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Proximate Composition and Minerals Profile of Selected Rice (*Oryza sativa L.*) Varieties of Pakistan

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Rice (*Oryza sativa L.*) is a staple food cereal that encompasses half of the world's food requirements. Pakistani rice is popular world over due to unique taste and aroma. The present work reports the proximate composition and minerals profile of the selected rice (*Oryza sativa*) varieties: super basmati, basmati 515, basmati 198, basmati 385, basmati 2000, basmati 370, basmati Pak, KSK 133, KS 282 and Irri 6 of Pakistan. Among the varieties tested, the contents (g/100 g) of basic fractions of paddy rice namely rice husk, rice bran and white rice grain varied from 17.02 (basmati 515) to 25.72 (KSK-133), 13.45 (Irri-6) to 19.25 (basmati 370) and 63.88 (basmati 198) to 74.93 (basmati 515), respectively. Moisture and ash contents among the varieties varied from 6.84 to 9.08 % and 1.92 to 1.98 %, respectively. The amount of crude protein, lipids and carbohydrates were found to be within the range of 7.50 to 9.16 g/100 g, 1.92 to 2.72 g/100 g and 0.170 to 0.186 g/100 g, respectively. The content of polysaccharides (starch), the main rice component, was determined to be 76.98 to 79.86 %. Minerals profile as studied by inductively coupled plasma optical emission spectrometry (ICP-OES), showed that the tested varieties of rice mainly contained calcium 825 to 1330 mg/kg, magnesium 960 to 1225 mg/kg, zinc 191 to 319 mg/kg, ferric 186 to 317 mg/kg, copper 13.24 to 16.65 mg/kg, aluminum 59 to 105 mg/kg, manganese 19.25 to 26.10 mg/kg and chromium 10.90 to 24.45 mg/kg. The amounts of sodium and potassium, determined flame photometerically, were noted to be 89 to 109 mg/kg and 2378 to 2794 mg/kg, respectively. The results of the present analysis revealed the tested varieties of Pakistani rice to be a potential source of valuable minerals together with balanced level of other nutrients.

Key Words: Local rice cultivars, Rice lipids, Proximate parameters, Minerals, ICP-OES.

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the largest staple foods valued for human food and nutrition across the world. Almost 50 % people of the world, especially in the Asian countries fulfill their nutritional needs using rice and rice products. According to an estimate more than 2000 varieties of rice are cultivated throughout the world[1,2]. Research revealed that rice is a potential source of functional macro and micro components such as, gluten, starch, fiber, fatty acids, amino acids and vitamins, phenolic acids and ferulic esters[3,4]. Such health promoting constituents of rice can control hypertension, assist in curing cardiovascular diseases, regulate body hormones caused by food imbalance and protect the body from chemical contamination[5].

Total worldwide paddy rice production was estimated to be 680 million tons in 2009. Among the top rice producer countries were China, India and Indonesia with contribution of 26, 20 and 9 % of the world's share, respectively[6-8]. In the recent decade per capita consumption of rice has increased many folds not only in the Asian countries but also in rest of the continents. Currently, the predicted per capita consumption is between 50-80 kg/person per year in Asia, 30, 60 and 60 kg/person per year in South America, Africa and the Middle East, respectively. In Europe and the United States, rice consumption is quite low where every person consumes less than 10 kg per year[9,10].

Paddy rice has to pass through a process known as dehulling before being marketed for commercial uses. As result of the process of dehulling due to removal of outermost protective surface sheath, the hull, of the paddy rice, brown rice is produced. This practice least minimally affects the nutritional value of rice whereas it has great economic potential because the removed hulls are most often used in the paper and silica producing industries. Another process named as debraning or polishing is employed to remove the outer brown layer from the rice kernel (brown rice grain), thus yielding polished rice or white rice.

Although rice is mainly utilized as a staple food due to its high starch contents, however it also contains considerable amounts of available proteins, lipids and mineral elements. It is one of the important cereal grains, containing high-value chemical components and bioactive compounds including phenolic acids (especially ferulic acid), tocopherols (α, β, γ, δ isomers), tocotrienols (α, β, γ, δ isomers), sterols and γ-oryzanol[11]. Rice tocopherols and tocotrienols (vitamin E) are composed of a series of saturated and unsaturated methyl tocols (benzopyranols) that markedly retained in the grain tissues and rice oil. γ-Oryzanol (steryl ferulates) is a major chemical secondary metabolite in addition to primary metabolites found in the rice. Rice lipids (oils) mainly contained 18:1 (oleic acid) and C18:2 (linoleic acid). Other fatty acids present in rice lipids are C14:0 (myristic acid), C16:0 (palmitic acid), C18:0, (stearic acid) and C20:1 (eicosenoic acid)[12].

During polishing, a major portion (80 - 90 %) of the rice vitamin, 60 % of the iron and 50 % of the manganese and phosphorus and a considerable amount of valuable antioxidant compounds is lost as well as it also destroys almost all of the dietary fat and fiber decreasing the overall nutritive value of the rice. It is interesting to note that consumers preferably like de-braned (milled/polished) rice, although it has less nutritive and functional food value due to loss of major amounts of functional components such as fat, vitamins, protein, antioxidants and minerals[13].

Rice is the second largest staple food in Pakistan. After wheat it is the major cash crop contributing to country's economy. Rice crop is cultivated on huge areas mainly in the province of Punjab and Sindh. In the year 2008 - 09, total paddy rice production from Pakistan was estimated to be 6.3 million tons[14]. Rice is usually consumed in polished form (white rice) in Pakistan as there is low demand for brown rice among the people due to lack of awareness of its high nutritional value and health-related beneficial effects[15]. Although, some detailed studies on the nutritional composition of different types of rice have been reported from various regions of the world[16-19] but to the best of our knowledge there is no earlier detailed study so far conducted on the proximate composition and minerals profile of different rice varieties grown in Pakistan. The present work therefore was planned to study the detailed proximate composition and mineral elements of ten commonly cultivated varieties of rice (*Oryza sativa* L.) in Pakistan.

EXPERIMENTAL

Collection and pre-treatment of rice samples: The rice samples were collected in paddy form from rice research centre Kalashahkaku, Lahore, Pakistan. Samples, packed in polyethylene bags, were brought to the laboratory of the Department of Chemistry & Biochemistry, University of Agriculture, Faisalabad, Pakistan. Hot-air dried rice samples, of each variety under testing, were then de-hulled using the laboratory de-hulling machine. After that, the de-hulled rice were divided into two portions: one portion analyzed with out further processing (the brown rice) and the other polished further to get white rice using a laboratory scale machine. The brown and white rice samples were then placed into clean plastic bags and labeled and stored in a clean, dry place at 20 ºC.

All the chemicals used were of analytical grade from Merck (Darmstadt, Germany) or Sigma Chemicals Co. (St, Louis, MO, USA). These included *n*-hexane, sulphuric acid, nitric acid, sodium hydroxide, hydrogen peroxide, hydrochloric acid, boric acid, mix indicator, standards of minerals, *etc*.

Oven (IM-30, Irmeco, Germany), Desiccators, Muffle Furnace TMF-2100 (EYELA), Steam Water Bath (SB-651, Japan), Soxhlet Extractor (Behr Labor Technik), Hot Plate (PC101, Corning), UV-VIS Spectrophotometer (U-2001, Hitachi Instruments Inc. Tokyo, Japan), high performance liquid chromatography HPLC (LC-10A, Shimadzu, Japan), Digestion apparatus (Digestion system KI 9/16 Science Direct USA), Distillation assembly (Digestion System EV-14 Science Direct USA), Flame photometer (Perkin-Elmer model No. 52-A), Inductively coupled plasma optical emission spectroscopy (ICP-OES) (Profile plus 2005 Leeman-Lab-USA), Milling machine (McGill Mill #1), Centrifuge machine (Beckman J20XP, Beckman Scientific) and Rotary vacuum evaporator (EYELA, N-N Series, Rikakikai Co. Ltd. Japan) were used through out the study.

Proximate composition of rice: The determination of proximate parameters was carried out using standard methods[20]. Moisture content of rice was estimated by drying the samples in an oven at 105 ºC until constant weight achieved. Ash contents were determined by muffle furnace and crude proteins by micro-Kjeldahl, apparatus[21]. Rice lipids were extracted using soxhlet apparatus. Briefly, 250 g of ground material (80 mesh) for each rice variety was placed in a Soxhlet extractor fitted with a 1-L round bottomed flask and a condenser. The extraction was performed on a water bath for 6 h with 0.50 L *n*-hexane as extracting solvent. After the oil extraction, the excess solvent was distilled off under reduced pressure in a rotary evaporator (EYELA, N-N Series; Rikakikai Co Ltd., Tokyo, Japan).

Minerals composition after digestion of samples: Analysis of the minerals of rice was carried out with inductively coupled plasma optical emission spectrometer (ICP-OES) after digestion with nitric acid. For this purposes, approximately 2.0 g of dehulled rice grain powder was weighed accurately and transferred into a digestion flask, to this 5.0 mL nitric acid HNO_3 (conc.) was added. The flasks were subjected to preliminary digestion by heating on a heating chamber at temperature of 80 - 90 ºC for about 2 h. The temperature was then raized to 170 - 180 ºC and during this second phase of heating 3-5 mL of each of the hydrogen peroxide (H_2O_2) and sulphuric acid (concentrated) were occasionally added and heating continued untill the whole organic matter completely digested/oxidized.

The digested material was then transferred to a 50 mL measuring flask and the volume made up to the mark with deionized water. The analytical solutions thus obtained were analyzed by inductively coupled plasma optical emission spectroscopy (ICP-OES). The concentration of sodium and potassium was determined using flame photometer. Primary standard solutions of Na, K, Mg, Ca, Fe, Mn, Zn, Cu, Al and Cr, were prepared and diluted successively to obtain required series of solutions for construction of standard calibration curve. The operational parameters for ICP-OES instrumental analysis are given in Table-1.

Analysis of carbohydrates: For the analysis of total free carbohydrates of rice, 2 g of finely ground rice flour was extracted with a mixture of water/ethanol (3:2 v/v) for 2 h. The mixture was then centrifuged at 5000 × g, using ultra centrifugation machine (Beckman J20XP, Beckman Scientific). The supernatant thus obtained was filtered with 0.45 micron filter paper. From the filtered sample 0.5 mL was taken into a test tube; to this 0.5 mL of 5 % phenol solution was added and finally 2.5 mL conc. sulphuric acid was added. The contents of the test tube were vigorously shaken for thorough mixing and the total soluble sugars were determined colourimetrically by recording the absorbance at 480 nm using a UV-VIS spectrophotometer. Standard curve of glucose was used for calculations purposes[22].

TABLE-1
CONDITIONS FOR ICP-OES INSTRUMENTAL ANALYSIS

Parameter	Specification
Power	1.1 Kw
Cups per second	60
Align Wavelengths	Quick
Pump Flow Rate	1.5 mL/min
Plasma	On
Rinse Time	01 min
Gas Flow	
Auxiliary	0.8 L/min
Coolant	17 L/min
Nebuliser	50 PSI

Analysis of monosaccharides and disaccharides was carried out using high performance liquid chromatography. The supernatant (ethanol extract) was distilled off under reduced pressure to remove ethanol and the residue obtained were dissolved in 0.4 M sulfuric acid. The solution obtained was filtered through 0.25 micron filter paper before analysis by HPLC system equipped with a refractometer detector (waters 410). For separation purposes, a 20-µL sample was injected into a 300 × 7.8 mm reversed-phase column (ION-300, Interaction Chromatography Inc., San Jose, CA), maintained at 24 ºC by a temperature controller (waters). A diluted (17 mM) sulfuric acid solution was used as a mobile phase at a flow rate of 0.4 mL/min. Pure standards of soluble sugars were used for the identification and quantification purposes following the method as described by Perez, *et al.*[23].

Statistical analysis: Three different samples for each rice variety were assayed and each sample was analyzed individually in triplicate. The data is reported as mean ± SD for (n = 3 × 3). Analysis of variance (ANOVA) was applied using STATISTICA 5.5 (Stat Soft Inc, Tulsa, Ok, USA) software and a probability value of $p = 0.05$ was considered to denote the statistical significance difference.

RESULTS AND DISCUSSION

Main rice fractions and proximate composition: The paddy rice were evaluated for the primary fractions namely husk, bran and white rice. Fig. 1 illustrates the compositions of three main fractions (g/100 g) of rice varieties tested. Among the varieties tested the value of husk ranged from 17.02 (basmati 515) to 25.72 (KSK-133), bran 6.58 (KS-282) to 11.07 (basmati 385) and white rice 63.88 (basmati 385) to 74.93 (basmati 515). The proximate parameters analyzed for the selected varieties of rice are presented in Table-2. Moisture content of whole brown grain was ranged from 6.84 g/100 g (basmati super) to 9.02 g/100 g (KSK133), whereas ash content varied from 1.48 g/100 g (basmati 370) to 1.98 g/100 g (basmati super). Analysis of the brown rice showed higher contents of starch (79.43 g/100 g) in Irri-6 and lower value (76.98 g/100 g) in basmati 385. Crude protein and lipid contents among the rice varieties tested were found to be 7.50 to 9.16 g/100 g and 1.96 to 2.72 g/100 g, respectively.

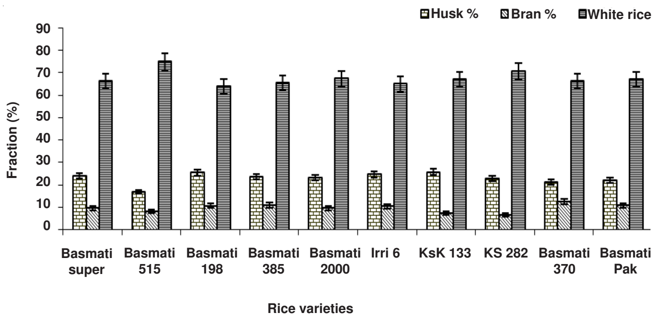

Fig.1 Different fractions of rice grain

Aleuronic and subaleuronic parts of rice are rich in protein and lipid fractions. Rice protein comprises mainly a size of 0.5 to 4 µm throughout the rice structure[24], where as crystalline proteins (spherical protein) lies in the subaleuronic part. Some previous studies reported that rice may contain upto 15 % protein[25-27]. The amounts of the crude fiber were determined to be 0.71 to 0.92 g/100 g in rice. Abdul-Hamid and Luan[26] studied the dietary fiber properties of rice by product (Bran) and identified that rice bran is a good source of fiber and can be used as a viable therapeutic additive in various functional foods. Some other studies also suggest that use of fiber

TABLE-2
PROXIMATE COMPOSITION (g/100g) OF DEHULLED RICE GRAIN OF SELECTED VARIETIES OF RICE

Variety	Moisture	Ash	Protein	Lipids	Crude fiber	Simple sugars	Starch
Basmati Super	6.84 ± 0.31^{a}	1.98 ± 0.07^{b}	9.10 ± 0.43^{b}	2.06 ± 0.09^{ab}	0.87 ± 0.02^{c}	0.17 ± 0.08^{a}	78.91 ± 1.21^{a}
Basmati 515	8.68 ± 0.32^{cd}	1.97 ± 0.05^{b}	7.91 ± 0.22^{a}	2.26 ± 0.12^{b}	0.82 ± 0.03^{b}	0.18 ± 0.07^{a}	78.18 ± 2.23^{a}
Basmati 198	8.45 ± 0.21^{c}	1.90 ± 0.05^{b}	7.70 ± 0.34^{a}	2.36 ± 0.19^{b}	0.85 ± 0.03^{bc}	0.18 ± 0.04^{a}	78.56 ± 1.11^{a}
Basmati 385	8.30 ± 0.20^{c}	1.98 ± 0.06^{b}	9.14 ± 0.31^{b}	2.70 ± 0.09^{c}	0.71 ± 0.03^{a}	0.20 ± 0.05^{a}	76.98 ± 2.87^{a}
Basmati 2000	8.22 ± 0.16^{c}	1.96 ± 0.05^{b}	7.70 ± 0.38^{a}	2.14 ± 0.08^{b}	0.89 ± 0.03^{c}	0.18 ± 0.06^{a}	78.92 ± 2.56^{a}
Irri 6	8.19 ± 0.18^{c}	1.86 ± 0.07^{b}	7.50 ± 0.24^{a}	2.06 ± 0.08^{ab}	0.81 ± 0.03^{b}	0.18 ± 0.06^{a}	79.43 ± 1.19^{a}
KSK 133	9.08 ± 0.22^{d}	1.94 ± 0.06^{b}	7.52 ± 0.26^{a}	2.04 ± 0.09^{ab}	0.88 ± 0.02^{c}	0.18 ± 0.03^{a}	78.43 ± 1.32^{a}
KS 282	9.02 ± 0.31^{d}	1.95 ± 0.05^{b}	7.75 ± 0.20^{a}	2.17 ± 0.11^{b}	0.79 ± 0.02^{b}	0.18 ± 0.05^{a}	78.19 ± 2.57^{a}
Basmati 370	7.62 ± 0.25^{b}	1.48 ± 0.05^{a}	8.75 ± 0.23^{b}	2.72 ± 0.09^{c}	0.89 ± 0.03^{c}	0.18 ± 0.07^{a}	78.37 ± 1.73^{a}
Basmati Pak	6.99 ± 0.20^{a}	1.92 ± 0.04^{b}	9.16 ± 0.26^{b}	1.92 ± 0.07^{a}	0.92 ± 0.03^{c}	0.17 ± 0.05^{a}	78.92 ± 2.45^{a}

Values are mean ± SD for three samples of each variety, analyzed individually in triplicate
Small superscripts letters with in the same column indicate significant differences ($p < 0.05$) of means among rice varieties

TABLE-3
ICP-OES ANALYSIS OF MINERALS IN DIFFERENT VARIETIES OF DEHULLED RICE GRAIN

Variety	Na	K	Mg	Ca	Zn	Fe	Cu	Al	Mn	Cr
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Basmati Sup.	101 ± 2^{b}	2395 ± 88^{a}	960 ± 44^{a}	860 ± 39^{a}	319 ± 9^{e}	301 ± 16^{d}	14.60 ± 0.50^{b}	103 ± 3.0^{e}	26.1 ± 0.86^{d}	20.70 ± 0.53^{c}
Basmati 515	92 ± 3^{a}	2488 ± 97^{a}	1021 ± 50^{a}	945 ± 34^{b}	257 ± 12^{cd}	186 ± 8^{a}	13.24 ± 0.42^{a}	74.5 ± 2.8^{c}	24.0 ± 0.95^{c}	19.15 ± 0.64^{b}
Basmati 198	104 ± 4^{b}	2519 ± 107^{ab}	1235 ± 43^{c}	1330 ± 42^{e}	191 ± 7^{a}	193 ± 7^{a}	14.75 ± 0.52^{b}	71.5 ± 1.5^{c}	24.5 ± 0.75^{c}	20.20 ± 0.66^{bc}
Basmati 385	97 ± 3^{ab}	2378 ± 93^{a}	1225 ± 52^{c}	1175 ± 37^{d}	210 ± 9^{b}	197 ± 7^{a}	14.45 ± 0.48^{b}	70.5 ± 1.4^{c}	29.8 ± 0.97^{e}	19.45 ± 0.56^{b}
Basmati 2000	102 ± 5^{b}	2794 ± 111^{b}	1075 ± 39^{b}	1190 ± 40^{d}	263 ± 14^{d}	256 ± 9^{c}	12.61 ± 0.46^{a}	82.5 ± 2.2^{d}	20.9 ± 0.88^{b}	18.45 ± 0.71^{b}
Irri-6	89 ± 3^{a}	2629 ± 126^{b}	1065 ± 41^{b}	825 ± 41^{a}	231 ± 11^{c}	226 ± 11^{b}	13.25 ± 0.44^{a}	59.0 ± 1.0^{a}	21.5 ± 0.54^{b}	20.55 ± 0.63^{bc}
KSK-133	93 ± 2^{a}	2423 ± 109^{a}	1040 ± 49^{ab}	1005 ± 36^{b}	239 ± 8^{c}	236 ± 5^{b}	14.15 ± 0.49^{b}	82.5 ± 1.7^{d}	20.5 ± 0.69^{ab}	19.35 ± 0.68^{b}
KS-282	98 ± 1^{ab}	2501 ± 91^{ab}	1040 ± 48^{ab}	1175 ± 32^{d}	321 ± 17^{e}	317 ± 9^{d}	15.60 ± 0.33^{c}	105 ± 2.6^{e}	22.2 ± 0.73^{b}	10.90 ± 0.55^{a}
Basmati 370	109 ± 4^{c}	2791 ± 110^{b}	1190 ± 40^{bc}	1065 ± 25^{c}	264 ± 13^{d}	253 ± 12^{c}	14.45 ± 0.43^{b}	73.5 ± 2.0^{c}	24.3 ± 0.75^{c}	24.45 ± 0.51^{d}
Basmati Pak	107 ± 4^{c}	2677 ± 114^{b}	1195 ± 47^{bc}	995 ± 33^{b}	201 ± 10^{ab}	191 ± 5^{a}	16.65 ± 0.45^{d}	63 ± 1.2^{b}	19.3 ± 0.57^{a}	22.80 ± 0.65^{c}

Values are mean ± SD for three samples of each variety, analyzed individually in triplicate
Small superscripts letters with in the same column indicate significant differences ($p < 0.05$) of means among rice varieties

containing functional foods exhibit beneficial effects against lethal diseases, such as cardiovascular, diverticulosis, diabetes and colon cancer[28-33]. According to a previous study rice was investigated as a potential source of fiber and carbohydrates, protein and lipids. It was reported that increase in fiber content in rice may improve the human health by lowering the plasma cholesterol Varo *et al.*[34]. Proximate composition of Nigerian rice analyzed by Ibukun[33] revealed the presence of moisture 13.11-13.65 %, fat 1.47-1.84 %, protein 5.60- 8.86 %, crude fiber 1.02-1.76 %, ash 1.15-2.76 % and carbohydrates 73.63-76.74 %. Another study conducted by Heinemann *et al.*,[34] on proximate profile of different Brazilian rice depicted the contents of moisture 9.53-13.50 %, fat 2.37-3.02 %, protein 6.34-7.42 % and ash 0.91-1.46 %. Abdulaziz and AI-Bahrany[35] analyzed proximate parameters of some rice varieties and reported some what different values for carbohydrates and crude protein with amounts varying between 75.38 and 77.88 % and 9.24 and 4.68 %, respectively.

Mineral composition: Minerals, both macro and micro such as Na, K, Mg, Ca, Zn, Fe, Cu, Al, Mn and Cr are considered essential and important in the biological systems due to their potential role in regulating the body functions. It has been reported that different rice genotypes contain differing concentrations of minerals[36]. Nutritionally important elements for example zinc, copper and manganese, which have considerable contribution, fall within the range of 6-35 % of the recommended dietary allowance (RDA), depending on the rice form, whereas, the minerals required in higher proportion such as potassium, phosphorous and iron, provide 4 % of the recommended dietary allowance[37].

Pakistani rice varieties were investigated for minerals profile using ICP-OES (operating conditions are given in Table-1). The results of mineral analysis of selected varieties of rice are shown in Table-3. The content of sodium in basmati 370 was found to be highest *i.e.*, 109 mg/kg whereas lowest 89 mg/kg in irri-6. The concentration of potassium, ranged from 2378 mg/kg (basmati 385) to 2794 mg/kg (basmati 2000) was found to be higher among the minerals investigated. Both of the given electrolytic minerals play an important role in reducing blood pressure. It is suggested that increased potassium intake and reduction in sodium, especially in the form of cooking salt, in the diet are needed for the control of hypertension[38]. It is recognized that in most of the developing countries, hypertension is a major public health concern and dietary balance of Na and K in could be used to maintain and control blood pressure-related health issues[39].

The content of magnesium, another important mineral, was found to be in the range of 960 mg/kg in basmati super to 1235 mg/kg in basmati 385. After, magnesium, calcium, with contribution of 825 mg/kg (Irri-6) to 1330 mg/kg (basmati 198) was another important mineral determined. The content of zinc, a micro mineral, was highest (319 mg/kg) in basmati super and least (191 mg/kg) in basmati 198. The amount of iron, a very essential part of blood protein hemoglobin and also participates in some other body functions *e.g.* regulation of hormones and homeostatic conditions of body, was found to be in the range of 186 mg/kg (basmati 515) to 317 mg/kg (KS-282). Copper was noted to be at levels of 12.61 mg/kg in basmati 2000 to 16.65 mg/kg in basmati Pak. Aluminum, also contained a considerable proportion in the mineral profile of rice varieties tested with its amount varying from 59.0 mg/kg Irri-6 to 103 mg/kg in basmati Pak. The content of manganese was varied over 19.3 mg/kg (basmati Pak) to 29.9 mg/kg (basmati 385) while that of chromium 18.45 mg/kg in basmati 2000 to 24.25 mg/kg in basmati 370. Anjum *et al.*[40] estimated some coarse varieties of Pakistani rice and their milling fraction for mineral composition and reported the values of iron, zinc, manganese and copper notably higher in milled rice. Present minerals composition of Pakistani rice varieties was somewhat comparable with the minerals profile of Australian rice as studied by Batten *et al.*[41] minerals composition of Pakistani rice was also observed to be fairly similar to those investigated for Vietnam's rice varieties as analyzed by Phoung *et al.*[42].

Carbohydrates: Carbohydrates of rice play a key role in regulating body functions, production of serotonin (mood-elevating neurotransmitter) in the brain[43]. Rice carbohydrates show moderate level of glycemic index (GI) value, which is an important indicator for individuals who are conscious towards controlling glycemic index lifestyle[44]. The tested varieties of rice in the present work were analyzed spectrophotom-eterically for total soluble carbohydrates/sugars. While the analysis of individual sugars *i.e.*, glucose, sucrose and fructose was performed using high performance liquid chromatographic technique. The results of total soluble carbohydrates/sugars are presented in Table-2, showing the amounts varying from 0.17 g/100 g (basmati super, basmati Pak) to 0.20 g/100 g (Basmati 385). As far as is concerned about the presence of three individual carbohydrates, the tested varieties of rice mainly consisted of sucrose followed by fructose and glucose (Table-4) with contribution of 0.43-0.75, 0.14-0.48 and 0.08-0.20 mg/g, respectively. Overall, the sum of the amounts of three individual carbohydrates was found to be highest 1.36 mg/g in basmati 515 and lowest 0.540 mg/g in Irri-6 type of rice. It is evident that basmati rice have reasonable amount of sugars. Cao *et al.*[45] studied rice flour for simple carbohydrates sucrose, glucose and fructose and reported the values of these components within the range of Pakistani rice varieties as determined in the in the present research work.

TABLE-4
INDIVIDUAL CARBOHYDRATES OF DIFFERENT VARIETIES OF DEHULLED RICE GRAIN

Variety	Glucose (mg/g)	Sucrose (mg/g)	Fructose (mg/g)	Total
Basmati Super	0.20 ± 0.04^b	0.75 ± 0.03^c	0.40 ± 0.01^d	1.35 ± 0.06^d
Basmati 515	0.19 ± 0.05^b	0.69 ± 0.02^{bc}	0.48 ± 0.02^e	1.36 ± 0.07^d
Basmati 198	0.20 ± 0.03^b	0.66 ± 0.03^{bc}	0.23 ± 0.02^b	1.09 ± 0.04^c
Basmati 385	0.18 ± 0.04^b	0.43 ± 0.02^a	0.25 ± 0.02^b	0.86 ± 0.04^b
Basmati 2000	0.11 ± 0.03^a	0.73 ± 0.03^c	0.28 ± 0.01^b	1.12 ± 0.05^c
Irri 6	0.08 ± 0.03^a	0.47 ± 0.02^a	N.F	0.55 ± 0.03^a
KsK 133	0.10 ± 0.02^a	0.59 ± 0.02^b	0.14 ± 0.03^a	0.83 ± 0.04^b
KS 282	0.09 ± 0.02^a	0.62 ± 0.02^b	0.35 ± 0.02^c	1.06 ± 0.04^c
Basmati 370	0.19 ± 0.04^b	0.64 ± 0.03^b	0.41 ± 0.02^d	1.24 ± 0.05^d
Basmati Pak	0.12 ± 0.02^a	0.73 ± 0.03^c	0.43 ± 0.02^d	1.28 ± 0.06^d

N.F: not found; Values are mean ± SD for three samples of each variety, analyzed individually in triplicate; Small superscripts letters with in the same column indicate significant differences ($p < 0.05$) of means among rice varieties.

Conclusion

It could be concluded from the findings of the present study that Pakistani rice varieties are a potential source of valuable minerals, especially the electrolytic minerals such as sodium and potassium and other micro minerals including iron and zinc which play a key role in marinating physiological and biochemical process of the body. Similarly, presence of appropriate amounts of lipids, proteins and crude fiber and sugars suggests the functional food potential of these local rice cultivars.

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