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Mineral and Pasting Characterization of Indica Rice Varieties with Different Milling Fractions

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ABSTRACT

Four indica rice varieties namely IRRI-6, KS-282, Basmati 2000 and Super Basmati were milled to obtain brown rice and white rice. Mineral components were significantly higher in brown rice than white rice. Sodium (Na), potassium (K), iron (Fe) and zinc (Zn) contents ranged from 3.87 to 4.88 mg 100^{-1} g, 102.0 to 229.0 mg 100^{-1} g, 0.77 to 1.72 mg 100^{-1} g and 1.31 to 2.01 mg 100^{-1} g, respectively among different milling fractions. The mineral contents ranged from 4.06 to 4.78 mg 100^{-1} g, 155.50 to 173.50 mg 100^{-1} g, 1.20 to 1.31 mg 100^{-1} g and 1.59 to 1.71 mg 100^{-1} g among different varieties. The Na and K contents were higher in rice variety Basmati 2000, while Fe and Zn contents were higher in Super Basmati rice cultivar. The lowest contents of these elements were observed in KS-282 rice cultivar. Amylose content ranged from 22.90 to 26.14% and 24.14 to 25.31% among the rice varieties and milling fractions of brown and white rice, respectively. The amylose content was found to be higher in IRRI-6 followed by KS-282, Super Basmati (SB) and the lowest amylose content was observed in Basmati 2000. Pasting characteristics (Peak viscosity, Final Viscosity at 95^{o}C, Cooling viscosity at 50^{o}C, Consistency & Set back value) showed that peak viscosity (PV), final viscosity at 95^{o}C ($FV_{95^{o}C}$), cooling viscosity ($CV_{50^{o}C}$), consistency and set back (SB) value were significantly affected between milling fractions and rice varieties. In sensory evaluation Basmati white rice got the maximum scores for color, texture and taste, while the Basmati brown rice got the maximum scores for aroma.

Key Words: Brown rice; White rice; Minerals; Amylose; Pasting characteristics; Brabender amylograph

INTRODUCTION

Rice has been considered the best staple food among all cereals. It has higher digestibility, biological value and protein efficiency ration owning to presence of higher concentration (~ 4%) of lysine. Minerals like calcium, magnesium, phosphorus are present along with some traces of iron, copper, zinc and manganese (Yousaf, 1992).

Rice is a starchy staple food, which gives a large portion (~ 90% in Asia) of dietary energy. Brown and milled rices contains about 75-85% and 90% carbohydrates, respectively. Starch properties are therefore an important factor to determine the grain quality. Rice starch is usually digested quite rapidly, compared with other starch foods such as noodles, sweet potato etc (Sidhu, 1989). Cooking and eating characteristics are mainly determined by the properties of the starch that makes up 90% of milled rice. Gelatinization temperature, amylose content and gel consistency are the important starch properties that influence cooking and eating properties.

The consumers are interested in to get rice of good cooking and eating quality. These characteristics are largely depending on the physico-chemical properties of starch, which make up 90% of milled rice. Other important characteristics like apparent amylose content (AC), water absorption ratio, volume expansion ratio and final starch gelatinization temperature (GT) collectively determine cooking and eating qualities of rice (Sidhu, 1989).

Consumers taste varies from country to country. In basmati and non-basmati varieties not only the taste but average precook length, aroma, taste, color, cooking, eating and pasting characteristics are also considered in quality determination (Normita & Cruz, 2002). Pakistan is the major rice exporting country (IRRI, 1997). The rice production in the world during 2007 has been reported as 645 million tons. In Pakistan rice was the third major crop after wheat and cotton in 2007-08 and it was cultivated on an area of 2594 thousand hectares with a production of 5720 thousand tons (GOP, 2007). The Pakistani rice varieties have special pleasant aroma, long slender grain with soft texture on cooking. Basmati rice is exported to more than 80 countries mainly to Gulf and European Countries. Thus, it is of great importance to analyze the Pakistani rice varieties for their quality parameters. Present study was designed to assess the nutritional, cooking and pasting properties of different rice cultivars and milling fractions to better understanding for the consumers and world exporters.

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MATERIALS AND METHODS

Sampling and sampling procedure. Four rice cultivars i.e., IRRI-6, KS-282, Basmati 2000 and Super Basmati, respectively were obtained from Rice Research Institute, Kala Shah Kakoo, Sheikhupura.

The paddy of each variety was dehulled and milled by passing through stake sheller. The McGill laboratory mill (Rapsco, Inc, Brookshire, TX) was used to obtain two fractions of each rice variety i.e. brown rice and white rice designated IRRI-6 as (IRRI-B, IRRI-W) KS-282 (KS-B, KS-W), Basmati 2000 (B2-B, B2-W) and Super Basmati (SB-B, SB-W). The "B" shows brown and "W" for white rice, respectively. Portion of rice fractions was ground by passing through cyclone mill (Udy Corp, Fort Collins, Co) to get rice flour.

Mineral contents. The flour sample of each variety was digested in di-acid mixture (3:1) of HNO_3:$HClO_4$ at 180°C for 2 h. The digested samples were transferred to 100 mL volumetric flask and volume was made with distilled water and then filtered. The mineral contents i.e., Na, K Fe and Zn in the digested samples were estimated by using Atomic Absorption Spectrophotometer (Model Varian Spectra AA 250 plus) according to the method given in (AOAC, 2000).

Amylose and pasting characteristics. Amylose contents of all rice samples were determined by using spectrophotometerical techniques according to modified method of (Juliano, 1971).

The pasting properties of rice flour samples were determined by using Brabender Viscoamylograph according to the method of Lee *et al.* (1995). The pasting properties of all rice samples were evaluated using a Brabender Viscoamylograph 1725E. Ten percent slurry was made from rice flour (40 g, dwb) and deionized water (300 mL) and homogenized by blending for 1min. The contents were then transferred into a viscometer bowl. The blending bowl was rinsed with deionized water (60 mL) and the washing was added to make a total volume of 360 mL in the viscometer bowl. The slurry in the viscometer bowl was equilibrated at 25°C and the measuring device was adjusted to zero. After 5 min of equilibration, the slurry was heated to 95°C at 1.5°C min^{-1} and held for 30 min followed by cooling at 1.5°C min^{-1} to 50°C. The amylograms generated information about peak viscosity, final viscosity at 95°C, cooling viscosity at 50°C, setback viscosity and gel consistency all in Brabender units (BU).

Sensory evaluation. All rice varieties (brown & white rice) were cooked as reported under volume expansion ratio and sensory characteristics such as texture, aroma, color, taste and overall acceptability were evaluated by a panel of judges using 9-point hedonic scale system as described by (Land & Shephered, 1988).

Statistical analysis. Data collected in triplicate, were subjected to analysis of variance. Completely randomized design was applied on the data to assess the significance level and differences among the means of treatments showing significant differences were compared with Duncan's multiple range test described by Steel *et al.* (1996).

RESULTS AND DISCUSSION

Mineral contents. In all mineral contents, significant differences were observed in varieties and milling fractions. The highest Sodium content was found in Basmati 2000 (4.78 mg 100^{-1} g) and lowest was found in KS-282 (4.06 mg 100^{-1} g). While in milling fractions the sodium content was highest in brown rice (4.88 mg 100^{-1} g) and lower in white rice (3.87 mg 100^{-1} g) (Table I) Dikeman *et al.* (1981) also reported that the sodium content present in brown and milled rice flour ranged from 17 to 340 and 5 to 86 µg g^{-1}, respectively. Likewise the highest Fe content was found in rice variety Super Basmati (SB) followed by Basmati 2000 (B2), IRRI-6 and the lowest iron content was found in KS-282. Similarly among milling fractions, the highest iron content (1.72 mg 100^{-1} g) was found to be in SB-B and the lowest iron content (0.77 mg 100^{-1} g) was observed in KS-W rice fraction. Since the early 1990's IRRI in cooperation with the University of Adelaide has been analyzing variations in iron content in rice varieties. Rice grown under uniform conditions at the IRRI research center ranged in iron content from 0.75 to 2.44 mg 100^{-1} g, with a mean of 1.21 mg 100^{-1} g (Graham *et al.*, 1999). Villareal *et al.* (1991) reported the 35% loss of iron content during milling to produce well milled white rice (Table I). Similarly, highest Zn content was found in rice variety Super Basmati (SB) followed by Basmati 2000 (B2), IRRI-6 and the lowest Zn content was found in KS-282. Among milling fractions the Zn content was found to be higher in brown rice than white rice. The highest zinc content (2.01 mg 100^{-1} g) was

Table I. Minerals content (mg 100 g^{-1}) of different rice cultivars and their milling fractions

Samples	Na	Fe	Zn	K
IRRI-B	4.52 ± 0.13	1.64 ± 0.04	1.97 ± 0.03	212.00 ± 3.05
IRRI-W	3.75 ± 0.14	0.83 ± 0.03	1.36 ± 0.01	104.00 ± 3.98
KS-B	4.48 ± 0.08	1.63 ± 0.05	1.88 ± 0.03	209.00 ± 5.77
KS-W	3.63 ± 0.03	0.77 ± 0.03	1.31 ± 0.03	102.00 ± 2.02
B2-B	5.39 ± 0.1	1.67 ± 0.04	1.99 ± 0.06	229.00 ± 4.56
B2-W	4.17 ± 0.07	0.91 ± 0.02	1.39 ± 0.02	118.00 ± 5.19
SB-B	5.14 ± 0.12	1.72 ± 0.03	2.01 ± 0.05	223.00 ± 2.77
SB-W	3.96 ± 0.08	0.89 ± 0.005	1.41 ± 0.01	115.00 ± 1.61
Pooled means				
Fractions				
Brown	4.88a	218.25a	1.67a	1.96a
White	3.87b	109.75b	0.85b	1.37b
Pooled means				
Varieties				
IRRI	4.14c	158.00b	1.24ab	1.67ab
KS-282	4.06c	155.50b	1.20b	1.59b
Basmati 2000	4.78a	173.50a	1.29a	1.69a
Super Basmati	4.55b	169.00a	1.31a	1.71a

Means ± SE. SB, Super Basmati; B2 Basmati-2000; B, brown; W, white
Means carrying same letter in a column do not differ significantly ($P \geq 0.05$)

Table II. Sensory profile (scores) of different rice samples with milling fractions

Samples	Color	Aroma	Texture	Taste	Overall acceptability
IRRI-B	7.04 ± 0.11	6.17 ± 0.18	6.73 ± 0.11	6.36 ± 0.15	6.57 ± 0.11
IRRI-W	7.25 ± 0.08	5.99 ± 0.08	6.84 ± 0.05	6.79 ± 0.17	6.71 ± 0.14
KS-B	7.09 ± 0.14	5.98 ± 0.07	6.83 ± 0.07	6.43 ± 0.07	6.58 ± 0.15
KS-W	7.28 ± 0.11	5.73 ± 0.07	6.90 ± 0.11	6.86 ± 0.11	6.69 ± 0.10
B2-B	7.11 ± 0.12	7.99 ± 0.09	7.11 ± 0.12	6.87 ± 0.13	7.27 ± 0.007
B2-W	7.57 ± 0.06	7.33 ± 0.06	7.17 ± 0.23	7.59 ± 0.16	7.41 ± 0.07
SB-B	7.08 ± 0.18	7.79 ± 0.07	7.24 ± 0.12	6.89 ± 0.17	7.25 ± 0.14
SB-W	7.53 ± 0.09	7.20 ± 0.15	7.29 ± 0.22	7.48 ± 0.16	7.37 ± 0.15
Pooled mean					
Fractions					
Brown	7.08b	6.98a	6.98a	6.64b	6.92a
White	7.41a	6.56b	7.05a	7.18a	7.05a
Pooled mean					
Varieties					
IRRI-6	7.15a	6.08b	6.79c	6.58b	6.64b
KS-282	7.19a	5.86c	6.86bc	6.65b	6.63b
Basmati 2000	7.34a	7.66a	7.14ab	7.23a	7.34a
Super Basmati	7.31a	7.50a	7.27a	7.19a	7.31a

Means ± SE. SB, Super Basmati; B2 Basmati-2000; B, brown; W, white
Means carrying same letter in a column do not differ significantly (P≥0.05)

observed in SB-B and the lowest zinc content (1.31 mg 100^{-1} g) was observed in KS-W. The mineral contents were loosed during milling for seven rice varieties from the International Rice Research Institute and observed the zinc content (22.4 µg g^{-1}) in brown rice and (16.4 µg g^{-1}) in milled white rice (Villareal *et al.*, 1991).

Potassium content was found to be the highest in Basmati 2000 followed by Super basmati and IRRI-6 and the lowest was observed in KS-282. Among milling fractions the highest value of potassium content was observed in B2-B and the lowest value was found in KS-W. (Table I). Mahoney (1982) reported the minimum and maximum concentration of potassium content in rice milling fractions 0.6 to 2.8 mg g^{-1} in brown and 0.7 to 1.3 mg g^{-1} in white rice. Eppendorfer *et al.* (1983) findings were on the same lines as observed by Mahoney (1982). The potassium is essential for synthesis of proteins, for enzyme functions within cells and for maintenance of the body's fluid balance. One half cup serving of cooked brown rice provides 1% of the U.S. Daily value (DV) for potassium and one half cup cooked white rice contains less amount of potassium than brown rice (American Rice Inc, 2004). The results obtained in the present study are well supported by the above said statement. Rice bran is rich in potassium contents. Significant variation between brown and white rice was may be due to the bran portion, which significantly increased the potassium content of brown rice as reported by Anjum *et al.* (2007).

Amylose content. Amylose content ranged from 22.90 to 26.14% and 24.14 to 25.31% among the rice varieties and milling fractions of brown and white rice, respectively. The amylose content was found to be higher in IRRI-6 followed by KS-282, Super Basmati (SB) and the lowest amylose content was observed in Basmati 2000. Among milling fractions the highest amylose content was found in IRRI-W (26.81%) followed by KS-W (26.69%), IRRI-B (25.46%),

Fig. 1. Amylose content (AC) of rice cultivars with their milling fractions

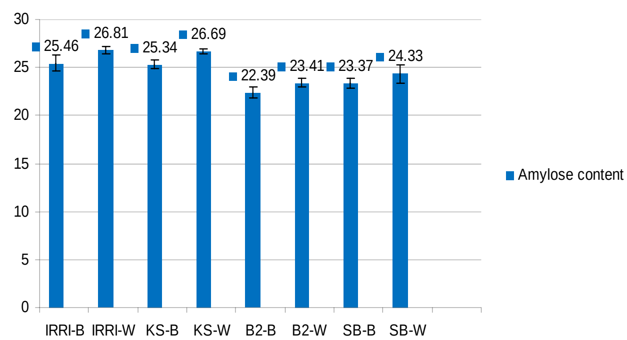
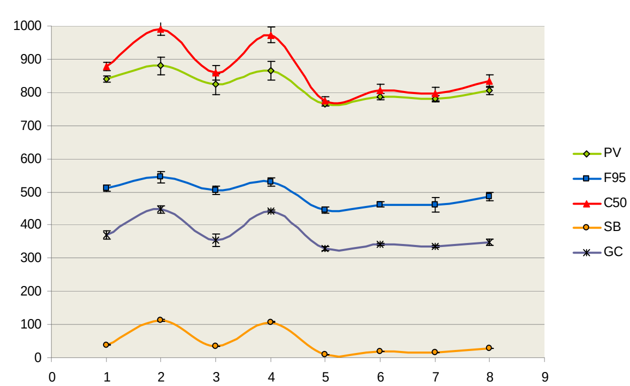


Fig. 2. Pasting behavior of different rice samples by Visco-amylograph in (BU)

BU=Brabender unit, 1=IRRI-B, 2=IRRI-W, 3=KS-B, 4=KS-W, 5=B2-B, 6=B2-W, 7=SB-B, 8=SB-W, PV=Peak viscosity, F_{95}=Final viscosity at 95 °C, C_{50}=Cooling viscosity at 50 °C, SB=Set back value, GC=Gel consistency.



KS-B (25.34%), SB-W (24.33%), B2-W (23.41%) SB-B (23.37%) and the lowest amylose content was found in B2-B (22.39%) (Fig. 1). The result of this study are in conformity with the earlier findings of Dipti *et al*. (2002) who reported the amylose content in different rice varieties in the range of 18.60 to 28.0%. Panlasigui *et al*. (1991) reported the amylose content 26.0 to 27.0% in white rice of different rice varieties. The amylose content of brown rice is lower than that of milled rice, mainly because of its lower starch content (Perez & Juliano, 1978). In the present study Basmati rice contained intermediate amylose content, which co-relate to extreme elongation during cooking and soft texture of cooked rice as reported by Juliano and Pascual (1980) and similarly the coarse rice varieties contained high amylose content, which co-relate to the properties of dry cooking, less tenderness and becomes hard upon cooling, which is supported to the results of this findings.

Pasting characteristics. In this study different rice samples were obtained and these samples were analyzed for different pasting characteristics (Peak viscosity, Final Viscosity at 95°C, Cooling viscosity at 50°C, Consistency & Set back value). It is obvious from the results that peak viscosity (PV), final viscosity at 95°C ($FV_{95}{^o}_C$), cooling viscosity ($CV_{50}{^o}_C$), consistency and set back (SB) value were significantly affected between milling fractions and rice varieties, which is illustrated in Fig. 2.

The highest PV was found in rice variety IRRI-6 (860.0 BU) followed by KS-282 (845.0 BU), Super Basmati (792.50 BU) and the lowest PV (776.0 BU) was observed in Basmati 2000 (B2). Among milling fractions the highest PV was observed in IRRI-W (880.0 BU) followed by KS-W, IRRI-B, KS-B, SB-W, B2-W, SB-B and the lowest PV was found in milling fraction B2-B (765.0 BU).

The highest $FV_{95}{^o}_C$ was found in rice variety IRRI-6 (527.0 BU) and the $FV_{95}{^o}_C$ was found to be the lower in rice variety Basmati 2000 (453.0 BU). The $FV_{95}{^o}_C$ of KS-282 and Super Basmati (SB) rice varieties were 517.0 BU and 472.0 BU, respectively. When the milling fractions were obtained of these rice varieties the mean value (505.50 BU) of white rice was higher than brown rice (480.0 BU). The $FV_{95}{^o}_C$ was observed to be the highest in milling fraction IRRI-W (545.0 BU), while the lowest (445.0 BU) $FV_{95}{^o}_C$ was observed in B2-B.

The $CV_{50}{^o}_C$ ranged from 789.0 to 935.0 BU and found to be the higher in rice variety IRRI-6 followed by KS-282 (916.0 BU), while the lowest $CV_{50}{^o}_C$ was found in Basmati 2000. In milling fractions, the $CV_{50}{^o}_C$ ranged from 826.75 to 900.75 BU in brown and white rice, respectively. The highest $CV_{50}{^o}_C$ was found in IRRI-W (992.0 BU) followed by KS-W (973.0 BU), IRRI-B (879.0 BU), KS-B (859.0 BU), SB-W (833.0 BU), B2-W (805.0 BU), SB-B (795.0 BU) and the lowest $CV_{50}{^o}_C$ was found in B2-B (774.0 BU).

The highest (408.0 BU) consistency value was observed in IRRI-6 followed by KS-282 (398.0 BU) and Super Basmati (341.0 BU), while the lowest (336.0 BU) consistency value was found in Basmati 2000. After milling fractions the consistency value ranged from 346.75 to 395.25 BU in brown and white rice, respectively. Individually the highest consistency value was observed in IRRI-W (447.0 BU) and the lowest value was observed in B2-B (329.0 BU). Rice chemistry and technology (1985) reported that the peak viscosity (PV), $FV_{95}{^o}_C$ and $CV_{50}{^o}_C$ ranged from 765-940 BU, 400-500 BU and 770-880 BU in different long grain rice varieties. This statement was well supported in our study, because mostly the rice varieties along with their milling fractions falls within above mentioned range except IRRI-W and KS-W which showed higher values than reported values. But Biswas and Juliano (1988) reported that the PV, $FV_{95}{^o}_C$, $CV_{50}{^o}_C$, Consistency and Setback values ranged from 460-900 BU, 355-680 BU, 400-1680 BU, 45-1000 BU and -200-780 BU in brown and milled rice of different rice varieties. According to Biswas and Juliano, all the rice varieties along with milling fractions fall with in the range of above mentioned values.

High amylose rice varieties IRRI-6, KS-282 along with their milling fractions i.e., IRRI-W, IRRI-B, KS-W and KS-B had peak viscosity (825 to 880 BU), which were with in the range of 745 to 900 BU in other five high amylose rice varieties (> 25%) reported by (Biswas & Juliano, 1988). The variation between the values of pasting properties i.e., peak viscosity can be affected by the amylose content (Juliano, 1985), starch water concentration, lipids, residual proteins (Whistler & Bemiller, 1997) and instrument operating conditions (Batey *et al*., 2000).

Sensory evaluation. The rice varieties Basmati 2000 (B2) followed by Super Basmati (SB) got maximum scores, while the rice varieties IRRI-6 followed by KS-282 got the lowest scores for color by the panel of judges. Among milling fractions white rice got the highest score than brown rice for color. The rice variety Basmati 2000 (7.66) and Super Basmati (7.50) possessed higher score for aroma, while the lowest were observed in IRRI-6 (6.08) and KS-282 (5.86). After milling fractions the B2-B followed by SB-B got the highest score, while KS-W followed by IRRI-W got the lowest scores for aroma. The maximum score for texture was attained by the cooked rice variety Super Basmati followed by Basmati 2000 (B2). while the lowest score for taste was obtained by IRRI-6 followed by KS-282. In milling fraction of rice varieties, the highest score for texture was attained by SB-W followed by B2-W, while the IRRI-B and KS-B got the lowest score for texture. Overall white rice got the maximum score for texture than brown rice. As for as taste is concerned, the rice varieties Basmati 2000 (7.23) and Super Basmati (7.19) possessed higher taste, while the rice varieties KS-282 (6.65) and IRRI-6 (6.58) possessed the lower taste scores. On the basis of overall acceptability the rice varieties Basmati 2000 (B2) and Super Basmati (SB) got the highest score and rice varieties IRRI-6 and KS-282 got the lowest scores. After milling fractions the B2-W and SB-W got the highest score and IRRI-B and KS-B fractions got the lowest score for overall acceptability. The findings of the present study are in agreement with the earlier research work reported by (IRRI, 1983) who also reported that Pakistani basmati rice have better aroma with better sensory quality characteristics.

Saeed (2004) and Javed (2004) found that overall acceptability of basmati rice varieties have better sensory attributes especially for their aroma than coarse rice varieties.

CONCLUSION

In conclusion, brown rice of different rice cultivars has better nutritional quality than white rice due to much more availability of minerals. Basmati rice varieties showed intermediate amylose level and good pasting behavior, which is mostly preferred by the people due to its less tenderness, cook moist and do not become hard upon cooling. White basmati rice also got the maximum scores in sensory evaluation due to its pleasant aroma and taste.

REFERENCES

American Rice Inc., 2004. *Nutritional Information*. http://www.amrice.com/6-4.cfm

Anjum, F.M., I. Pasha, M.A. Bugti and M.S. Butt, 2007. Mineral composition of different rice varieties and their milling fractions. *Pakistan J. Agric. Sci.*, 44: 332–6

AOAC. 2000. *Official Methods of Analysis, 17th edition.* Association of the Official Analytical Chemists, Washington D.C, USA

Batey, I.L. and B.M. Curtin, 2000. Effects on pasting viscosity of starch and flour from different operating conditions for the Rapid Visco-Analyser. *Cereal Chem.,* 77: 754–60

Biswas, S.K. and B.O. Juliano, 1988. Laboratory parboiling procedures and properties of parboiled rice from varieties differing in starch properties. *Cereal Chem.,* 65: 417–23

Dikeman, E., B.D. Bechtel and Y. Pomeranz, 1981. Distribution of elements of the rice kernel determined by X-ray analysis and atomic absorption spectroscopy. *Cereal Chem.,* 58: 148–52

Dipti, S.S., S.T. Hossain, M.N. Bari and K.A. Kabir, 2002. Physicochemical and cooking properties of some fine rice varieties. *Pakistan J. Nutr.,* 1: 188–90

Eppendorfer, W.H., S.W. Bille and S. Prabuddham, 1983. *Fertilizer and Water Stress Effects on Yield, Mineral Composition, Protein Production and Protein Quality of Tropical Food Crops*, pp: 157–87. Asian Institute Technology, Bangkok Research Reproduction

GOP (Government of Pakistan), 2007. *Economic survey 2007-08*. Government of Pakistan, Economic advisor wing, Financial division, Islamabad, Pakistan

Graham, R.D., D. Senadhira, S.E. Beebe, C. Iglesias and I. Ortiz-Monasterio, 1999. Breeding for micronutrient density in edible portions of staple food crops: conventional approaches. *Field Crops Res.,* 60: 57–80

IRRI (International Rice Research Institute), 1997. *Almanac*, 2nd ed. Manila, Philippines: International Rice Research Institute Los banos, Laguna, Philippines

Javed, M.K., 2004. Role of different storage temperatures in chemical and sensory characteristics of coarse varieties of rice. *M.Sc (Hons) Thesis*. Institute of Food Sci and Technology University of Agriculture, Faisalabad, Pakistan

Juliano, B.O., 1971. A simplified assay for milled rice amylose. *Cereal Sci. Today.,* 16: 334–40

Juliano B.O, 1985. *Rice Chemistry and Technology*. The American Association of Cereal Chemists, Inc. 3340 St.Paul, Minnesota

Juliano, B.O. and C.G. Pascual, 1980. *Quality Characteristics of Milled Rice Grown in Different Countries*, p: 25. IRRI Research Paper Series No. 48: International Rice Research Institute Los Banos: Laguna, Philippines

Land, D.G. and R. Shephered, 1988. Scaling and ranking methods *In*: Piggot, J.R. (ed.), *Sensory Analysis of Foods*, pp: 155–8. Elsevier Applied Science, New York

Lee, M.H., N.S. Hettiarachchy, R.W. McNew and R. Gnanasambandam, 1995. Physicochemical properties of calcium-fortified rice. *Cereal Chem.,* 72: 352–5

Mahoney, A.W., 1982. Mineral contents of selected cereals and baked products. *Cereal Foods World,* 27: 174–50

Normita, M. and D. Cruz, 2002. *Rice Grain Quality Evaluation Procedures*. Graham R. A Proposal for IRRI to establish a grain quality and nutrition research centre: IRRI discussion paper series No. 44 Los Banos, Philippines: International rice research Institute

Panlasigui, L.N., L.N. Thompson and B.O. Juliano, 1991. Rice varieties with similar amylose content differ in starch digestibility and glycemic response in humans. *American J. Clin. Nutr.,* 54: 871–7

Perez, C.M. and B.O. Juliano, 1978. Modification of the simplified amylose test for milled rice. *Staerke.,* 30: 424–6

Saeed, M.K., 2004. Effect of different storage temperatures on the chemical and cooking characteristics of fine rice cultivars. *M.Sc (Hons) Thesis*. Institute of Food Science and Technology University of Agriculture Faisalabad, Pakistan

Sidhu, G.S., 1989. Quality rice for export purpose. *In*: *Ann. AICRIP Workshop held at HAU Hisar*, *April,* 19-22

Steel, R., J. Torrie and D. Dickey, 1996. *Principles and Procedures of statistics. A Biometrical Approach*, 3rd edition. McGraw Hill Book Co. New York, USA

Villareal, C.P., J.W. Maranvill and B.O. Juliano, 1991. Nutrient content and retention during milling of brown rice from the International Rice Research Institute. *Cereal Chem.,* 68: 437

Whistler, R.L. and J.N. BeMiller, 1997. *Carbohydrate Chemistry for Food Scientists*. American Association Cereal chemistry: St. Paul, MN, USA

Yousaf, M., 1992. Study on some physicochemical characteristics affecting the cooking and eating qualities of some Pakistani rice varieties. *M.Sc. Thesis*. Departmentof Food Technology, University of Agriculture Faisalabad, Pakistan

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