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SCREENING OF PAKISTANI COARSE RICE CULTIVARS FROM PUNJAB AND SINDH FOR END-USE QUALITY

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Rice (*Oryza sativa L*) is the second largest grown and consumed cereal in Pakistan. Coarse rice cultivars are famous for puffing characteristics; hence mostly used in many puffed or extruded products. The present study was conducted to screen out Pakistani coarse rice cultivars for their end-use quality and value addition by probing various quality attributes. Five coarse rice varieties namely IRRI-9, IRRI-6, KSK-133, KSK-434 and Shadab were milled to obtain brown rice and white rice fractions. The length (7.67mm) and width (2.35mm) was higher in KSK-434 whereas higher thickness (2.05mm) was observed in KSK-133. The highest bulk density (0.93g/cm^3) was observed in IRRI-6 whereas, IRRI-9 showed the lowest (0.88g/cm^3) values. Thousand kernel weight (TKW) was ranged from 15.83 to 20.02g and 18.28 to 22.84g among the milled fractions of white and brown rice, respectively. It was higher in KSK-434 trailed by Shadab, KSK-133 and the lowest values were observed in IRRI-9. Proximate and mineral composition revealed significantly higher contents of these nutrients in brown than that of white rice. The moisture, ash, fiber, protein, fat and nitrogen free extract ranged from 9.23 to 12.26, 0.67 to 3.81, 0.98 to 4.21 and 6.04 to 8.98, 1.23 to 5.45 and 65.87 to 80.28g/100g, respectively among different milling fractions. The amylose content for IRRI-9, IRRI-6, KSK-133, KSK-434 and Shadab were ranged from 27.07 to 28.25, 27.55 to 29.78, 26.48 to 27.96, 26.80 to 28.98 and 29.03 to 30.88%, respectively. With respect to amylose, length, thousand kernel weight and bulk density, higher values were observed in KSK-434 and Shadab. Among the coarse rice cultivars, Shadab showed better amylose and lower protein contents, exhibiting its suitability for extrusion and puffing purposes. Additionally, brown rice fraction of all cultivars should be made part of regular diet due better nutritional values with respect to protein, fiber and mineral contents.
Keywords: Puffed rice, brown rice, white rice, amylose, thousand kernel weight, bulk density.

INTRODUCTION

Rice is one of the most significant produce nourishing more than two billion individuals in Asia. It is the dietary staple of about 50%global population, regardless of lower micronutrient contents (Bhattacharya, 2004). The chief rice producing countries are China, Bangladesh, India, Vietnam and Indonesia. It is the leading source of the calories for rural and urban populations (Sasaki and Burr, 2000). Approximately 80% of daily calorie intake of three billion people is provided by rice. Paddy production in the world amounts to 718.35 million metric tons (MMT), out of which more than 90% production is in Asia (Kumar and Prasad, 2013). Pakistan produces about 6 million tonnes rice each year and together with rest of South Asia, supplying 25% paddy rice of the world (Prasad *et al*., 2010). According to Pakistan Economic Survey 2018-19, rice was cultivated on 2810thousand hectares and its production was 7202thousand tons. It contributes 0.6% of the GDP and 3.0% value added in agriculture. Both fine (40%) and coarse cultivars (60%) are mainly grown in Punjab and Sindh provinces. Super Basmati, Super Kernal, Kainat, Basmati 515, Pk-386, IRRI-6, IRRI-9, KSK-133, KSK-434, KS-282, Shadab and Shua-92 are the major rice varieties cultivated to meet the dietary needs of local population as well as for export especially to the Middle East.

Rice, being rich in carbohydrates, contributes about 60-70% of the daily energy needs and approximately 15% protein requirements of the masses. Seed is fully enclosed by the hull which is removed during milling and yielding "brown rice". In second stage of milling, outer brown layer called "rice bran" is removed to produce "white rice". Rice bran is composed of rice germ and several sub layers. It contains over 60% nutrients of the rice. Rice is source of minerals like Mg, Ca and phosphorus but nutritionally low in protein and micronutrients including Fe, Zn, Mn, cobalt, *etc.*(Oko and Ugwa, 2011). Today with advance technology, rice has emerged as an efficient vehicle for fortification. Rice has been considered the best starchy staple food among all cereal crops that has high biological value, digestibility and protein efficiency ratio due to presence of higher lysine concentration (~ 4%). Rice starch is digested rapidly as compared with starch of other foods like sweet potato. (Frei and Becker, 2003). Rice is extensively used in convenience foods for example puffed, multigrain flakes, breakfast cereals, extruded and popped rice. Cooking and eating properties are generally determined by the characteristics of the rice starch that makes upto 90% of milled rice grain. Other important properties such as amylose content, volume expansion ratio, water absorption ratio and final starch gelatinization temperature also determine cooking and eating qualities of rice (Shabbir *et al*., 2008). The consumers are now more concerned to purchase rice according to its use in diverse food applications. The present study was undertaken to determine suitability of Pakistan coarse rice cultivars for their use in puffed rice-based food products. The information derived will be helpful for the rice products manufacturers, farmers, breeders and policy makers to get quick information about the utilization of coarse rice cultivars in Pakistan.

MATERIALS AND METHODS

***Sample Collection*:** Five Pakistani coarse rice cultivars (IRRI-9, IRRI-6, KSK-133, KSK-434 and Shadab) were obtained from Rice Research Institute, Kala Shah Kaku (Punjab) and Rice Research Institute Dokri (Sindh).

***Milling of Paddy Samples*:** After drying, paddy was dehulled into brown rice using husker (Satake Rice Husker, Tokyo, Japan). Subsequently, brown rice was converted into white rice and co-products through rice polisher (Satake Rice Polisher, Tokyo, Japan). Furthermore, brown and white rice samples were milled through UDY Cyclone Mill (Cyclotec Sample Mill, Tecator, Sweden) to obtain flour for further analysis.

***Analysis of Physical Characteristics*:** The physical characteristics like grain size (length, width and thickness) was measured by using micrometer (Vernier Caliper) and thousand kernel weight (TKW) was recorded in gram by counting 1000 grains and weighing on an electric balance. Bulk density was determined by the ratio of the mass to a given volume (Park, 2001).

***Proximate Composition*:** The rice samples of each cultivar were analyzed individually in triplicate for moisture, ash, crude fiber, crude protein, crude fat and NFE following respective procedures as described in AACC (2000).

***Amylose Content (%)*:** The amylose content in each sample was determined by using Spectrophotometer according to modified method of Juliano (1971) and Hoke *et al.* (2005).For the standard curve, 40mg of potato amylose in 100mL conical flask was wetted with 1mL ethanol and then added 9mL of 1N NaOH followed by heating in boiling water bath for 10 min. Samples were cooled down and volume was made upto 100mL by adding distilled water with a pipette. Afterwards, 1, 2, 3, 4 and 5mL portions were taken with pipette and poured separately in 100mL volumetric flasks and acidified with 1N acetic acid (0.2, 0.4, 0.6, 0.8 and 1.0mL, respectively). Then 2mL of iodine solution was added (0.2g iodine and 2g potassium iodide in 100 mL of aqueous solution) and allowed to stand for 30 min. Absorbance of the solutions was measured at a wavelength of 620nm with a spectrophotometer (Varian AA240, Australia). Absorbance values were plotted against the concentrations (mg) of anhydrous amylose. A straight-line relationship was obtained (Fig. 1). Rice samples were prepared according to the procedure like that of standard solution with some minor modifications and absorbance of each sample solution was measured as described in the preparation of standard curve. The dilution factor 20 for the sample was included in the conversion formula. Amylose content was determined by the following formula and expressed on dry weight basis**:**

Amylose content = Optical density × Slope of the curve × Dilution factor

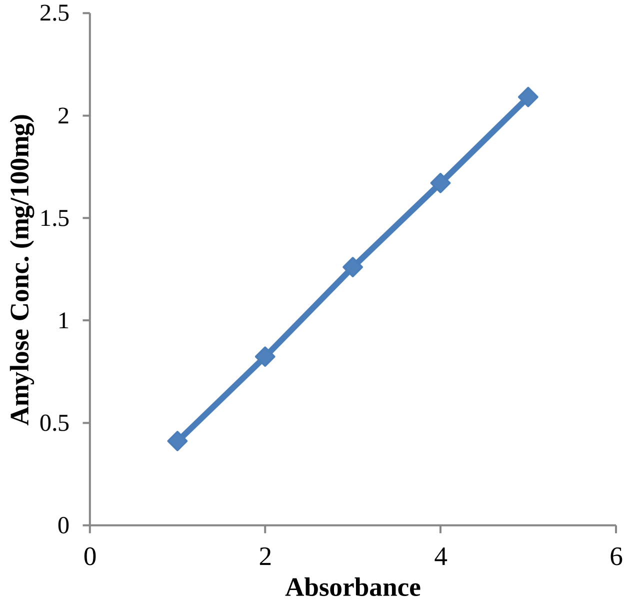

Figure 1. Standard curve for determination of amylose contents

***Mineral Analysis*:** Rice samples were analyzed for sodium (Na), potassium (K), Calcium (Ca), Magnesium (Mg), Manganese (Mn), iron (Fe) and Zinc (Zn) by following the method given by AOAC (2016).

***Statistical analysis*:** The data was evaluated statistically using Completely Randomized Design (CRD) to find out analysis of variance (ANOVA). The significant difference among the means of the treatments ($p \leq 0.05$) were determined using Duncan's Multiple Range test (Steel *et al*. (1997).

RESULTS

***Physical Characteristics*:** The maximum length was observed in brown fraction as compared to white rice. Among the different cultivars, KSK-434 showed highest length (7.67±0.03mm) and width (2.35±0.04mm) whereas the lowest length (6.62±0.04mm) and width (1.76±0.01mm) values were noted in IRRI-6 and IRRI-9, respectively (Table 1) .Means for length showed values ranged from 6.62 to 7.67mm. The highest length (7.67mm) was observed in brown fraction as compared to white rice (7.16mm). Among the different cultivars, KSK-434 showed highest length (7.67mm) followed by Shadab (7.62mm) and KSK-133 (7.46mm) whereas the lowest value (6.62mm) was noted in IRRI-6.

Means for kernel width showed values ranging from 1.76 to 2.35mm. The highest kernel width (2.35mm) was observed in brown fraction as compared to white rice (2.28mm). Among the different cultivars, KSK-434 showed highest width (2.35mm) followed by KSK-133 (2.29mm) and IRRI-6 (2.18mm) whereas the lowest value (1.76mm) was noted in IRRI-9. The results of this instant activity are in close agreement with those reported by earlier investigators with variations depending upon their nature of study.

Means for kernel thickness showed values ranged from 1.61-2.05mm. The maximum kernel thickness (2.05mm) was observed in brown fraction as compared to white rice (1.89mm). Among the different cultivars, KSK-133 showed highest kernel thickness (2.05mm) followed by KSK-434 (1.90mm) and IRRI-9 (1.78mm) whereas the lowest value (1.56mm) was noted in IRRI-6.

Means for bulk density showed it ranges from 0.88-0.93g/cm^3. Higher bulk density (0.93g/cm^3) was observed in white fraction as compared to brown fraction (0.90g/cm^3). Among the different cultivars, IRRI-6 showed the highest bulk density (0.93g/cm^3) for white fraction followed by Shadab (0.88g/cm^3) and IRRI-9 (0.91g/cm^3) whereas the lowest value (0.90g/cm^3) was noted in KSK-133.

The brown rice fraction showed higher thousand kernel weight (TKW) whereas, high bulk density was observed in white fraction. Among the different cultivars, KSK-434 showed highest thousand kernel weight (22.84±0.15g) followed by Shadab (21.92±0.16g) and KSK-133 (20.77±0.18g) whereas the lowest value (15.83±0.04g) was noted in IRRI-9. The TKW of mutant rice varieties cultivated in Sindh was ranged from 1.73-21.1g (Ansari *et al*., 2013). IRRI-6 showed highest bulk density (0.93±0.01g/cm^3) whereas the lowest value (0.88±0.01g/cm^3) was noted in IRRI-9.

***Proximate composition*:** The moisture content varied from 9.23 to 12.26g/100g among rice varieties (Table 2). The highest moisture content was observed in brown fraction as compared to white rice. Among the different cultivars, IRRI-6 showed highest moisture (12.26/100g), followed by IRRI-9 (12.21g/100g) and Shadab (12.09g/100g) whereas the lowest

Table 1. Means for physical characteristics of brown and white rice fractions of different rice cultivars.

Variety	Rice Fraction	Length (mm)	Width (mm)	Thickness (mm)	Bulk density (g/cm$^{3)}$	TKW (g)
IRRI-9	**Brown**	7.18±0.02	1.96±0.03	1.70±0.04	0.88±0.01	18.28±0.03
	White	6.87±0.03	1.76±0.01	1.61±0.00	0.88±0.05	15.83±0.04
IRRI-6	**Brown**	6.80±0.07	2.18±0.05	1.78±0.02	0.90±0.02	19.03±0.02
	White	6.62±0.04	2.12±0.05	1.56±0.04	0.93±0.01	17.53±0.17
KSK-434	**Brown**	7.67±0.03	2.35±0.04	1.90±0.02	0.90±0.02	22.84±0.15
	White	7.25±0.05	2.28±0.02	1.79±0.02	0.91±0.03	20.02±0.07
KSK-133	**Brown**	7.46±0.05	2.29±0.03	2.05±0.05	0.89±0.03	20.77±0.18
	White	7.16±0.04	2.17±0.04	1.89±0.04	0.90±0.01	18.96±0.18
Shadab	**Brown**	7.62±0.01	2.10±0.05	1.66±0.05	0.92±0.01	21.92±0.16
	White	7.18±0.02	1.97±0.03	1.58±0.05	0.92±0.02	19.75±0.22

Note: Values are presented as Means±SD; n=9

Table 2. Means for proximate composition (g/100g) and amylose contents (%)in brown and white rice fractions of different rice cultivars.

Variety	Fraction	Moisture	Ash	Fiber	Protein	Fat	NFE	Amylose content
IRRI-9	**Brown**	12.21±0.05	3.75±0.05	4.21±0.05	8.49±0.02	5.45±0.05	65.87±0.01	27.07±0.01
	White	11.33±0.05	2.36±0.01	1.63±0.02	7.24±0.01	3.51±0.05	73.91±0.04	28.25±0.01
IRRI-6	**Brown**	12.26±0.01	3.46±0.01	3.77±0.05	8.27±0.05	3.78±0.01	68.60±0.02	27.55±0.01
	White	10.25±0.01	1.86±0.05	1.68±0.05	6.73±0.06	2.02±0.01	76.63±0.07	29.78±0.05
KSK-434	**Brown**	11.26±0.01	3.81±0.05	3.21±0.05	8.98±0.01	4.02±0.01	68.70±0.07	26.48±0.01
	White	09.23±0.01	1.88±0.01	0.98±0.05	7.92±0.01	2.06±0.01	77.92±0.02	27.96±0.05
KSK-133	**Brown**	11.03±0.02	1.73±0.05	3.06±0.05	8.28±0.01	2.53±0.07	73.36±0.11	26.80±0.10
	White	10.57±0.01	0.67±0.01	1.08±0.05	6.16±0.01	1.23±0.05	80.28±0.05	28.98±0.01
Shadab	**Brown**	12.09±0.02	2.l0±0.01	3.58±0.01	8.13±0.05	3.57±0.05	68.42±0.02	29.03±0.05
	White	11.06±0.03	1.16±0.01	1.73±0.01	6.04±0.01	1.92±0.05	76.47±0.30	30.88±0.01

Note: Values are presented as Means±SD; n=3 value (9.23g/100g) was noted in KSK-434. The brown fraction had higher moisture content (12.21g/100g) than that of white fraction (11.33g/100g).

The crude protein content (8.98g/100g) was higher in brown fraction as compared to white fraction (7.92g/100g). Among the different cultivars, KSK-434 showed the highest crude protein contents (8.98g/100g) followed by IRRI-9 (8.49g/100g) and IRRI-6 (8.27g/100g), whereas the lowest value (6.04g/100g) was noted in Shadab.

Means for crude fat contents showed values ranged from 1.23 to 5.45g/100g. The highest crude fat content (5.45g/100g) was observed in brown fraction as compared to white rice (1.23g/100g). Among the different cultivars, IRRI-9 showed the highest crude fat content (5.45g/100g) followed by KSK-434 (4.02g/100g) and IRRI-6 (3.78g/100g); whereas the lowest value (1.23g/100g) was noted in KSK-133.

The brown fraction had higher crude fiber content (4.21g/100g) as compared to white fraction (1.08g/100g). Among the different cultivars, IRRI-9 showed highest crude fiber content (4.21g/100g) followed by IRRI-6 (3.77g/100g) and Shadab (3.58g/100g), whereas the lowest value (1.08g/100g) was noted in KSK-434.

The ash contents reveal that the brown fraction had higher ash content (3.81g/100g) as compared to white fraction (2.36/100g). Among the different cultivars, KSK-434 had the highest ash content (3.81g/100g) followed by IRRI-9 (3.75g/100g) and IRRI-6 (3.46/100g) whereas the lowest value (0.67/100g) was noted in KSK-133.

Means for nitrogen free extract (NFE) content showed values ranged from 65.87 to 80.28g/100g. The NFE content in white fraction (80.28g/100g) was higher as compared to brown fraction (68.99g/100g). Among the different cultivars, KSK-133 showed highest NFE value (80.28g/100g) followed by KSK-434 (77.92g/100g) and IRRI-6 (76.63g/100g), whereas the lowest value (65.87g/100g) was noted in IRRI-9.

***Amylose content (%)*:** Means for amylose content showed values ranged from 26.80 to 30.88% (Table 2). The amylose content was higher (30.88%) in white fraction as compared to brown fraction (27.07%). Among the different cultivars, Shadab showed the highest amylose (30.88%) followed by IRRI-6 (29.78%) and KSK-133 (28.98%) whereas the lowest value (26.48%) was noted in KSK-434.

***Mineral analyses*:** Means for sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn), iron (Fe) and zinc (Zn)are given in Table 3. Mean values for Na contents were ranged from 11.27 to 28.10mg/kg. The Na content (28.10mg/kg) was higher in brown fraction as compared to white fraction (14.38mg/kg). Among the different cultivars, IRRI-9 showed highest Na content (28.10mg/kg) followed by IRRI-6 (25.12mg/kg) and Shadab (23.56mg/kg) whereas the lowest value (11.27mg/kg) was noted in KSK-133.

The potassium (K) contents of different rice varieties and rice fractions ranged from 1048.2 to 2786.9mg/kg. The K content of brown fraction was significantly higher (2786.9mg/kg) as compared to white fraction (1048.2mg/kg). Among the different cultivars, IRRI-9 showed the highest K content (2786.9mg/kg) followed by KSK-434 (2534.9mg/kg) and Shadab (2481.0mg/kg) whereas the lowest value (1048.2mg/kg) was noted in IRRI-9.

Means for Ca contents showed values ranged from 135.68-223.90mg/kg. The Ca content (223.90mg/kg) was higher in brown fraction as compared to white rice (135.68mg/kg). Among the different cultivars, Shadab showed the highest Ca content (223.90mg/kg) followed by KSK-133 (218.28mg/kg) and IRRI-6 (213.40mg/kg) whereas the lowest value (135.68mg/kg) was noted in IRRI-9. Ca content in different rice cultivars ranged from 135.68-223.90mg/kg in brown and white fractions of different rice cultivars.

Means for Mg contents showed values ranged from 133.78-785.95mg/kg. The Mg content (785.95mg/kg) was higher in brown fraction as compared to white rice (133.78g/kg). Among the different cultivars, KSK-133 showed highest Mg contents (785.95mg/kg) followed by IRRI-6 (735.88mg/kg) and Shadab (555.06mg/kg) whereas the lowest value (133.78mg/kg) was noted in IRRI-9. Mg content in different rice cultivars was ranged from 133.78 to 785.95mg/kg.

Means for manganese (Mn) contents showed values ranged from 14.45 to 27.16mg/kg. The Mn content (27.16mg/kg) was higher in brown fraction as compared to white rice

Table 3. Means for mineral contents (mg/kg) in brown and white fractions of different rice cultivars.

Variety	Fraction	Na (mg/Kg)	K (mg/Kg)	Ca (mg/Kg)	Mg (mg/Kg)	Mn (mg/Kg)	Fe (mg/Kg)	Zn (mg/Kg)
IRRI-9	**Brown**	28.10±0.23	2786.9±0.91	204.06±0.08	265.84±1.02	24.51±0.03	15.33±0.77	17.05±0.48
	White	14.38±0.22	1048.2±0.25	135.68±0.70	133.78±0.53	16.06±0.05	13.69±0.77	15.05±0.20
IRRI-6	**Brown**	25.12±0.54	2213.9±0.91	213.40±0.54	735.88±0.86	27.16±0.050	21.44±0.17	22.66±0.21
	White	13.15±0.33	1108.0±0.35	145.34±0.46	476.70±0.57	19.45±0.09	19.79±0.85	20.35±0.84
KSK-434	**Brown**	20.54±0.33	2534.9±0.15	212.16±0.75	435.18±0.22	25.01±0.640	13.39±0.15	15.51±0.20
	White	11.99±0.25	1547.7±0.25	140.93±1.05	277.44±0.54	14.45±0.22	11.38±0.25	13.15±0.22
KSK-133	**Brown**	16.84±0.22	2190.6±0.44	218.28±0.42	785.95±0.88	24.40±0.230	14.60±0.25	16.48±0.24
	White	11.27±0.54	1404.6±0.50	149.35±0.54	296.30±0.39	17.61±0.33	12.59±0.87	14.17±0.48
Shadab	**Brown**	23.56±0.74	2481.0±0.12	223.90±0.86	555.06±0.92	26.35±0.080	24.01±0.87	24.00±0.84
	White	13.29±0.23	1828.2±0.29	151.78±0.85	245.73±1.08	18.63±0.24	22.37±0.77	21.69±0.20

Note: Values are presented as Means±SD; n=3

(14.45mg/kg). Among the different cultivars, IRRI-6 showed highest Mn contents (27.16mg/kg) followed by Shadab (26.35mg/kg) and KSK-434 (25.01mg/kg) whereas the lowest value (14.45mg/kg) was noted in KSK-434.

Means for iron (Fe) contents showed values ranged from 11.38 to 24.37mg/kg. The Fe content (24.37mg/kg) was higher in brown fraction as compared to white rice (11.386mg/kg). Among the different cultivars, Shadab showed the highest Fe content (24.01mg/kg) followed by IRRI-6 (21.44mg/kg) and IRRI-9 (15.33mg/kg) whereas the lowest value (14.60mg/kg) was noted in KSK-434.

Means for zinc (Zn) contents showed values ranged from 14.09 to 22.58mg/kg. The Zn content (18.75mg/kg) was higher in brown fraction as compared to white rice (16.88mg/kg). Among the different cultivars, Shadab showed the highest Zn content (24.00mg/kg) followed by IRRI-6 (22.66mg/kg) and IRRI-9 (17.09mg/kg) whereas the lowest value (15.51mg/kg) was noted in KSK-434.

DISCUSSION

The physical characteristics of milled rice are influenced by numerous factors such as types of cultivars, climatic conditions, agronomic practices and degree of milling. The variation in the length of brown and white rice fractions of same cultivars were might be due to slight differences in degree of milling and presence of bran on brown rice. In a study, physicochemical properties and selected quality attribute of mutant rice varieties cultivated in Sindh were investigated. The results revealed variations in kernel length (6.95 to 7.5mm), width (1.8 to 2.5mm) (Ansari *et al*., 2013). Akhtar *et al*., (2007) has noticed 7.07mm length, 2.11mm width and 1.79mm thickness in KSK 133 which is a high yielding, stiff stemmed and extra-long grain coarse rice variety cultivated in Pakistan. Even higher values of kernel thickness (2.53-2.75mm) have been documented by Jouki and Khazaei, (2012) while studying some physical properties of rice seed. Likewise, in another study, cooking and physicochemical properties of five rice varieties produced in Ohaukwu showed differences in kernel length (5.95-7.53mm), width (2.17-2.87mm) (Chukwuemeka *et al*., 2015).The variation in the bulk density of brown and white rice were might be due to the presence of bran on brown rice fraction. The bran is mainly consisting of fiber which is lower in density than that of the rest of the grain. The bulk density of parboiled rice was ranged from 0.72-2-0.82g/mL in brown rice and 0.74-0.82g/mL in white rice fraction (Saeed *et al*., 2011). Likewise, in a study, the effect of milling variables on the selected quality attribute of rice cultivars was assessed. The bulk density of the investigated varieties was ranged from 0.71 to 0.83g/mL (Singh *et al*., 2002).

The proximate composition is affected by the various rice varieties and their milled brown and white rice fractions. The variations in the moisture, crude protein, crude fiber, crude fat, ash and nitrogen free extract of brown and white rice fractions of the same cultivar were might be due to presence of bran which being hygroscopic in nature has the tendency to absorb more moisture, rich in crude fat (bran and germ portion contain more fat as compared to endosperm), fibre (contributed by bran layers), total ash (bran on brown rice fraction contain more minerals) and NFE (brown fraction has high fiber, fat, protein and minerals as compared to white rice which is mainly endosperm). Likewise, differences among the varieties were due to different climatic conditions, and agronomic practices used in different rice growing areas of Sindh and Punjab. In a study, Anjum *et al*., (2007) evaluated different rice varieties and their milling fractions for proximate and mineral composition. The results revealed distinctions among the rice varieties and their fractions with respect to moisture content (9.19 to 11.10%), crude fiber (2.17 to 2.57%), ash (0.54 to 6.04%), and NFE (67.75 to 71.43). In another study, physico-chemical and cooking attributes of different rice cultivars processed through parboiling showed moisture content ranged from 9.39 to 12.84% in white rice and 12.10 to 13.50% in brown rice (Saeed *et al*., 2011). Heinemann *et al*., (2005) studied composition of commercial brown, parboiled and milled rice from Brazil. The findings revealed comparatively high levels of protein (9.70 vs 6.85g/100g) and crude fat (1.29 vs 0.66g/100g) in brown rice fraction.

The variation in the amylose content of brown and white rice of same cultivar was might be due to slight differences in degree of milling and presence of bran on brown rice fraction which contain less amylose as compared to endosperm, whereas differences among the varieties were due to genetic variations. In a study, amylose content in Pakistani rice cultivars was found ranged from 21.6 to 30.7% (Khurram *et al*., 2007). Likewise, in another study, cooking and eating characteristics of rice were investigated by Asghar *et al*.(2012). The amylose content was comparatively high in brown rice (24.14 to 25.31%) than that of white milled rice (22.90 to 26.19%).The amylose in rice is responsible for its puffing attributes. It is comprised of linear chain of glucose molecules which align themselves in the shear fields; hence difficult to pull apart during the extrusion processing (Moraru and Kokini, 2003).

The minerals in white and brown rice fraction were quiet different with significantly higher levels in brown milled rice mainly due to the presence of bran which is rich in ash and minerals (Reddy *et al*., 2017; Mir *et al*., 2017). Likewise, differences among the varieties were due to genetic variations, soil type, water used for irrigation, dissimilarities in climatic conditions and agronomic practices. In a study, mineral profile of selected rice varieties from Pakistan was significantly different with respect to Na (89 to 109mg/Kg), K (2378 to 2794mg/Kg), Ca (825 to 1330mg/Kg), Mg (960 to 1225mg/Kg), and Mn (19.25 - 26.10 mg/Kg), respectively (Zubair *et al*., 2012). Likewise, Shabbir *et al*., (2008) investigated mineral and pasting characterization of different milling fractions of Indica varieties. Among the minerals analyzed, the concentrations of Na, K, and Fe were ranged from 36.3 to 53.9, 1020 to 2290, and 7.7-17.2mg/Kg, respectively. Kennedy *et al*. (2003) during studying nutritional contribution of rice and impact of biotechnology and biodiversity in rice-consuming countries has reported 69.67mg/Kg Ca in white and 263mg/Kg in brown rice. Anjum *et al*. (2007) found Fe content of Pakistani rice varieties ranged from 13.7 to 19.4mg/Kg. The lower mineral contents of brown and white rice fractions in current study compared with those reported by Zubair *et al*., (2012) and Shabbir *et al*., (2008) were might be due to differences in rice cultivars like Super Basmati, Basmati-515, Basmati 198, Basmati-385, Basmati-2000, Basmati-370, Basmati Pak, and KS 282 as well as degree of milling.

***Conclusion*:** Shadab and KSK-434 were found more suitable for the production of puffed rice due to better physiochemical characteristics (more TKW, length and amylose content). Furthermore, brown rice of all coarse rice cultivars has better nutritional quality compared to their white rice because of significant amount of bran portion. The characterization of rice cultivars for en-use quality will be helpful in enhancing the export of rice. Government should devise polices to export more good quality brown rice in those European countries where the people are inclined towards brown rice due to its better nutritional value.

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