
5	PK7899	0.56	0.67	93.2	94	0.94	0.95	6.78	6.91	0.43	0.44	ND	1.89
6	PK8809	0.48	0.76	94.8	93	0.87	0.87	7.26	7.54	0.43	0.4	ND	3.96
7	PK8650	0.49	0.52	93.2	93	0.82	0.84	7.39	7.88	0.38	0.34	ND	1.75
8	PK8431	0.44	0.73	93.6	92.9	0.79	0.81	6.98	7.02	0.41	0.42	1.5	1.6
9	Shaheen Basmati	0.65	0.62	93.9	93.5	0.9	0.92	8.14	8.11	0.45	0.46	ND	ND
10	PK8647	0.78	0.64	92.9	92.9	0.84	0.86	6.91	7	0.4	0.39	ND	ND
11	NIAB-IR9	0.48	0.58	93.98	93.1	0.88	0.89	8.05	8.14	0.39	0.37	2.56	2.98

*WR = Raw Rice
**PBR = Parboiled rice



(a) (b)



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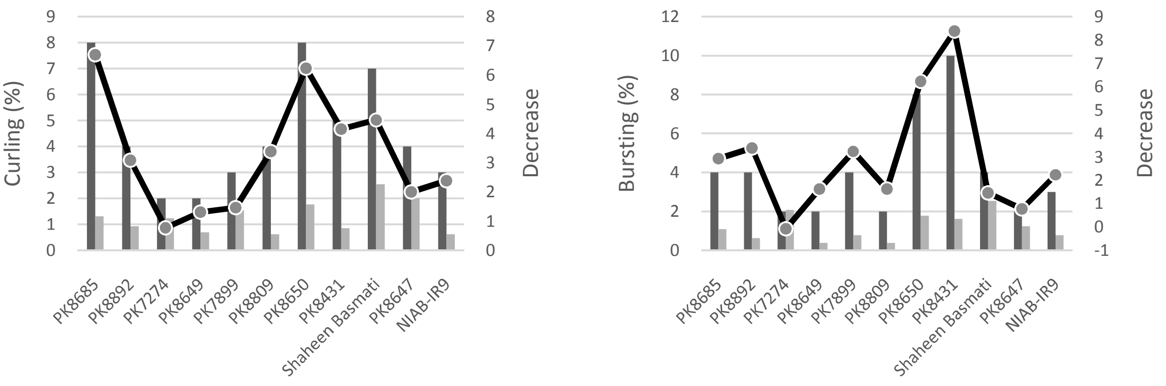

(e) (f)

Fig. 2. Nutritional quality parameters of parboiled and un-parboiled milled samples of all the studied lines/ varieties of rice. Line graph indicates increase or decrease in percentage. Points in graph line above and below the reference line at zero indicates increase and decrease respectively

Maximum increase (11.8%) in crude protein was recorded for line PK7274 followed by line PK8649 (10.3%) while minimum increase in case of PK8431 (0.6%) as in fig 1 (d). Maximum decrease in crude protein percentage was recorded in line PK8685 (6.3%) while minimum decrease in Shaheen Basmati (0.4%). Padua and Juliano (1974) also reported decrease in protein contents due to parboiling, which may be due to leaching of protein during socking phase of parboiling as well as rupturing that occurs in molecules while steaming phase. Parboiling makes the protein sink into the compact gelatinized starch grain mass, that makes protein bodies less extractable ultimately decreasing its contents. (Chukwu and Oseh, 2009).However, Patindol (2008) in his study on laboratory scale parboiled rice, concluded that parboiling sparingly changed protein content. He concluded that reduction in protein content might be due to the fact that oil and protein diffuse outward during parboiling, based on microscopic observations, they cannot diffuse as readily through cell walls as water-soluble vitamins.

The findings further showed that in most parboiled samples, crude fiber was decreased except four samples, and its maximum decrease was observed in line PK8650 (11.8%) whereas minimum in PK8647 (2.6%). Similarly maximum increase of crude fiber percentage was recorded in line PK8649 (7.5%) with minimum in case of the line PK7899 (2.3%) as shown in fig 1 (e). line graph here in fig 1e indicates increase percentage in crude fiber after parboiling for each genotype separately. Line graph points below the reference line at zero indicates that crude fiber was decreased as in case of PK8685, PK8892, PK7274, PK8809, PK8650 and PK8647. While crude fiber was increased in case of PK8649, PK7899, Shaheen Basmati and PK8431 as indicated by line graph above the reference line at zero. Sareepuang *et al.* (2008) also reported significant increase in crude fat, crude protein and crude fiber after parboiling at 50^{o}C. It has already been found out that dietary fiber, crude fat and crude protein increases after germination, probably because of formation of new compounds (Jung *et al.,* 2005 and Lee *et al.,* 2007). The same results also were obtained by Rhaghavendra and Juliano (1970). Newton *et al*. (2011) also found increase in these nutritional indices in parboiled rice samples.

Vitamin B-6

Vitamin B-6, as presented in Fig. 1 (f), was considerably increased in all parboiled samples with maximum increase in line PK8649 (5210%) and minimum in line PK8431 (6.3%). This increase in vitamin B-6 content in parboiled rice samples may be attributed to the migration of vitamin B-6 content from bran layers into the kernel. The complete milling and polishing that converts brown rice into white rice destroys 67% of the vitamin B3, 80% of the vitamin B1, 90% of the vitamin B6, half of the manganese, half of the phosphorus, 60% of the iron, and all of the dietary fiber and essential fatty acids (Ituen, 2011). Fully milled and polished white rice is additionally required to be "enriched" with vitamins B1, B3 and iron. Therefore, parboiling can be used to increase nutritionally essential vitamins that are lost during milling and processing. This agreed with the findings of Gariboldi (1973) that it may be due to the fact that during steaming, water soluble vitamins are spread throughout the grain, thus altering their distribution and concentration.

Milling and Cooking Quality Parameters

Fig. 2(a-f) summarizes the results of milling and cooking quality of raw milled rice (Pre-parboiled) and parboiled milled rice (post-parboiled). Significant variation was found among the studied genotypes for the traits. It can be concluded from the Fig. 2(b) that total milling recovery (TMR %) was increased in all the studied samples that showed significant variation among themselves. Highest TMR was obtained for line PK8649 followed by line PK7274 and PK8809 respectively. Minimum TMR was shown by line PK8892 (Fig. 2b). Likewise, among the lines tested maximum HRR (64.04%) was recorded for line PK8647 (fig 2c) while minimum (49.0) in case of PK7899. Maximum brown rice (81.27%) was recorded for PK8431, however, minimum in case of PK8647 (19.6%) as in Fig. 2(c). Almost all the lines showed significant increase in cooked grain length when subjected to parboiling. Cherati *et al.* (2012) also analyzed and studied the parboiling methods and the following impacts on waste reduction and yield increase in Iranian rice in paddy conversion phase and found fracture or broken percentage and bran percentage decrease while head rice recovery increase after parboiling. Fig. 2 (f) clearly emphasizes that bursting of cooked grain was reduced significantly for almost all the genotypes except for PK7274. Bursting of grains in all the parboiled samples was also found to be significantly low as compared to un-parboiled white rice (Fig. 2f). Rao and Juliano (1970) also showed increase in head rice recovery and cooking quality in parboiled rice. Kaddus Miah *et al.* (2002) also observed a large reduction in fissured grains in parboiled samples of rice as compared to non-parboiled. They further added that it is due to the fact that parboiling fills the void spaces in the endosperm and hence the cracks within the grains are cemented, making the grain harder leading it to less brokens. Insect infestation is also reduced due to the hardness.

Conclusion

As a conclusion to the study, it may be abridged that by using proper techniques of parboiling, nutrition of rice may be conserved within endosperm, even after removal of outer layer i.e. bran, during milling and processing. Hence, parboiling maintains nutritional quality of milled and polished rice that is often lost during milling and polishing processes. It can further be concluded that parboiling process could be a good tool to save time when trying to improve certain physical and nutritional quality traits of freshly harvested rice that additionally assist in improving head rice recovery, total milling recovery and enhances shelf life of rice grains. Among all the studied varieties and lines, PK8649, PK7899, PK8809 and PK8650 respectively were found best for parboiling. Among others, PK8647, PK7274 and Shaheen Basmati were found more responsive to parboiling respectively. Other lines/ varieties showed less suitability to parboiling.

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