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EFFECT OF PARBOILING ON PHYSICO-CHEMICAL & COOKING ATTRIBUTES OF DIFFERENT RICE CULTIVARS

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Abstract

The current study was aimed to elucidate the effect of parboiling on physico-chemical and cooking attributes of different rice varieties. The results indicated that parboiling has less significant effect on thousands kernel weight i.e. 15.51- 21.80g and 14.53-19.418g for raw and parboiled fraction respectively. Length breadth ratio exhibited non-significant effect of parboiling but less significant on bulk density. Parboiling demonstrated a significant effect on protein content of brown, milled rice and bran of all varieties. Among cooking parameters, parboiling enhanced cooking time for milled rice fractions but reduced cooking time for brown rice fraction. The results are imperative for stockholders to select appropriate rice variety for specific use.

Key words: Rice, Milling Fractions, L/B ratio, Parboiling, Cooking properties

Introduction

Rice (Oryza sativa L.) is the imperative food crop for half the world's population. Its production and consumption is concentrated in Asia where more than 90% of the world's rice is grown and consumed [20]. Pakistan grows high quality rice to accomplish both domestic demands and for exports. It accounts for 6.4 percent of value added in agriculture and 1.4 percent in gross domestic production. [11]. In recent years, eating, cooking and sensory attributes that affect cooked rice palatability and consumer acceptability have received increasing research consideration in rice-producing countries [38,16].
Rice grain quality traits command worldwide attention not only from consumers, but they also play a vital economic role for millers, manufacturers of conventional and convenience foods, and exporters to international markets [24]. Appearance, eating, cooking, and milling qualities comprise the primary components of rice grain quality [19].

Physicochemical and metabolic properties of rice are influenced by numerous factors such as grain composition, cultivars, conditions of climate, cultivation, postharvesting, milling yield and cooking process [5,10]. In addition, Hu et al. [15] reported that high-amylose rice exhibited lower glycaemic values than low-amylose varieties. Rice is mostly consumed after milling, which is a combination of several unit operations to convert paddy into well-milled silky-white rice, which has better cooking quality properties [9].
Rice is subjected to various unit operations for processing. Milling, an important processing step of rough rice, is usually done to produce white, polished grain. A commercial rice milling system is a multi-stages process where the rough rice is first subjected to dehusking and then to the removal of brownish outer bran layer, known as whitening [35]. Among milling characteristics, the recovery of milled rice yield is of prime concern, which is the main determinant of market price and is directly related to brown and milled rice yield [36]. Brown rice comprises of 6-7% bran, 90% endosperm and 2-3% embryo [6]. On average, paddy rice produces 25% hulls, 10% bran and 65% white rice [12,25]. Rice bran is rich in nutrients with 14-16%

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protein, 12-23% fat, and 8-10% crude fiber. Milled rice is referred to as “polished” or “whitened” and there are various degrees or fractions of polishing [22,29].

Parboiling of paddy is a hydro-thermal process, intended to improve milling, nutritional and organoleptic attributes of rice. In addition, it reduces broken grain, increases rice yield and reduces nutritional loss during polishing process [3]. Soaking is an indispensable step in wet milling or parboiling [3,8]. During process water diffuses into the rice kernel and some components leach out. The leached out components include soluble protein, sugars, and non-starch bound lipids [7]. Keeping in view all above facts, following study was mainly aimed to study the effect of parboiling on physico-chemical cooking properties of rice varieties.

Material and Methods

Procurement of Raw Material. Six commercially available rice varieties including three Basmati varieties (super basmati, 98316 and 00515) and three course varieties (KSK 282, KSK 434, and KSK 133) were obtained from Rice Research Institute, Kala Shah Kaku-Pakistan.

Methods

Parboiling. Rough rice or rice paddy samples (1Kg + 50 g) were soaked in beakers containing water and placed in a water bath at 60℃ for a time period of 7-8 hrs, after soaking samples were quickly withdrawn, washed and cooled to room temperature. The soaked rough rice were steamed for 30 min at 0.5 kg/cm2 pressure in autoclave at 100oC temperature. The samples were cooled to room temperature and dried in trays with moisture content up to 10-12% remaining [4].

Rice Milling. Before milling moisture content of hulled raw rice kernels and parboiled rice kernels was reduced to 9-10% and then dehulled into brown rice by the use of dehuller or husking machine (SATAKE RICE MACHINE, Type THU, No. 1011020 made in Tokyo, Hiroshima) located in Kala Shah Kaku Rice Research Institute. One Kg of this brown rice was then milled through polisher (RICE POLISHING MACHINE, Model No. 3, Serial No. 148F648 made in USA) sited in Kala Shah Kaku Rice Research Institute, to produce white rice along which bran (bran, germ and polish) was obtained as a by product. White rice and remaining brown rice then milled through UDY Cyclone Mill to obtain flour for further analysis.

Sample Preparation. Brown and milled whole rice kernels were separated from broken rice for the evaluation of physicochemical, cooking and textural properties.

Rice Cooking. To study the effects of cooking 15 g of milled and brown rice were soaked separately in a beaker containing distilled water for 1 hour and then cooked in the electric hot plate at 100oC temperature for appropriate cooking time.

Physical Characteristics. The raw milled, brown rice and parboiled milled, brown rice of different varieties were analyzed for different physical characteristics like thousand kernel weight, Length–breadth ratio (L/B) and Bulk density (g/ml) [28].

Chemical Analysis. The brown and milled rice samples of each variety were analyzed for the moisture, ash, fat and protein content according to there respective methods [1].

Cooking Properties

Minimum Cooking Time. 10 g of milled and brown rice samples were taken in a beaker from each variety and cooked in 50 ml distilled water at hot plate with 100 oC. The cooking time was determined by removing a few kernels at different time intervals during cooking and pressing them between two glass plates until no white core was left [27].

Elongation Ratio. Cumulative length of 10 cooked milled and brown rice kernels were divided by the length of 10 uncooked raw milled and brown kernels and the result was reported as elongation ratio. A mean of 3 replications was reported [27].

Cooked Length–Breadth Ratio. Cooked length-breadth ratio for both milled and brown rice was determined by dividing the cumulative length of 10 cooked kernels by the breadth of 10 cooked kernels. A mean of 3 replications was reported [27].

Statistical Analysis. The data obtained for each parameter was subjected to statistical analysis to determine the level of significance between quality parameter of different fraction of each rice variety by using complete randomized design technique and means were compared according to the appropriate methods described by Steel et al. [31].

Results and Discussion

The results regarding the different physical, chemical characteristics of different raw and parboiled rice varieties and cooking properties have been discussed here.

Effect of parboiling on physical characteristics

Thousand Kernel Weight. The results regarding mean values of thousand kernel weight are tabulated in Table 1. In raw brown rice the thousand kernel weight was highest in variety KSK133 (21.806g) followed by KSK282 (21.32g) and KSK434 (20.27g), while lowest thousand kernel weight was found in a brown rice of Basmati variety 98316 (15.52g) followed by super basmati (15.897g) and 005151 (18.007g) respectively. Raw milled rice also followed the same pattern with highest thousand kernel weight in coarse variety KSK133 (19.42g) followed by KSK434 (18.71g) and KSK282 (18.67g) correspondingly and lowest thousands kernel weight was in 98316 (14.53g) followed by super basmati (15.02g) and 00515 (17.197g) respectively.

Parboiled brown and milled rice followed the same pattern as mentioned in raw varieties with respect to thousand kernel weight. In parboiled brown fraction the highest value was observed in KSK133 (20.356g) followed by KSK434

(19.87g) and KSK282 (19.79g) while lowest was found in 98316 (14.2g). In milled parboiled fraction maximum value was observed in KSK133 (20.247g) followed by KSK434 (19.003g).

First three coarse varieties significant differ from last three fine varieties, but less significantly differs with each other, while fine varieties were significantly differs among each other. Parboiling showed less significant effect on brown rice fraction as minute decline in thousands kernel weight was observed and their data was in the range of 15.51-21.80g and 14.53 19.418g for raw and parboiled fraction respectively. For milled rice less significant effect of parboiling was found and the data for raw and parboiled fraction was in the range of 14.53- 19.418g and 14.2 – 20.247g respectively. Thousands kernel weight of parboiled milled rice reduced to some extant except in variety KSK 133 and KSK 434.

The thousand kernel weight is a measurement of the net weight in grams of 1000 rice grain. The weight varies from one variety to another variety. The thousand kernel weight of Basmati varieties was significantly lower than coarse varieties for both brown and milled rice grains of raw and parboiled rice. The results of thousand kernel weight in the present study falls with in the range as reported by Otegbayo et al. [21] (13.3- 19.9g), Thakur and Gupta [33] (19.875±0.082 for brown rice), Singh et al. [29] (28.83g), Khatoon and Prakash [18] (16.52-17.32g), Singh et al. [26] (15.56- 21.53g for raw and for parboiled 16.17-22.08g).

Table 1. Physical analysis in milling fractions of Rice

VARIETIES	Test Weight	Thousand Kernel Weight				Length Breadth Ratio				Bulk Density			
		FRACTIONS				FRACTIONS				FRACTIONS			
		Un parboiled (gms)		Parboiled (gms)		Un parboiled		Parboiled		Un parboiled		Parboiled	
		Brown rice	Milled rice	Brown rice	Milled rice	Brown rice	Milled rice	Brown rice	Milled rice	Brown rice	Milled rice	Brown rice	Milled rice
KSK 133	52.33	21.82	19.42	20.36	20.25	3.38	3.38	3.43	3.47	0.82	0.82	0.81	0.79
KSK 282	51.67	21.32	18.67	19.79	18.56	3.65	3.68	3.48	3.46	0.81	0.82	0.82	0.80
KSK 434	51.33	20.27	18.71	19.87	19.00	3.88	3.81	3.91	3.95	0.78	0.79	0.80	0.77
Super Basmati	46.33	15.90	15.02	15.33	15.18	4.58	4.54	4.16	4.29	0.72	0.76	0.75	0.74
515	42.67	18.01	17.20	18.00	16.62	4.22	4.12	4.28	4.41	0.76	0.76	0.71	0.75
98316	40.67	15.52	14.53	15.23	14.20	4.62	4.72	4.49	4.54	0.73	0.74	0.74	0.71

Length Breadth ratio. Data revealed that all varieties are significantly differ from each other while their fractions are non significant but the interaction of varieties and their fractions differs less significantly. The results regarding mean values of length breadth ratio are tabulated in Table 1. The highest length breadth ratio was found in 98316 for both milled and brown rice fraction. For milled rice of 98316 length breadth ratio was 4.723cm followed by super basmati and 00515 varieties with 4.543cm and 4.117cm respectively and for brown rice of 98316 length breadth ratio was 4.617cm followed by super basmati (4.583cm) and 00515 (4.127 cm). The lowest length breadth ratio of brown rice was observed in KSK 133 (3.38cm) followed by KSK282 (3.65cm) and KSK 434 (3.88cm) respectively. Raw milled rice also followed the same trend with KSK133 having less value (3.38cm) followed by KSK 282 (3.68cm) and KSK 434 (3.81cm) respectively. Statically data revealed that milling and parboiling did not have significant effect on length breadth ratio.

Length breadth ratio of basmati and coarse varieties were significantly differing from each other. Brown and milled rice fractions of Basmati varieties possessed more length breadth ratio in comparison with fractions of coarse varieties in both raw and parboiled varieties and there was no significant difference was found after parboiling. The results in this study of length breadth ratio were found in the range as reported by Vanaja and Babu [34] (1.95- 3.85), Singh et al. [29] (2.43- 3.98 for brown rice and 2.20- 3.65 milled rice), Singh et al.[27] (2.62- 4.55), Khatoon and Prakash [18] (2.21-4.12), Singh et al. [26] (2.55-4.03 for raw an d for parboiled 2.58-4.18) and Otegbayo et al. [21] (2.12 for parboiled, 2.62 for non parboiled white rice and 2.56 for parboiled, 2.22 for non parboiled brown rice).

Bulk Density. Data demonstrated that all varieties and their fractions are significantly differ from each other while their interaction is non significant. The results regarding mean values of bulk density are tabulated in Table 1. The highest bulk density was found in brown rice fraction of parboiled rice. For raw rice brown fraction the highest bulk density was found in KSK 133 (0.817g/ml) followed by super KSK 282 (0.805 g/ml) and KSK 434 (0.784 g/ml) respectively while for milled rice the highest bulk density was observed in KSK 282 (0.822 g/ml) followed by KSK 133 and KSK 434 (0.819 g/ml) and (0.794 g/ml) respectively. The lowest length bulk density for brown rice was observed in super basmati (0.724 g/ml) followed by 98316 and 00515 (0.728 g/ml) and (0.762 g/ml) respectively and for milled rice less bulk density was observed in 98316 (0.739 g/ml) followed by 00515 (0.760 g/ml) and super basmati (0.764 g/ml) respectively.

After parboiling a little decrease in bulk density of both fractions was observed. The highest bulk density for brown rice was found in KSK 282 (0.824 g/ml) and lowest in 00515 (0.705 g/ml), while for milled rice highest value was observed in KSK 282 (0.802 g/ml) and lowest in 98316 (0.711 g/ml). Statically data revealed that milling and parboiling have less significant effect on bulk density. In raw rice for bulk density there is an increasing trend was observed in milled rice while after parboiling there is a slightly decrease. All varieties were also significantly differing from each other. Coarse varieties (ksk133, KSK 282 and KSK434) showed highest bulk density as compared to fine varieties (super basmati, 98316 and 00515). The consequences in this study were found in the range as reported by Thakur and Gupta [33] (0.857g/ml ±0.015), Singh et al. [27] (0.77- 0.88g/ml), Khatoon and Prakash [18] (0.781-.860g/ml), Correa et al. [9] (0.754-0.779g/ml for brown and 0.780-0.805g/ml for milled rice) and Singh et al. [26] (0.714-0.838g/ml for raw and for parboiled 0.616-0.743g/ml).

Test Weight. Data showed a significant difference among varieties. The results regarding mean values of test weight are tabulated in Table 1. Test weight is a measure of the weight of grain (usually expressed in pounds) per volume bushel. Highest test weight was found in KSK 133 (52.33 Kg/hl) followed by KSK 282 (51.67 Kg/hl) and KSK 434 (51.33 Kg/hl) respectively. Lowest value was observed in 98316 variety (40.67 Kg/hl) followed by 00515 (42.67 Kg/hl) and super basmati (46.33 Kg/hl) respectively. According to data coarse varieties (KSK133, KSK282 and KSK 434) possessed more test weight in comparison with fine varieties (super basmati, 98316 and 00515).

The results obtained in this study were found in the range as reported by Reddya and Chakraverty [23] (500kg/hl at 7-19% moisture) and Vanaja and Babu [34] (523- 542Kg/hl).

Effect of parboiling on chemical characteristics

Protein Content. Analysis of variance revealed highly significant difference between varieties and fractions. Interactive effect of varieties and fraction also imparted differential impact. The results regarding mean values of protein content are tabulated in Table 2.

In raw brown rice fraction the highest protein content were found in 00515 (10.05%) followed by 98316 (9.497%) and KSK282 (7.827%) varieties respectively while less protein was observed in super basmati (6.82%) followed by KSK133 (7.347%) and KSK434 (7.34%), respectively. In raw milled fraction high protein was found in 98316 (9.83%) followed by 00515 (9.797%) and KSK282 (7.787%) respectively whereas a reduced amount of protein was found in KSK434 (6.083%) and pursued by KSK133 (6.553%). Bran of raw KSK133 (13.11%) showed high protein content pursued by 00515 (9.48%) and 98316 (8.132%) though lowest was found in KSK282 (6.16%) followed by super basmati (7.143%). For parboiled brown rice fractions elevated protein content were found in KSK282 (8.72%) followed by KSK434 (7.47%) and KSK133 (7.11%) correspondingly. Less protein content were experiential in super basmati (4.187%) followed by 00515 (6.15%). In parboiled brown rice fractions high protein content were found in super basmati (8.317%) followed by 98316 (7.613%) and low protein content were experiential in KSK133 (6.297%). Bran fraction of KSK434 (12.15%) illustrate high protein content followed by KSK133 (11.66%) and 98316 (11.187%) correspondingly, while low protein was observed in 00515 (9.99%).

Protein content of raw brown, milled rice and bran fraction of all varieties was less significantly differs with each other and recorded in the range of 6.82-13.11%. In parboiled rice fraction a significant difference was found and it was observed in the range of 6.15-12.15% with an exception in super basmati brown rice having 4.187% protein. Parboiling demonstrated a significant effect on protein content of brown, milled rice and bran of all varieties and a significant difference was experiential. A reduction in protein content was empirical in both parboiled brown and milled rice in comparison with raw brown and milled rice fraction of all varieties. But in case of bran fraction, parboiling significantly increased protein content, due to the discharge of protein from inner portion of rice to the outer portion.

Table 2: Chemical analysis in milling fractions of Rice

Varieties	Protein content						Moisture content						Ash content					
	Fractions						Fractions						Fractions					
	Un parboiled Rice fraction (%)			Parboiled Rice fraction (%)			Un parboiled Rice fraction (%)			Parboiled Rice fraction (%)			Un parboiled Rice fraction (%)			Parboiled Rice fraction (%)		
	Brown	Milled	Bran	Brown	Milled	Bran	Brown	Milled	Bran	Brown	Milled	Bran	Brown	Milled	Bran	Brown	Milled	Bran
KSK 133	7.47	6.55	13.11	7.11	6.30	11.66	3.67	4.17	5.95	6.59	4.98	5.18	1.14	0.75	7.89	0.95	0.74	8.92
KSK 282	7.83	7.79	6.16	8.72	7.44	10.27	3.67	5.37	6.07	5.72	5.95	4.84	1.14	0.52	6.52	1.17	0.77	8.51
KSK 434	7.34	6.08	7.58	7.47	7.55	12.15	5.36	5.50	5.70	5.51	6.08	5.42	0.97	0.37	10.18	0.93	0.78	9.27
Super Basmati	6.82	7.08	7.14	4.19	8.32	10.16	6.60	6.17	5.58	4.87	4.28	5.45	1.38	0.51	6.50	0.99	0.52	6.31
515	10.05	9.80	9.48	6.15	7.01	9.99	5.71	4.10	6.40	5.28	4.62	5.12	1.33	0.59	10.22	0.98	0.64	9.31
98316	9.50	9.83	8.13	6.52	7.61	11.19	5.60	5.83	5.44	4.75	6.15	5.00	1.13	0.58	8.15	1.17	0.54	7.61

The results obtained were in the range as reported by Singh et al. [29] (6.61- 7.28% for brown rice and 6.17- 6.93% for milled rice), Zhou et al. [38] (6.6- 7.3% for brown rice, 6.2-6.9% for milled rice and 8.2- 8.4% for basmati rice), Hamid et al. [13] (12.2% for bran), Otegbayo et al.[21] (8.31% for parboiled, 9.70% for non parboiled white rice and 6.56% for parboiled, 6.85% for non parboiled brown rice) and Heinemann et al. [14] (6.36% for parboiled, 6.66% for non parboiled white rice and 6.85% for parboiled, 6.76% for non parboiled brown rice).

Moisture Content. Analysis of variance revealed non significant difference among varieties and fractions. Interactive effect of varieties and fraction imparted less differential impact. The results regarding mean values of moisture are tabulated in Table 2. Statistically data revealed that there was no significant difference observed in six different varieties while fractions illustrated less significant difference among each other.

Highest moisture was observed in raw super basmati brown rice fraction (6.597%) followed by parboiled brown rice fraction (6.587%) of KSK133 variety. In raw brown rice fraction, high moisture content were observed in super basmati (6.597%) followed by 00515 (5.71%) and 98316 (5.6%) respectively although less moisture content was found in KSK133 and KSK282 (3.667%) followed by KSK434 (5.36%). For milled fraction, high moisture was analyzed in super basmati (6.167%) followed by 98316 (5.83%).

The high moisture in bran fraction was observed in 00515 (6.4%) variety followed KSK282 (6.07%). Parboiling did not show any significant effect as no significant difference was observed in parboiled brown, milled rice and bran fractions in comparison with their raw fractions.

Moisture content of raw brown, milled rice and bran fraction of all varieties was less significant with each other and recorded in the range of 3.67-6.597%. In parboiled rice fractions a non significant difference was found and it was observed in the range of 4.227-6.587%. Parboiling demonstrated a non significant effect on moisture content of brown, milled rice and bran of all varieties as a result no significant difference was observed. Less moisture content was observed in all fractions in both raw and parboiled varieties, reason is that before milling paddy was dried up to 9% moisture level and during milling it was again reduced. UDY Cyclone mill also caused for reduction in moisture content during their conversion into flour for further use. The results obtained were in the range as reported by Hamid et al. [13] (8.5% for bran), Otegbayo et al. [21] (10.30% for parboiled, 9.70% for non parboiled white rice and 9.50% for parboiled, 9.60% for non parboiled brown rice), Heinemann et al. [14] (9.58-11.63% for parboiled, 9.39-12.84% for non parboiled white rice and 11.01-13.38% for parboiled, 12.10-13.50% for non parboiled brown rice).

Fat Content. The results regarding mean values of fat content are tabulated in Table 2. In raw brown rice fraction the highest fat content were found in KSK133 (3.15%) followed by 98316 (2.683%) and 00515 (2.617%) varieties respectively and less fat was observed in KSK434 (1.6%) followed by KSK282 (2.35%).

While milled raw rice fraction of 00515 (2.05%) showed high value followed by KSK282 (1.282%) and less fat was observed in KSK133 (.383%). In case of raw bran high value was found in 005151 (21.163%) followed by 98316 (19.847%) and less fat was observed in KSK282 (KSK133.16%). In parboiled brown rice fraction the high value was found in KSK434 (3.483%) followed by 98316 (2.97%) and lowest was found in KSK133 (2.337%). For parboiled milled fraction high value was observed in 00515 (1.083%) and less value was found in 98316 (0.797%) while for bran of parboiled rice maximum value was in KSK434 (24.867%) and lowest in super basmati (17.07%).

Fat content of raw brown, milled rice and bran fraction of all varieties was significantly different and recorded in the range of 1.6-21.163%. A significant difference was also found in parboiled rice fractions and it was observed in the range of 0.797-24.867%. Parboiling demonstrated a non significant effect on fat content of brown and milled rice of all varieties. In raw brown rice it was in the range of 1.6-3.15% while parboiled having a range of 2.337- 3.483%. Milled rice fat is significantly lower than brown rice fraction due to the removal of bran, while raw and parboiled milled rice is non significantly differ from each other and present in the range of 0.383- 2.05% and 0.797- 1.083% respectively. Bran fraction showed a significantly high fat percentage for both raw and parboiled varieties in comparison with other fractions. A significant effect of parboiling was observed on bran fraction and high fat content were found in bran of parboiled varieties, due to the leaching of fat from inner portion of rice to the outer portion. Fat in bran of raw and parboiled rice varieties were found in the range of 13.16 - 21.163% and 17.07- 24.867% respectively. The results obtained were in the range as reported by Singh et al. [29] (2.11- 3.17% for brown rice and 0.61- 0.95% for milled rice), Zhou et al. [38] (2.2%) (brown rice), Hamid et al. [13], 18.9%±o.33 (bran), Otegbayo et al. [21] (0.36% for parboiled, 0.66% for non parboiled white rice and 1.28% for parboiled, 1.29% for non parboiled brown rice) and Heinemann et al. [14] Soponronnarit et al. [30] (0.31-0.47% for parboiled, 0.38-0.60% for non parboiled white rice and 2.53-2.89% for parboiled, 2.37-3.02% for nonparboiled brown rice).

Ash Content. The results regarding mean values of ash are tabulated in Table 2. Statistically data revealed that there was a significant difference observed in six different varieties and in their fractions

In raw brown rice fraction highest ash was observed in super basmati (1.38%) followed by 00515 (1.33%) and 98316 (1.13%) respectively although less ash content was found in KSK434 (0.97%) followed by KSK133 and KSK 282 (1.14%). For raw milled fraction, high ash was analyzed in KSK133 (0.75%) followed by 00515 (0.59%) and 98316 (0.58%) respectively and lowest was observed in KSK434 (0.37%). For raw bran fraction high ash was observed 00515 (10.22%) variety followed KSK434 (10.18%) and 98316 (9.15%) and the lowest was found in super basmati and KSK282 respectively. Parboiling rice fractions exhibited no significant difference in comparison with their raw fractions. In parboiled brown rice highest ash was observed in 98316 and KSK242 (1.17%) while lowest was found in KSK434 (0.93%). For parboiled milled rice high value was found in KSK434 and lowest in 98316 while in parboiled bran maximum value was observed in 00515 and lowest in super basmati.

Ash content of all varieties was significantly differing from each other and was observed in the range of 2.70% 3.84%. Raw brown, milled rice and bran fraction of all varieties was significant with each other with respect to ash. Parboiling demonstrated a non significant effect on ash as their no significant difference was observed.

Less ash content was observed in milled fraction for both raw and parboiled varieties and it was in the range of 0.37-0.75% (raw) and 0.52-0.78% (parboiled). For brown rice fraction it was recorded in the range 0.97-1.38% (raw) and 0.93-1.17% (parboiled). Highest values were found in bran fraction and reported in the range of 6.52-10.22% (raw) and 6.31-9.31% (parboiled). The data demonstrate that maximum amount of minerals are present in outer bran portion that can be used in other product to improve the nutrition [2].

The results obtained were in the range as reported by Otegbayo et al. [21] (0.6% for parboiled, 0.8% for non parboiled white rice and 0.9% for parboiled, 1.00% for non parboiled brown rice), Heinemann et al. [14] (0.49-0.60% for parboiled, 0.32-0.59% for nonparboiled white rice and 0.91-1.46% for parboiled, 1.15-1.29% for non parboiled brown rice), Ajmal et al. [2] (10.66% for defatted rice bran), Zhou et al . [37] (1.4% for brown rice) and Hamid et al. [13] (7.7% for bran).

Effect of parboiling on cooking characteristics

Cooking Time. Data showed that all varieties, their fractions as well as their interaction are significantly differing from each other. The results regarding mean values of cooking time are tabulated in Table 3. The maximum cooking time was found in brown rice fraction of KSK434 (38.33 min) followed by KSK282 (34.67 min) and 98316 (34.33 min) respectively and lowest cooking time was observed in KSK 133 (30.33min) followed by 00515 (33.67 min). In milled fraction maximum time was found in KSK 434 (24.667 min) followed by KSK282 (24.33 min) and KSK133 (20.667 min) respectively. For parboiled brown rice fractions maximum cooking time was observed in coarse variety KSK 424 (36.667 min) followed by KSK 133 and KSK282 having same value (34.667 min). Less cooking time was found in basmati variety 98316 and super basmati (15.667 min) followed by 00515 (16.33 min). For parboiled milled rice fraction maximum time was found in KSK133 and KSK282 (25 min) followed by KSK434 (24 min) and minimum cooking time was observed in basmati varieties.

Table 3. Mean values of cooking time and elongation ratio in milling fractions of Rice

VARIETIES	Cooking Time				Elongation Ratio			
	FRACTIONS				FRACTIONS			
	Un parboiled (min)		Un parboiled (min)		Un parboiled (min)		Un parboiled (min)	
	Brown rice	Milled rice	Brown rice	Milled rice	Brown rice	Milled rice	Brown rice	Milled rice
KSK 133	30.33	24.33	34.67	25.00	1.25	1.41	1.25	1.59
KSK 282	34.67	20.67	34.67	25.00	1.36	1.75	1.18	1.61
KSK 434	38.33	24.67	36.67	24.00	1.26	1.64	1.23	1.67
Super Basmati	33.33	15.67	29.33	17.67	1.20	1.75	1.25	1.76
515	33.67	16.33	29.33	17.67	1.18	1.72	1.21	1.72
98316	34.33	15.67	28.67	17.33	1.23	1.77	1.21	1.93

Cooking time of basmati varieties were non significant with each other and highly significant with coarse varieties. Coarse varieties KSK133 and KSK283 were non significant with each other but significant with KSK434. A significant effect was observed after parboiling. For brown rice fractions parboiling resulted in reduction of cooking time while for milled rice fractions it was responsible for increase in cooking time. The results obtained were in the range as reported by Singh et al. [27] (13-24 min for soaked rice), Tetens et al. [32] (15.42-17.20min for raw and for parboiled rice 20.70-23.05min), Otegbayo et al. [21] (56 min for parboiled, 49 min for non parboiled white rice and 52 min for parboiled, 45 min for non parboiled brown rice) and Kar et al. [17] (22 min for normal parboiled and 15 min for raw rice).

Cooked length breadth ratio

The results regarding mean values of cooked length breadth ratio are tabulated in Table 3. The maximum Cooked length breadth ratio was found in brown rice fraction of 98316 (4.39) followed by super basmati (4.007) respectively and lowest cooked length breadth ratio was observed in KSK 133 (2.413) followed by KSK282 (2.567) and KSK434 (2.63) varieties respectively. In milled fraction maximum length breadth ratio was found in super basmati (5.583) followed by 98316 (5.493) and 00515 (4.913) respectively and less length breadth ratio was found in KSK133 (3.043). For parboiled milled rice fractions high length breadth ratio was found in 98316 variety (5.533) followed by 00515 (4.72) and super basmati (4.527). Less length breadth ratio was observed in coarse variety KSK 434 (4.177) followed by KSK282 (3.76) and KSK 133 (3.71). For parboiled brown rice fractions length breadth ratio was found to be non significant.

Cooked length breadth ratios of all varieties were significant with each other. Brown rice fractions of all varieties possessed less length breadth ratio due to the presence of bran that resist their elongation as well as their width augmentation and also affected their uniformity or symmetry as on heating bran rupture after water absorption. Same trend was observed in parboiled brown rice. While a reduction in length breadth ratio was observed in parboiled milled rice fractions in comparison with raw milled rice fraction. The results obtained were found in the range as reported by Singh et al. [27] (2.78- 4.80).

Elongation Ratio

The results regarding mean values of elongation ratio are tabulated in Table 3. In brown rice fraction the maximum elongation ratio was found in KSK 282 (1.36) followed by KSK434 (1.257) and KSK133 (1.247) varieties respectively and less elongation ratio was observed in 00515 (1.18) followed by 98316 (1.227) and super basmati (1.227) respectively. In milled fraction maximum elongation ratio was found in 98316 (1.772) followed by super basmati (1.75) and 00515 (1.723) respectively and less elongation ratio was found in KSK133 (1.413). For parboiled milled rice fractions high elongation ratio was found in 98316 variety (1.93) followed by super basmati (1.757) and 00515 (1.723). Less elongation ratio was observed in coarse variety KSK133 (1.59) followed by KSK282 (1.613) and KSK 434 (1.673). For parboiled brown rice fractions elongation ratio was found to be non significant with raw brown rice fraction.

Elongation ratio of raw brown rice fraction of all varieties was non significantly different and possessed less elongation ratio due to the presence of bran that resists their elongation in cooking. Same trend was observed in parboiled brown rice. On the other hand raw and parboiled rice fractions showed less significant difference in elongation ratio. In some varieties a reduction in elongation ratio was observed after parboiling. The results obtained were in the range as reported by Vanaja and Babu [34] (1.11- 1.603), Singh et al. [27] (1.29- 1.74), Khatoon and Prakash [18] (1.80-1.94) and Tetens et al. [32] (1.42-1.60 for raw and for parboiled rice 1.46-1.56).

Conclusion

Black tea phytochemicals that contributed towards its cup quality in Pakistan are in close proximity with international market. Difference between the key chemical parameters might be due to the processing technology, fermentation and storage period. The result of recent investigation indicates that tea is a hidden tool for enhancing the human resistance against various ailments. Furthermore, there is a dire need for exploration of its potential that reputized its role as a functional drink that can be applied as a nutraceutical intervention.

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