A Comparative Study on Proximate and Micronutrient Composition of Various Varieties of Rice Produced in Punjab, Pakistan

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ABSTRACT

The present work aims to assess and compare the nutritional composition of the indigenously produced samples of Basmati Pak, Basmati KS 282, Super Basmati, Organic Brown Rice, 1121 Kainat Sella Rice (parboiled), Super Kernel (parboiled). The proximate analysis of macronutrients and micronutrients (Thiamine, Riboflavin Niacin, Fe, Ca, and Zn) was conducted according to AOAC, 2005 and AOAC, 2008 official methods respectively. The results showed that protein (N×5.7), crude fiber and ash contents were found to be highest in the Organic Brown rice, while the fat content was similar in all rice types. The highest moisture and protein content was found in Super Kernel Rice. Basmati Pak had the lowest percentage of moisture and ash, Super White Basmati had the least amount of protein and crude dietary fiber while the lowest percentage of fat was found in BasmatiKS 282. In terms of micro-nutrients, Super Kernel Rice showed to have a higher content of Thiamin,Riboflavin, and Niacin as compared to the rest of the varieties. 1121 Kainat Sella Rice had the highest contents of Ca. Organic Brown Rice was found to have the highest level of Fe and Zn. The significantly lower levels of Thiamin and Riboflavin were found in Basmati Pak and lowest level of Niacin was found in Super Basmati. Similarly Basmati Pak had the lowest level of Ca and Zn while Kainat Sella Rice (parboiled) had the lowest levels of Fe content. The nutritional composition data suggests that some nutrients are present in one variety of rice while others are present in another variety. Basmati Pak variety had least amount of nutrients. The information obtained from this research may be of interest to food manufacturers and consumers for acknowledging the compositional variation in indigenous rice varieties.

***Key Words:** Basmati Pak, Basmati KS 282, Super Basmati, Organic Brown Rice, 1121 Kainat Sella Rice (parboiled), Super Kernel (parboiled) Rice, proximate analysis*

1. INTRODUCTION

Rice is extensively consumed as a staple food by large proportion of the population, across the world, especially in Asia and it is the third produced crop worldwide after sugarcane and maize (Varnamkhasti et al., 2008). Rice is the seed of grass species *Oryza Sativa* (Asian rice) or *Oryza Glaberrima* (African rice). It is generally considered a semi-aquatic annual grass plant. Rice providesaround 21% of global human per capita energy, 15% of per capita protein, Brown Rice good sourceof fiber, B complex vitamins, and also some minerals (Varnamkhasti et al., 2008).

Rice endosperm cells are thin-walled and are packed with amyloplasts which are polyhedral starchgranules. The outermost subaleurone layers are rich in protein and lipid and have smaller amyloplasts and compound starch granules than the inner endosperm (Sharif, Butt, Anjum, & Khan, 2014).

Protein is mainly distributed throughout the endosperm as crystalline protein bodies and small spherical protein bodies (Banerji, Birol, Karandikar, & Rampal, 2016). Rice has a negligible amount of proteins such as albumin, globulin, and prolamin, and most parts of the proteins consist of glutelin (Ju *et al.* 2001). The protein percentage is highest in embryos, less in bran, and least in milled rice. Rice also has a significant amount of unsaturated fatty acids, accounting for up to 80 %, which causes the liquid consistency of the oil. Due to its high level of unsaturation, rice bran oil is known to have blood cholesterol-lowering effects. After carbohydrate, protein is the second most abundant constituent of rice (Mancini et al., 2015). Rice is a good source of insoluble dietary fiber which is most abundant in the bran layer. Brown rice has a considerably high percentage of dietary fiber (2.4 gm) as compared to polished rice (Kahlon, 2009).

The highest percentage of B vitamins are resent in bran and lowest in the aleurone layers. Rice is a good source of B vitamins, thiamine, riboflavin (Ndolo, 2013). The milling process results in considerable loss of these vitamins. Most of the riboflavin, thiamin, and niacin content of whole brown rice is retained if the rice is steamed

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(parboiled) before milling. Brown rice is a usually highercontent of these vitamins as compared to the milled varieties (Kyritsi, Tzia, & Karathanos, 2011).

Milled Rice is not a very good source of calcium than other minerals (Zubair, Anwar, Ali, & Iqbal, 2012). however whole brown rice and degermed brown rice and short-grained brown rice have a higher percentageof minerals such as Ca, Zn, Fe, Cu, and Mn (Verma & Srivastav, 2017).

Pakistan is the 10th largest producer of rice and it important for the national economy and foreign exchange earnings producing 7600 thousand metric tons (USDA Foreign Agricultural Service, 2018). Around 2 million tons of rice are produced yearly for local use in Pakistan (Tariq & Iqbal, 2010). Punjab is the leading contributor and producer in Pakistan's total output of rice production 3.17 million tons (Wakil, Riasat, & Lord, 2013). Themost popular variety of rice in Central Punjab is Paddy rice, Basmati 370, Basmati 385, brown rice, Basmati Pak, Sella, Super kernel basmati, Kainat basmati, and Broken rice (Memon, 2013).

The present study aims to find out the proximate nutritional composition of various varieties of indigenously grown rice along with a special emphasis on crude protein, crude fat, carbohydrate, ash content, crude fiber, lignin, cellulose, and micro-nutrients like B-complex vitamin (Thiamine, Riboflavin, and Niacin) content and mineral (Iron, Calcium, and Zinc) content. The daily diet is deficient in calcium and due to processing, it also became deficient in B-Vitamins (Abbas et al., 2011). The knowledge obtained from this analysis may be helpful to consumers and suppliers regarding the nature of the identified pigmented rice varieties in terms of nutrient composition. The present study may ultimately lead to a better acknowledgment of pigmented rice and assist food processors in selecting rice varieties with unique features for specialty food preparations. (Jayaraman, Uluvar, Khanum, & Singh, 2019).

2. MATERIALS AND METHODS

2.1. Study Design

Randomized block design with three replications was adopted for comparing the nutritionalcomposition of various varieties of rice procured from indigenous sources (Punjab, Pakistan).

2.2. Sample Collection

Six varieties of indigenous rice (Basmati Pak, Basmati KS 282, Super Basmati, Organic Brown Rice, 1121 Kainat Sella Rice (parboiled), Super Kernel (parboiled)) were selected. Samples were collectedfrom The National Seed Council (NSC) Pakistan.

2.3. Sample Treatment

The samples were cleaned manually for the complete removal of any foreign material, immature seeds, and damaged grains. After cleaning, samples were stored in clean airtight polythene bags forlater use.

2.4. Place of Experimental Work

The research work was conducted in The Institute of Chemistry University of the Punjab Lahore andPakistan Council of Science & Industrial Research (PCSIR) Laboratories Lahore. Micronutrient analysis for zinc, iron, calcium, thiamin, riboflavin, and niacin estimation was done in The Laboratory of Rice Research Center Kala Shah Kaku according to the methods described in AOAC, 2008 Edition.Evaluation of Biochemical Properties (Proximate Analysis)

The proximate analysis consisted of the estimation of moisture, fat, protein, ash, fiber, lignin, and cellulose in the sample. Selected micronutrients (B vitamins -Thiamin, Riboflavin, Niacin and Minerals-Iron, zinc, and Calcium) were also determined. All estimations were conducted in the triplicate sample from the same source to ensure the accuracy of the results. Protocols described byAOAC, 2005 and 2008 were used for analysis.

2.5. Macronutrient, Ash, and Fiber Estimation

Following methods were used for estimation of macronutrient composition: moisture by over- drying method, ash content by muffle furnace ignition, crude fat by soxhlet method, nitrogen content by Kjeldahl's digestion method, and crude fiber by acid-base degradation (AOAC, 2005).

2.6. Lignin and cellulose content

2.6.1. estimation Lignin Content

The lignin was estimated through the official methods of AOAC (AOAC 1990 & Calixto et al. (1983). A defatted 1.0 g sample was taken in a reflux flask, 70 ml of 1.25% H2So4 was added and was refluxed for 2 hours. The

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solution was then washed with hot water until it was neutralized. Afterward, it was washed with chloroform. The sample was shifted to a beaker, 20ml of 72% H2SO4 was added and was heated on a hotplate using a magnetic stirrer for 4 hours. The resulting samplewas then diluted with 10ml of distilled water and filter through Whatman filter paper No1. After this, the residue was put in the muffle furnace at 500 ºC and heat for 2 hours till it changes into ash.

The percentage of Lignin was calculated as:

Percentage of Lignin= wt. of the digested sample- wt. of ash x 10 Total wt. of the sample

2.7. Estimation of Cellulose

For the estimation of Cellulose 15 ml of 80% conc. Acetic acid and 1.5ml of conc. HNO3 was added in a reflux flask containing 1.0 gm of a sample. The sample was heated on low flame for 20 minutes, filtered through synthetic silk cloth, washed with hot distilled water until it was neutralized. After which it was washed with alcohol and filtered through the Whatman filter paper and dried over- night. The next morning it is weighed. It was then taken in a pre-weighed crucible and placed in theMuffle Furnace at 550 ºC for 6 hours.

Percentage of Cellulose was calculated as; Cellulose content= wt. of biomass – wt. of ash

Percentage of Cellulose= wt of cellulose content /wt. of biomass x100 (Rosa, Rehman, de Miranda, Nachtigall, & Bica, 2012; Sun, Sun, Su, & Sun, 2004).

2.8. Micronutrient content

2.8.1. estimation Iron and Zinc

The following steps were followed to determine the amount of iron and zinc in all of the different samples. 10 grams of sample was weighed and dried in the drying oven. Out of this sample, 1 gramof sample was weighed. 25 ml of nitric acid + perchloric acid (2:1) was added to the sample and placed in the digestion tube. The sample was digested at 150-175°C until the clear liquid was obtained.

Digestion tubes were placed in the fume hood and 2ml of hydrogen peroxide was added to the sample. Digestion tube was placed in the digestion block for 8 to 13 hours at 700°C. The digestion sample was cooled overnight. Distilled water was added to the sample so that its volume became 50ml. The solution was filtered through filter paper so that any undigested or undissolved particle left in the solution may not block the capillary tube of the apparatus. The sample was analyzed on atomic absorption spectrophotometer using the respective lamp.

2.8.2. Calculation:

Micronutrients (ppm) = Reading x 50

2.9. Calcium

Ten ml of pre-treated aliquot was pipette out in a conical flask. 5 drops of sodium hydroxide were added. 50 mg of ammonium purport indicator was added to the solution. The solution was titratedagainst EDTA from red-orange to purple. When closed to the endpoint, EDTA was added dropwise (each drop after 5-10 seconds). Titration was repeated twice.

Calculation:

Ca++ = (ml of EDTA sol. for sample – ml of EDTA for blank) x N x 10 Aliquot in mlCa++ = (R1 – R2) x 0.01 x 1000

2.10. Thiamine, Riboflavin and Niacin

The AOAC Official Methods of Analysis (AOAC, 2005) were used to estimate the thiamine, riboflavinand niacin contents.

2.11. Data Analysis

Statistical Software (SPSS Version 15) was used to run one way ANOVA in order to find out the mean difference of nutritional composition in different rice varieties. The data was descriptively reported as Mean and Standard Deviation and interpreted with the help of p-value from analysis of variance.P-value <0.05 was considered as statistically significant. The inferences were done at 95% Confidence Interval.

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3. RESULTS

Table 1. Comparison of proximate analyses and insoluble fiber components in various varieties of rice indigenously grown in Punjab, Pakistan (n=6, results are shown as % ± SD)

Varieties	Moisture %	Ash%	Protein%	Fat%	Crude Fiber%	Cellulose%	Lignin%
Basmati Pak	10.22±0.19	0.30±0.54	8.12±0.20	0.52±0.81	0.45±0.40	0.23±0.62	0.21±0.95
Basmati KS 282	12.97±0.34	0.48±0.23	7.01±0.12	0.34±0.39	0.39±0.45	0.17±0.29	0.23±0.90
Super White Basmati	11.56 ±0.24	0.40±0.20	6.14 ±0.19	0.26±0.32	0.20±0.24	0.09±0.14	0.12±0.34
Organic Brown Rice	14.21±0.19	1.09±0.34	9.20±0.24	1.95±0.21	1.29±0.12	0.49±0.31	0.58±0.87
1121Kainat-Sella Rice	12.01 ±0.23	0.92±0.81	7.22 ±0.23	0.42±0.19	0.38 ±0.39	0.16±0.22	0.12±0.39
Super Kernel Rice	13.59± 0.95	1.98 ±0.76	8.98 ± 0.45	1.38 ± 0.23	1.81 ± 0.54	0.51 ± 0.95	0.67 ± 0.74

All values are significantly different (<0.05).

Table 1 depicts the comparison of six different types of rice for a percentage of moisture, ash, protein, fat, crude fiber, cellulose, and lignin. Super Kernel Rice had a significantly higher percentage of moisture (14.21±0.19) whereas Basmati Pak exhibited a significantly lower percentage of moisture (9.22±0.19; p<0.05). Organic Brown Rice had a significantly higher percentage of ash content (2.08±0.34) as compared to the rest of the varieties and Basmati Pak was with the lowest percentage of ash content (0.30±0.54; p<0.05). Protein percentage was significantlyhigher in Organic Brown Rice (9.20±0.24) and Super White Basmati exhibited a significantly low protein percentage (6.14 ±0.19; p<0.05). The highest percentage of fat was present in Organic Brown Rice (1.95±0.21) and Basmati KS 282 had the lowest percentage of fat (0.26 ±0.32). Organic Brown Rice was found to be the richest source of crude fiber (2.29±0.12) cellulose (1.49±0.31) and lignin (1.58±0.87) whereas Super White Basmati had a significantly lower percentage for crude fiber (0.20±0.24) cellulose (0.09±0.14) and lignin (0.12±0.34; p<0.05).

Table 2. Comparison of selected micronutrient content in various varieties of rice indigenously grown in Punjab, Pakistan (n=6, results are shown as mg/100 gm ± SD)

Varieties	Thiamine mg/100gm	Riboflavin mg/100gm	Niacin mg/100gm	Calcium mg/100gm	Iron mg/100gm	Zinc mg/100gm
Basmati Pak	2.23 ± 0.11	0.68 ± 0.15	45.10 ± 0.54	70.00 ± 0.12	56.30±0.67	49.20± 0.76
Basmati KS 282	3.93 ± 0.21	0.77 ± 0.06	50.10 ± 1.15	81.00 ± 2.00	43.33±1.46	38.30± 2.56
Super Basmati	3.83 ± 0.25	0.87 ± 0.06	31.17 ± 4.25	68.67 ± 2.52	56.17±2.75	32.17± 3.25
Organic Brown Rice	4.13± 0.25	0.83 ± 0.06	53.50 ± 1.53	70.67 ± 2.08	54.67±2.57	34.17± 2.75
1121 Kainat Sella Rice	2.13 ± 0.25	0.47 ± 0.06	38.10 ± 3.65	89.33 ± 2.08	40.17±3.25	31.67± 0.29
Super Kernel Rice	5.76 ± 0.58	0.93 ± 0.23	67.32 ± 0.78	78.23 ± 0.54	64.23±0.42	37.30 ±0.80

All values are significantly different (<0.05).

Table 2 shows the comparison of thiamine, riboflavin, niacin, calcium, iron, and zinc in six differenttypes of rice. A significantly higher level of thiamine (5.76 ± 0.58), riboflavin (0.93 ± 0.23), and niacin (67.32 ± 0.78) were present in Super Kernel Rice as compared to the other varieties (p<0.05). Whereas Basmati Pak had the lowest level of thiamine (1.97 ± 0.11) and riboflavin (0.47 ± 0.06), while Super Basmati had the significantly lowest level of niacin (31.17 ± 4.25) Calcium was found in the highest quantity in 1121 Kainat Sella Rice (89.33 ± 2.08a)

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and lowest amount was exhibited inSuper Basmati (68.67 ± 2.52b) ($p<0.05$). Iron was found in the highest quantity in Super Kernel Rice(64.23 ± 0.42) and the lowest amount of iron was exhibited in 1121 Kainat Sella Rice (40.17 ± 3.25a).Zinc was present in the highest amount in Basmati Pak (49.20 ± 0.76b) whereas the lowest amountwas found in 1121 Kainat Sella Rice (31.67 ± 0.29a) ($p<0.05$).

4. DISCUSSION

This study was conducted to determine the nutritional composition and selected micro-nutrient contents of six different varieties of rice (Oryza sativa L.) through Proximate Analysis (AOAC, 2005 and 2008). Six indigenously grown varieties in Punjab were analyzed using a randomized block design with three replications.

The results of this study suggest adequate differences in the composition of various indigenous yields of rice. In addition to the environmental factors, local production of grains can have considerable effects on the nutritional composition of yield (David et al., 2019).

The moisture content of rice is a significant determinant of its shelf life. In the current study, organic brown rice was found to contain the highest amounts of moisture among the varieties studied. Protein and fat contents were also found to be highest in organic brown rice. Aleurone layers and bran contain larger quantities of proteins than endosperm, thus colored rice contains larger amounts of proteins than polished rice (Priya, Eliazer Nelson, Ravichandran, & Antony, 2019). In addition to milling, protein contents of rice have been reported to be dependent upon a plethora of environmental and genetic factors,making the various varieties differ in the amounts of protein they contain (Wireko-Manu & Amamoo, 2017). Though rice contains lysine as special amino acid not commonly found in other cereal grains (Priya et al., 2019), the current study involved the proximate analysis of protein only rather than a complete amino acid profile.

Fat contents were found highest in organic brown rice in current research. This might be because lipid fractions of rice kernel are mainly confined to its bran which is removed during processing (Priya et al., 2019). Though fiber contents of brown rice were also high probably due to some reason, super kernel rice was found to contain the highest quantities of crude fiber. The insoluble fractions

of fiber (cellulose and lignin) were also found to be highest in quantity in the super kernel rice variety. Except for calcium and zinc, the largest quantities of all other micronutrients studied were extracted from the super kernel rice variety. The local rice varieties of Pakistan remain nutritionally uncharacterized and thus, there is not much-published data available for comparison. Milled rice is reportedly deficient in Vitamin B1 (Thiamine), referring to the decades-old discovery of geographical distribution of beriberi in milled rice-dependent regions (Wiley & Gupta, 2019). The findings fromthe current study also foster this relationship as is evident from higher amounts of Vitamin B1 present in brown rice. A review of Table 2 reveals a unique blend of minerals (calcium, iron, and zinc) in different varieties. The amounts of these minerals were quite proportionate to one another. 1121Kainat-Sella rice contained the highest amounts of calcium among the varieties studied while it contained the least amounts of iron and zinc. The variety containing the highest iron contents (Super Kernel Rice) was found to have moderate amounts of the other two minerals. The bioavailability of minerals from cereal sources is not very high with a variety of nutritional and non- nutritional factors hindering their absorption (Whitney & Rolfes, 2018). All three of the minerals studied, being divalent cations, may have an impact on each other's bioavailability and thus the natural composition in a way can help in increasing the utilization of each nutrient.

Rice is considered as a widely used staple food item after wheat in Pakistan. In recent times, Pakistan has faced high inflation and unemployment rates. The current economic conditions suggest that the local food security situation might have undergone further deterioration. Staple food items and cereal grains, thus, remain the basic food items available to a major part of the public to fulfill their food and nutrition requirements. Disseminating information on the composition of cereal varieties can help select the varieties which provide a better blend of nutrients.

5. CONCLUSION

The findings of current research suggest that the nutritional composition of various varieties of rice grown in similar environmental conditions (all were indigenous varieties) may be highly variable. Overall Organic Brown rice and Super Kernal rice varieties were found to be superior in nutritional quality as compared to other varieties studied. It is suggested to incorporate these analyses for usein the selection of rice varieties by manufacturers and consumers.

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CONFLICT OF INTEREST
The authors declare that they have no competing interests.

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DECLARATION
The authors declare that there is no financial, academic, commercial, political, or personal conflictof interest. All authors have read and approved the manuscript and choosing your journal is a combined decision of all authors. The authors ensure that the work is original and is currently notunder consideration by any other journal.

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