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RESEARCH ARTICLE

Nutritional Diversity of Elite Rice Landraces from Subsistence-oriented Farming Systems

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Twenty one prominent rice landraces belonging to different subsistence farming systems in India were evaluated. Manually de-husked rice samples were used for studying sixteen important nutritional parameters. Range of useful nutritional variability was observed among rice landraces and each landrace was found superior for at least one nutritional parameter. Landraces from North-eastern Himalaya in comparison to landraces from other niches were found superior for nutritional traits like protein (12.22-14.32%), phosphorus (0.363-0.740 g/100g), phytate (1.35-2.55 g/100g) and Cu (1.090-2.141 mg/100g) contents. However, clustering analysis revealed no linkage among landraces with respect to their specific traits or geographical origin. The red rice landraces Chuhartu (7.29%) and Katheri (6.63%) from North-western Himalaya registered higher value for crude fat than the check (3.05%). Protein, total phosphorus, antioxidant activity (CUPRAC mg/g GAE) and total anthocyanin content was remarkably higher in black rice (Chakhao amubi and Chakhao poireiton). Significant amount of correlation was observed among different nutritional parameters. Anti-oxidant activity was significantly correlated with phytate, anthocyanin, total phenol and total phosphorus content. 42.17% of nutritional variability was explained by Principal component I which was majorly contributed by total phosphorus, anthocyanin, phytate, CUPRAC and Cu content. The present study indicates the role of local communities in development and enrichment of nutritional diversity of rice.

Key Words: Anthocyanin, Aromatic rice, Black rice, Coloured rice, Nutrient composition, Red rice, Rice for health

Introduction

Rice is the most popular staple food, feeding almost half of the world population, providing 27% of global human per capita dietary energy, 20% of per capita dietary protein and 3% of per capita dietary fat. In Indian scenario, it provides 30.9% per capita dietary energy, 24.1% per capita protein and 3.6% per capita dietary fat (FAO, 2002). Rice, besides its energy and protein content, also serves as source of different minerals, vitamins, antioxidant compounds and dietary fiber. Unlike high yielding rice varieties, landraces are diverse having broad genetic base as being a product of repeated mass selection. They tend to be rich in one or more of these macro- and micro-nutrients. Much of the studies on rice nutrient composition are done on high yielding rice varieties and only limited information on nutritional profile of rice landraces is available. Cultivation of these landraces is restricted to marginal areas, in rainfed upland environments and they are fast depleting as evident from study on Jeypore tract of Odisha state, India where in the late 1950s around 1700 rice varieties were cultivated, by 1996 the number had dwindled down to slightly more than 300 varieties (Patra and Dua, 2003). These days particularly the pigmented rice (black, dark purple and red rice) is gaining importance in developing health conscious human society. These are used as natural food colorant for bread, liquor, functional food and many other local and highly valued dishes. Coloured rice is being consumed as traditional medicine in China, Japan, Korea, Thailand and India for treating anemia, diabetes, strengthening kidney function, promoting blood circulation, removing blood stasis, treating and ameliorating eye sight, etc (Wang *et al.*, 2007; Sompong *et al.*, 2011; Dipti *et al.*, 2012). On

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the other hand, aromatic rice always has been a higher priced commodity among local community and in global market. Aromatic rice landraces are even more valuable and rare food as they have evolved with local taste, aroma and cooking qualities preferred by local people. These traditional rice landraces are invaluable genetic resource and are much sought after by plant breeders and genetic engineers as a source of genes for biotic/abiotic stress tolerance and nutritional traits. Therefore, in this study the nutritional profile of rice landraces collected from diverse agro-ecologies has been investigated.

Materials and Methods

Landraces' Seed Collection and Multiplication

A total of 21 most popular rice landraces collected from diverse ethnic communities of North-western Himalayas (Jammu & Kashmir and Himachal Pradesh), North-eastern Himalayas (Assam and Manipur) and two landraces from Southern India (Andhra Pradesh) (Table 1). These were grown in the experimental farms of Division of Genetics, Indian Agricultural Research Institute, New Delhi (latitude: 28° 38′ 7.11′′ N and

Table 1. Passport information and special characteristics of some important rice landraces from different parts of India

S.No.	Landrace	District	State	Latitude/Longitude	Special remarks
1	Chuhartu	Shimla	Himachal Pradesh	31° 12' N; 77° 45' E	Red aleurone
2	Karad	Chamba	Himachal Pradesh	32° 33' N; 76° 7' E	Red aleurone, field resistant to disease and insects, drought tolerant, karad means very hardy and luxuriant, white awn
3	Mirzag	Budgam	Jammu and Kashmir	33° 54' N; 74° 39' E	Red aleurone, early maturing, high yield, better milling recovery, tolerant to lodging
4	Sukara	Chamba	Himachal Pradesh	32° 33' N; 76° 7' E	Red aleurone
5	Katheri	Kangra	Himachal Pradesh	32° 11' N; 76° 12' E	Red aleurone, aromatic, sweet, sticky rice, given to women after delivery as it is considered to restore certain internal reproductive body parts to normalcy, semi-spreading plant type, purple hull, pink awn
6	Mushk Budji	Pulwama	Jammu &Kashmir	33° 52' N; 74° 53' E	Red aleurone, bold and fine grains, cooks very good, the most popular scented rice of Kashmir valley, very costly, cooked in feasts only by rich people
7	Begumi	Kangra	Himachal Pradesh	32° 2' N; 76° 23' E	Red aleurone, aromatic, long, fine grains
8	Kalafulpatash	Mandi	Himachal Pradesh	31° 42' N; 76° 55' E	Aromatic, sweet grains, high swelling upon cooking, field resistant to diseases, glumes tip black, blackish purple stem
9	Lalbasmati	Kangra	Himachal Pradesh	32° 6' N; 76° 16' E	Aromatic, slightly red, long grains, high yield, orange-red hull,
10	Chittimuthyalu	Adilabad	Andhra Pradesh	19° 40' N; 78° 31' E	Aromatic, sweet, small and non-glutinous, white grains (chitti = tiny, muthyalu = pearl), landrace is in verge of extinction
11	Kalajoha	Dheemaj	Assam	27° 28' N; 94° 32' E	Aromatic, light blackish aleurone, non-glutinous, sweet rice, black hull
12	Chakhao amubi	Bishnupur	Manipur	24° 37' N; 93° 45' E	Aromatic, black aleurone, sweet, long, bold grains, glutinous rice, black hull
13	Chakhao poireiton	Bishnupur	Manipur	24° 37' N; 93° 45' E	Black aleurone, sweet, long, bold grains, glutinous rice, black hull
14	Lipya goal	Jaintia Hills	Meghalaya	25°11' N; 92°1'E	Bold white, chalky grains, glutinous rice
15	Suhagmani	Sonitpur	Assam	26°40' N; 92°51' E	Bold grains, glutinous rice, Semi-spreading plant type, good for flood affected areas
16	Himtu	Kangra	Himachal Pradesh	32° 6' N; 76° 16' E	Sweet, slender fine grains, very early maturing, dwarf, lodging resistant
17	Bohana dhan	Chamba	Himachal Pradesh	32° 33' N; 76° 7' E	Bold grains, high yield
18	Jhini	Kangra	Himachal Pradesh	32° 2' N; 76° 23' E	Sweet, bold, brownish grains
19	Ramjawain	Hamirpur	Himachal Pradesh	31° 36' N; 76° 30' E	Sweet, long and fine grains
20	Rangdi	Mandi	Himachal Pradesh	31° 38' N; 76° 43' E	Cold tolerant, small and fine grains, non-sticky, good yield
21	Ragalvanji	Adilabad	Andhra Pradesh	19° 40' N; 78° 31' E	Non glutinous rice especially used in religious purpose, landrace is in verge of extinction
22	HPR 2143	Pedigree: HPR 9020-2-2-2-1-1-1; Cross: Phulpatas 72 × HPU 741			Check variety

longitude: 77° 13′ 29.86′′ E). Standard field sowing practices for rice were followed. Freshly harvested seeds were used for nutritional analysis. An improved variety HPR-2143 from NEH region was also included in the study for comparison, as control.

Sample Preparation

Paddy grains were dehusked by hand without disturbing aleurone layer and homogenized using Foss Tecator cyclotech grinding mill. Homogenized flour was vacuum seal packed and stored at -20° C until used for analysis.

Estimation of Proximate Components

The proximate composition of homogenized samples was done using the official methods (AOAC 2005) with slight modifications in some cases.

Moisture content was estimated by weighing fresh (FW) weight of dehusked rice seed samples and then samples were dried at 60° C in hot-air oven for 72 h until constant dry weight (DW) was achieved. Then moisture content was calculated as 100 × [(FW-DW)/FW)] and expressed in per cent.

Ash content was estimated using 5 g of dried ground sample in silica crucible, which was first charred at 250° C for 1 h and then temperature was gradually raised to 450° C and maintained for 2 h. Ash was moistened with double distilled water and 2–3 drops of concentrated HNO_3 (69% GR Grade, Merck KGaA, Darmstadt, Germany) was added. Crucibles were again kept in muffle furnace at 450° C for 30 min for complete ashing. Ash content was expressed as g/100 g of fresh weight.

Crude fat was estimated as per AOAC official method 920.39 using petroleum ether at 40-60° C as solvent. Samples were extracted for 24 hours and dried overnight before and after extraction. To ascertain recovery food reference material AS-FRM 14 and in-house QC samples were used and recovery of 97.2 ± 2.2 was obtained.

Total protein was estimated as per AOAC official method 976.05 with some modifications in digestion of samples. The dried sample (100 mg) was homogenized and then digested with digestion mixture made of sulphuric acid, anhydrous sodium sulphate, selenium and hydrogen peroxide in glass digestion tubes at 350° C for 45 min as per the method of Forster (1995). Nitrogen percentage in digest was estimated by Kjeltech (FOSS Tecator) nitrogen autoanalyser. To ascertain recovery in-house QC samples and food reference material AS-FRM 14 were used as control. Recovery percentage of 99.8 ± 1.6 for AS-FRM 14 and 102.7 ± 1.2 for QC samples was obtained.

Dietary fibre was estimated by enzymatic-gravimetric method as per AOAC Official Method 985.29. Total dietary fibre assay kit (K-TDFR) and total dietary fibre control kit (K-TDFC) obtained from Megazyme, Ireland were used in analysis. AS-FRM 14 (Rice-2 from PT-8) obtained from Institute of Nutrition, Mahidol University, Thailand was used as control sample and we obtained 3.39±0.28 g/100 g dietary fibre which is acceptable limit of suggested value (3.48±0.36) for AS-FRM 14.

Sample Preparation for Sugars, Total Phenol, Antioxidants and Starch Estimation

Homogenized samples (100 mg) were extracted with 5 ml of 80% (v/v) ethanol in amber centrifuge tube on tube rotator for 30 min at 40 rpm. This was followed by sonication at 60° C for 20 min in bath sonicator and centrifugation at 5000 g for 15 min. The supernatant was collected and the residue was re-extracted twice. The supernatants were pooled and lyophilized to complete dryness and stored at -20° C until further analysis. Lyophilized extract was dissolved in 5 ml water just before use to determine the total sugar, total phenol and antioxidant capacity using appropriate methods. The residue left over was used for starch estimation.

Determination of Total Soluble Sugar, Total Phenolics Content, Antioxidant Potential and Starch Content

Total soluble sugar content in the extract was determined using phenol-sulphuric acid method by Dubois *et al.* (1956). Determination of TPC in the extract was done using Folin-Ciocalteu (FC) assay as described by Singleton *et al.* (1999) with slight modifications. Antioxidant activity was measured as cupric ion reducing antioxidant capacity (CUPRAC) of the extract and determined according to the method of Apak *et al.* (2004). Gallic acid was used as a positive control and results were expressed in mg GAE (Gallic acid equivalent)/g dry weight. Starch content was estimated as per AOAC 996.11.

Estimation of Phytate

Phytate and free phosphorous content were measured by enzymatic procedure using phytase and alkaline phosphatase enzymes. Phytic acid /total phosphorous assay kit (K-PHYT) from Megazyme, Ireland was used. Recovery of (95.2% ± 1.4) for control oat flour was obtained and results were expresses as g/100 g sample.

Estimation of Total Monomeric Anthocyanins

Anthocyanins were estimated as per AOAC official Method 2005.02. For each treatment two 10ml dilutions with pH 1.0 buffer and pH4.5 buffer were made and absorbance was taken at both 520 and 700 nm. Diluted test samples were read against the blank sample filled with distilled water. Anthocyanins content was calculated and expressed as Cyanidin-3-Glucoside equivalents, as follows:

$$\text{Anthocyanin pigment (cyanidin-3-glucoside equivalents, mg/l)} = \frac{A \times MW \times DF \times 10^3}{\varepsilon \times 1}$$

where A = (A520nm – A700nm)pH 1.0 – (A520nm – A700nm)pH 4.5; MW (molecular weight) = 449.2 g/mol for cyanidin-3-glucoside (cyd-3-glu); DF = dilution factor established; l = path length in cm; ε = 26 900 molar extinction coefficient ($L \times mol^{-1} \times cm{-}1$) for cyd-3-glu; and 103 = factor for conversion from g to mg.

Mineral Analysis

Mineral content was determined in accordance with the official analytical methods (AOAC, 2005) using with atomic absorption spectrometer (AAS, model-Varian Spectra AA 220 FS, Varian Australia Pty Ltd., Australia) equipped with a D2 lamp background correction system using an air-acetylene flame. Appropriately diluted acid digested samples were analyzed using AAS calibrated with related minerals in different concentrations for different macro (sodium, potassium and magnesium) and micro-minerals (copper, iron and zinc).

ASFRM-6 (fish meal), ASFRM-14 (Rice flour) food reference standards obtained from Institute of Nutrition, Mahidol University, Thailand were used to ascertain recovery and validate analytical methods.

Statistical Analysis

Statistical analysis was performed for analysis of variance, correlation coefficient, duncan's multiple range test and principal component analysis to understand trait relationship and factors responsible for maximum variability using SAS version 9.3 (2011).

Results

The range of variation for sixteen important nutritional quality traits is presented in Table 2. Wide variations among rice landraces were recorded particularly in anthocyanin content, phytate, total phosphorus, Cu, total phenol content and CUPRAC activity. Landrace were grouped based on their specific traits (aleurone colour, aroma) or original habitat (NEH, NEW) and nutritional compositions were compared between contrasting groups (Table 4). These groups were also demarcated on the basis of significant differences for mean values based on DMRT (Duncan's Multiple Range Test) with α value of 0.05. These comparisons gave some significant differences in terms of their nutritional composition like rice landraces from NEH region in comparison to landraces from NWH region exhibited substantially higher amount of total protein, total phosphorus, phytic acid and Cu content (Table 3, Table 4 and Supplementary Table 2). But rice land races from NWH region were found superior than NEH for crude fat content. In comparison to white rice black rice were found to have higher amount of moisture, protein, total phosphorus, phytate, anthocyanins, total phenol and CUPRAC. No linkage was observed between aromatic and non-aromatic rices. Various nutritional parameters like ash, dietary fiber, total carbohydrates, sugar and starch are randomly distributed with respect to their quantity among landraces irrespective of their geographical origin or known special characteristics (Table 3 and 4). The same is also observed in clustering analysis done using nutritional variables (Supplementary Figure 1).

Each individual landrace was found to be superior for one or more nutritional traits (Table 3a and 3b). Most important and useful result obtained in this study was that black rice (Chakhao amubi and Chakhao poireiton) used in this study recorded significantly higher protein content (14.3 and 14.1% respectively) than the check variety (8.1%) and reported protein range (6-9%) in rice (Tan *et al.*, 2001). Ash content was observed significantly higher in Mirzag (4.1%), Himtu (3.9%) and Rangdi (3.8%). The landrace Chakhao poireiton recorded highest value for total phosphorus, phytic acid and CUPRAC activity. The lowest value for phytic acid was observed in Rangdi and Chittimuthyalu (0.11% both). The phyatate content in the check variety HPR -2143 was 0.068%. Kalajoha an aromatic popular landrace from Assam (NEH) recorded highest Cu (2.1 mg/100g) and Zn content (8.3 mg/100g) than any other landrace. Chittimuthyalu from Southern India was found to have highest Mg content (145.1 mg/100g).

The total phenol, anthocyanins and CUPRAC which are considered as measurement parameters for

Table 2. Range of variation for different nutritional traits in rice landraces

Biochemical traits	Max	Min	Mean	SD	CV	SE
Moisture (%)	10.00	6.45	7.85	1.09	13.93	0.24
Ash (%)	4.11	0.77	2.67	0.89	33.41	0.20
Protein (%)	14.32	6.70	10.63	1.94	18.22	0.42
Crude Fat (%)	7.29	2.71	4.20	1.43	34.04	0.31
Dietary Fibre (%)	9.79	5.17	7.24	1.48	20.44	0.32
CHOAVL (%)	72.94	61.24	67.32	3.49	5.18	0.76
Sugar (%)	6.56	3.59	4.94	0.91	18.39	0.20
Starch (%)	66.85	56.90	62.15	3.17	5.11	0.69
Total Phosphorus (g/100g)	0.74	0.04	0.25	0.18	71.76	0.04
Phytate (g/100g)	2.56	0.11	0.79	0.62	78.08	0.14
Total Phenol g/100g	0.33	0.03	0.15	0.10	67.03	0.02
CUPRAC (mgGAE/g)	10.00	0.83	3.52	2.31	65.58	0.50
Anthocyanin (mg/g)	15.89	0.12	3.06	4.07	133.08	0.87
Cu (mg/100g)	2.14	0.22	0.73	0.50	68.84	0.11
Zn (mg/100g)	8.26	2.56	5.37	1.65	30.71	0.36
Fe (mg/100g)	6.78	1.02	3.93	1.43	36.35	0.31
Mg (mg/100g)	145.11	66.84	109.28	17.00	15.56	3.71

the antioxidant activity were significantly higher in the pigmented rice landraces than the non-pigmented rice landraces. As expected the antioxidant activity (CUPRAC mg GAE/g) observed highest in black seeded landraces i.e. Chakhao amubi and Chakhao poireiton (8.1 and 10 respectively) followed by red rices. The CUPRAC value for red rice landraces varied from 2.0 in Mushkbudji to 5.2 in Mirzag. Similarly total phenol content was also high in black rice (0.29 g/100 g) followed by red rice (0.19 g/100 g) and very less in white rice (0.1) (Table 3 and 4). Begumi, a red rice registered highest value (0.33g/100g) for total phenol content followed by black rice Chakhao amubi (0.31 g/100 g) and Chakhao poireiton (0.27 g/100 g). Anthocyanins in both the black rices was

Table 3a. Variations for different nutritional traits in rice landraces from diverse agro-ecologies

Landrace Name	Moisture (%)	Ash (%)	Protein (%)	CF (%)	DF (%)	CHOAVL (%)	Sugar (%)	Starch (%)	T Phos (g/100g)
Chuhartu	6.9±0.3	2.7±0.4	10.0 ±0.8	7.3±0.3	8.6±0.5	66.2	4.8±0.2	60.7±4.7	0.17 ± 0.02
Karad	7.3±0.4	1.7±0.4	10.5±1.4	4.5±0.3	6.4±0.4	67.9	4.4±0.2	64.5±3.7	0.19 ± 0.01
Mirzag	6.6±0.4	4.1±0.4	10.1±0.9	4.2±0.3	8.5±0.5	66.5	6.0 ±0.1	59.6±4.6	0.26 ± 0.01
Sukara	9.3±0.6	3.1±0.2	8.3±0.8	2.7±0.6	5.5±0.9	71.0	5.2±0.7	66.0 ±4.1	0.26 ± 0.06
Katheri	6.9±0.4	3.3±0.1	10.9±1.1	6.6±0.4	9.0 ±0.5	62.5	5.7±0.4	58.1±3.5	0.15 ± 0.01
Mushk budji	7.0 ±0.4	3.4±0.5	10.4±0.8	5.9±0.4	5.3±0.3	66.5	6.6±0.4	60.8±5.1	0.22 ± 0.01
Begumi	8.2±0.7	2.2±0.3	9.4±0.7	2.8±0.8	6.6±1.0	70.7	6.3±0.5	64.6±4.9	0.27 ± 0.04
Kalafulpatash	7.5±0.3	3.2±0.3	9.4±0.6	6.6±0.3	6.9±0.4	68.1	3.9±0.2	63.7±3.5	0.12 ± 0.01
Lalbasmati	7.4±0.4	3.3±0.2	9.9±0.9	6.0 ±0.3	8.3±0.5	66.6	3.6±0.3	62.2±3.2	0.13 ± 0.02
Chittimuthyalu	6.4±0.5	1.5±0.3	10.4±1.3	2.7±0.6	6.0 ±0.6	72.9	6.3±0.7	64.4±4.5	0.04 ± 0.02
Kalajoha	9.2±0.7	2.6±0.3	14.0 ±1.5	3.2±0.4	8.9±0.5	62.1	4.2±0.2	56.9±5.5	0.36 ± 0.02
Chakhao amubi	10.0 ±0.5	2.6±0.2	14.3±2.1	3.6±0.6	6.4±0.4	63.4	6.2±0.3	58.1±6.6	0.56 ± 0.02
Chakhao poireiton	9.1±0.4	2.2±0.4	14.1±2.0	3.6±0.6	9.3±0.5	61.2	5.5±0.3	57.0 ±6.1	0.74 ± 0.03
Lipya goal	9.3±0.5	2.4±0.2	12.7±1.1	3.3±0.5	5.2±0.3	66.7	4.5±0.2	62.9±6.6	0.49 ± 0.01
Suhagmani	9.1±0.5	2.9±0.3	12.2±1.5	3.4±0.5	6.1±0.4	65.9	4.5±0.2	60.7±6.2	0.40 ± 0.02
Himtu	7.7±0.4	3.9±0.2	11.7±1.4	3.5±0.2	9.1±0.6	64.0	4.4±0.3	58.6±4.1	0.20 ± 0.02
Bohana dhan	8.1±0.9	1.0 ±0.2	6.7±0.8	3.1±0.6	9.8±0.9	71.2	4.7±0.5	64.6±4.5	0.06 ± 0.01
Jhini	7.1±0.3	2.7±0.4	9.6±1.2	4.5±0.4	6.0 ±0.4	69.8	4.4±0.1	66.3±4.1	0.19 ± 0.02
Ramjawain	6.7±0.5	2.8±0.2	9.5±1.3	4.3±0.5	6.1±0.4	71.9	4.5±0.1	66.9±4.9	0.17 ± 0.01
Rangdi	6.8±0.4	3.8±0.2	9.9±1.1	3.6±0.3	7.5±0.5	66.2	3.7±0.3	63.8±3.4	0.04 ± 0.01
Ragalvanji	8.2±0.8	0.8±0.1	9.3±0.9	2.9±0.5	6.7±1.0	72.1	4.4±0.7	64.9±6.5	0.16 ± 0.02
HPR 2143	8.3±0.7	1.2±0.1	8.1±1.0	3.1±0.8	9.5±1.0	69.9	4.2±0.3	64.7±5.7	0.03 ± 0.00

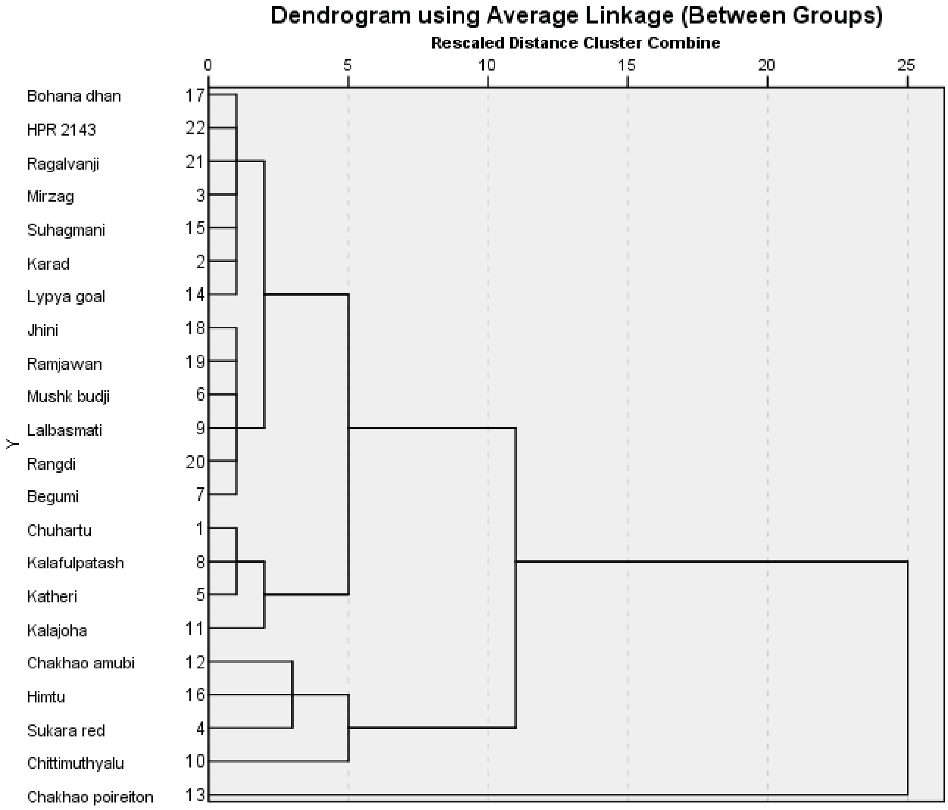

Fig. S1. Dendrogram based on the biochemical values

15.89 and 13.32 mg/g respectively. In comparison to black and red seed rice landraces, white rice landraces and improved check variety HPR-2143 recorded very low CUPRAC (2.2 and 0.95 mg GAE/g) and total phenol content (0.1 and 0.13 g/100g respectively). The dietary fibre content also has shown considerable variation among the landraces studied. This parameter has not shown any correlation with geographic origin or phenotypic characteristics of landrace. The lowest dietary fibre content was recorded in chalky grained Lipya goal (5.2%) and highest in Bohana dhan landrace (9.8%). Ash percent also has shown a great range of variation with minimum 0.77 % in Ragalvanji to maximum being 4.11 % in Mirzag. Crude fat ranged from 2.71 in Sukara to 7.29 in Chuhartu. Overall landraces performed better for all nutritional parameters than the check variety HPR-2143.

Some of the important correlations coefficients among different nutritional traits are given in Table 5. Total protein content was positively correlated with total phosphorus, phytate, anthocyanins, CUPRAC, Cu and Zn content and negatively correlated with total available carbohydrate (CHOAVL) and starch content. Phytate, anthocyanins and total phenol together are positively correlated with CUPRAC activity, protein content and total phosphorus. Zn is positively correlated with Cu and Fe.

Out of twenty one rice landraces studied, eleven rice landraces found superior for one or multiple biochemical nutritional traits (Table 6). But as listed (special remarks) in the Table 1, each and every landrace has its own unique characteristics and local importance. Other important traits (not related to nutrition) possessed by these landraces are seed/grain's physical characteristics like hull colour, aleurone colour, cooking qualities like glutinous/non-glutinous, aroma, adaptation traits like awns, plant height, early maturity, biotic and abiotic stresses tolerance as well as ethnic values.

Discussion

The local rice landraces in subsistence production systems are still popular despite their low yield compared to the high yielding modern varieties. Many of these landraces are under continuous cultivation because of their special taste, aroma, medicinal and nutritional qualities. The popularity of pigmented rice like red rice,

Table 3b. Variations for different nutritional traits in rice landraces from diverse agro-ecologies

Landrace Name	Phytate (g/100g)	Anthocyanin (mg/g)	Total Phenol (g/100g)	CUPRAC (mg GAE/g)	Cu (mg/100g)	Zn (mg/100g)	Fe (mg/100g)	Mg (mg/100g)
Chuhartu	0.49±0.07	4.67±0.02	0.19±0.01	4.5±0.24	0.4±0.06	5.4±0.59	4.5±0.56	91.5±8.5
Karad	0.58±0.06	5.17±0.33	0.16±0.01	5.0±0.11	0.5±0.10	7.8±0.46	4.3±0.67	114.1±6.9
Mirzag	0.85±0.07	3.7±0.11	0.24±0.01	5.2±0.25	0.4±0.11	5.7±0.49	4.7±0.60	115.5±9.5
Sukara	0.86±0.06	3.72±0.27	0.26±0.04	4.3±0.60	0.2±0.03	3.3±0.31	1.8±0.33	125.4±8.0
Katheri	0.38±0.06	3.12±0.9	0.13±0.01	3.6±0.21	0.4±0.06	5.4±1.25	3.4±0.51	90.3±12.7
Mushk budji	0.63±0.09	3.64±0.22	0.03±0.01	2.0 ±0.15	0.8±0.11	5.7±0.78	4.2±0.79	106.3±9.5
Begumi	0.88±0.10	3.44±0.11	0.33±0.02	5.0 ±0.64	0.9±0.08	3.5±0.39	3.5±0.42	99.7±9.3
Kalafulpatash	0.32±0.05	0.62±0.06	0.06±0.01	2.4±0.19	0.7±0.06	6.1±0.38	3.4±0.54	94.2±10.5
Lalbasmati	0.36±0.06	1.91±1.5	0.05±0.01	2.0 ±0.11	0.6±0.07	6.6±0.21	3.9±0.54	101.3±13.2
Chittimuthyalu	0.11±0.03	0.12±0.06	0.15±0.04	1.4±0.41	0.4±0.08	2.6±0.40	3.7±0.32	145.1±18.5
Kalajoha	1.20±0.09	0.88±0.1	0.10 ±0.01	3.1±0.11	2.1±0.08	8.3±0.45	5.5±0.57	100.2±10.3
Chakhao amubi	1.83±0.10	15.89±0.04	0.31±0.01	8.1±0.34	1.4±0.07	7.3±0.55	2.9±0.76	126.9±8.6
Chakhao poireiton	2.56±0.19	13.32±1.37	0.27±0.02	10±0.56	1.4±0.10	4.6±0.87	2.3±0.32	66.8±8.9
Lipya goal	1.65±0.02	1.07±0.08	0.08±0.00	3.3±0.15	1.1±0.12	6.5±0.56	3.9±0.75	112.0 ±9.7
Suhagmani	1.36±0.09	1.86±0.04	0.18±0.01	3.8±0.10	1.5±0.07	6.4±0.77	3.8±0.55	116.7±10.9
Himtu	0.65±0.08	0.12±0.1	0.03±0.00	1.1±0.11	0.4±0.05	4.5±0.18	5.0 ±0.77	136.5±8.6
Bohanadhan	0.18±0.05	0.83±0.04	0.10 ±0.01	0.8±0.04	0.2±0.06	2.6±0.38	2.2±0.33	115.0 ±6.6
Jhini	0.61±0.06	0.27±0.04	0.06±0.01	2.3±0.19	0.6±0.09	6.5±0.08	6.4±0.55	106.4±5.9
Ramjawain	0.54±0.06	0.62±0.02	0.09±0.01	3.1±0.09	0.4±0.08	4.7±0.31	5.2±1.34	109.4±13.1
Rangdi	0.11±0.03	1.34±0.22	0.03±0.01	1.9±0.16	0.5±0.09	6.2±0.07	6.8±0.45	105.4±8.4
Ragalvanji	0.52±0.06	0.49±0.15	0.30 ±0.03	1.0 ±0.27	0.4±0.07	3.2±0.26	1.0 ±0.28	116.4±6.1
HPR 2143	0.07±0.01	0.5±0.01	0.13±0.03	1.0 ±0.19	0.3±0.03	3.3±0.23	3.0 ±0.29	114.0 ±9.1

Table 4. Pattern of variation for nutritional traits among different groups of rice landraces

Landrace group	Moisture	Ash	Protein	CF	DF	CHOAVL	Sugar	Starch	T. Phos	Phytate	Antho-cyanins	Total Phenol	CUPRAC	Cu	Zn	Fe	Mg
Red rice	7.5a	2.9	9.9a	4.8	7.4	67.3b	5.5ab	62b	0.21a	0.6a	3.9ab	0.19ab	4.2ab	0.5a	5.1a	3.7a	106a
Black rice	9.5b	2.4	14.2c	3.5	7.9	62.3a	5.8b	57a	0.65b	2.2b	14.6c	0.29b	9.0c	1.4b	5.2	2.6a	97a
White rice	7.8a	2.5	10.4a	3.9	7.1	68.1b	4.4a	63b	0.19a	0.6a	0.8a	0.10a	2.1a	0.7a	5.9a	4.2a	113a
Aromatic	8.1a	2.6	11.5ab	4.4	6.6	66.6b	4.8ab	61ab	0.24a	0.7a	3.9ab	0.13a	3.4ab	1.0ab	5.3a	3.9a	113a
Non-aromatic	7.7a	2.6	10.3a	4.1	7.5	67.5b	4.9ab	62b	0.24a	0.8a	3.0ab	0.15a	3.5ab	0.6a	6.1a	3.9a	108a
NEH	9.3b	2.5	13.4bc	3.3	7.3	63.8ab	4.9ab	59ab	0.51b	1.7b	6.6b	0.18ab	5.6b	1.5b	6.6a	3.6a	104a
NWH	7.4a	3.0	9.8a	5.2	7.1	67.3b	5.1ab	62b	0.19a	0.6a	3.3ab	0.16a	3.7ab	0.5a	5.5a	3.7a	104a
Overall	7.8	2.7	10.6	4.2	7.2	67.3	4.9	62.2	0.25	0.79	3.2	0.15	3.5	0.73	5.4	3.9	109.3
HPR 2143	8.3	1.2	8.1	3.1	9.5	69.9	4.2	64.7	0.03	0.07	0.5	0.13	1	0.3	3.3	3	114
Normal value*	12.6	1.3	7.6	2.3	3.8	72.4	–	–	0.25	–	–	–	–	0.36	1.9	2.8	52

NWH: North-western Himalayas, NEH: North-eastern Himalayas, CF: crude fat, DF: dietary fat, CHOAVL: total carbohydrate available by difference, T Phos: total phosphorus content; CUPRAC: Cupric Reducing Antioxidant Capacity expressed as gallic acid equivalent (GAE). Superscripts a, b & c demarcate the groups on the basis of significant differences for mean values based on DMRT (Duncan's Multiple Range Test) with α value of 0.05. Values with no superscripts (like for CF%, DF%, Sugar % and Fe) have no differences for the grouping pattern of the rice landraces.

* Source (values for rice, brown, parboiled, home-pounded, raw): Food composition table for Bangladesh (2013) Institute of Nutrition and Food Science, University of Dhaka.

black rice and deep purple rice is partially due to the distinct compositions of phytochemicals, which gives them colour, local taste, and medicinal value and helps in the prevention of different kind of diseases especially associated with oxidative stress (Gunaratne *et al.*, 2013; Hao *et al.*, 2015). The other brown or white local rice landraces are especially grown for their aroma intensity, starch quality and local environmental adaptation like drought, low or high temperature, and better yield performance in low input. Rice landraces in this study are found superior for different nutritional parameters as discussed below.

A significant correlation between rice landrace's habitat and crude fat content was observed, which possibly may be due to the influence of local food taste of geographically isolated local communities and their selection pressure applied on the crop. But further study is required to assess the impact of local food taste on the nutritional diversity of crop plants. This trait can have commercial importance as rice fat is known to have high level of essential poly unsaturated fatty acids particularly oleic acid and linoleic acid (Yasumatsu and Moritaka, 1964). Rice fat also has been reported to help in lowering blood cholesterol (Rege *et al.*, 2014; Chithra *et al.*, 2015), acting as antioxidant (Bopitiya and Madhujith, 2014). The fat is also rich source of gamma-oryzanol and vitamin E (tocopherol and tocotrienols) which are good antioxidants (Min *et al.*, 2011). Similarly another significant correlation was observed between protein content and landrace's geographical origin. NEH originated rice landraces were higher in protein content than the rice landraces from NWH ascertained that not only climatic conditions, but the local traditions and food taste preferences plays an important role on existing pattern of genetic diversity of local landraces. Further it indicates that the existence of landrace diversity depends on various types of interactions between climatic conditions and human interventions like type of local farming practices, local food taste, local ritual and ethnic activities, medicinal use awareness, seed storage and sharing practices, etc. Another significant and useful correlation was observed between aleurone colour and protein content; rice with black aleurone colour found to have higher protein content than prevalent aleurone colored i.e. whitish-brown aleurone coloured rice landraces. This correlation as well as these genotypes (with >14% protein content) can be very useful in breeding rice varieties with enhanced protein content. Literature shows that the average protein content in the HYVs of rice is around six to nine percent; however some biochemical studies shows that the rice landraces have up to fourteen percent of protein content (Frei and Becker, 2004). This trait is of special significance as rice is a second major human food and therefore it can play vital role in nutritional quality improvement of human society. Rice protein have favorable amino acid composition with a high proportion of lysine and a high protein digestibility thereby increasing the biological value of the rice protein comparative to proteins of other cereals and pulses (Jolliet *et al.*,1998). The black rice landraces were also found superior for other important nutritional compounds like total phosphorus, anthocyanins, anti-oxidant activity and phytate. The phytic acid which was once considered as anti-nutritional compound due to its strong binding affinity for minerals such as calcium, magnesium, iron, copper, and zinc, making them unavailable for absorption in the intestines, is now a beneficial compound as it reduces starch digestibility which is good for diabetic patients. A study indicates that increase in phytic acid by

Table 5. Pearson correlation coefficient matrix for all biochemical traits

	Moist-ure	Ash	Protein	CF	DF	CHO-AVL	Sugar	Starch	TPhos	Phy-tate	Antho-cyanin	Total Phenol	Phy+ Anth+ Phe	CUP-RAC	Cu	Zn	Fe
Ash	-0.25	1.00															
Protein	0.46*	0.21	1.00														
CF	-0.50*	0.42	-0.07	1.00													
DF	-0.06	-0.02	0.05	-0.08	1.00												
CHOAVL	-0.27	-0.48*	-0.77**	-0.29	-0.47*	1.00											
Sugar	0.00	0.02	0.18	-0.08	-0.09	-0.03	1.00										
Starch	-0.27	-0.37	-0.75**	-0.20	-0.45*	0.92**	-0.26	1.00									
TPhos	0.69**	0.07	0.80**	-0.22	-0.06	-0.57**	0.30	-0.56**	1.00								
Phytate	0.70**	0.06	0.79**	-0.25	-0.05	-0.56**	0.28	-0.54**	1.00**	1.00							
Anthocyanin	0.44*	0.03	0.55**	0.02	0.08	-0.50*	0.46*	-0.50*	0.72**	0.70**	1.00						
Total Phenol	0.43*	-0.34	0.14	-0.35	-0.10	0.07	0.49*	-0.09	0.44*	0.44*	0.57**	1.00					
Phy+ Anth+ Phe	.0.65**	0.01	0.72**	-0.18	-0.01	-0.54**	0.41	-0.55**	0.55**	0.94**	0.89**	0.60**	1.00				
CUPRAC	0.40	0.12	0.59**	0.00	0.01	-0.50*	0.43*	-0.47*	0.81**	0.81**	0.89**	0.62**	0.92**	1.00			
Cu	0.63**	0.02	0.81**	-0.20	-0.01	-0.58**	0.06	-0.57**	0.73**	0.73**	0.37	0.16	0.6**	0.46*	1.00		
Zn	0.11	0.42*	0.59**	0.36	-0.04	-0.61**	-0.25	-0.40	0.33	0.31	0.22	-0.26	0.25	0.28	0.56**	1.00	
Fe	-0.47*	0.54**	0.15	0.22	0.08	-0.21	-0.25	-0.04	-0.19	-0.20	-0.29	-0.50**	-0.30	-0.17	0.09	0.53*	1.00
Mg	0.00	-0.11	-0.16	-0.99*	-0.25	0.45*	0.11	0.29	-0.30	-0.29	-0.27	-0.02	-0.29	-0.42	-0.29	-0.25	-0.03

* Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level.

Table 6. Rice landraces superior for one or multiple nutritional traits studied

Landrace	Nutritional Trait
Chuhartu	High crude fat (7.29%)
Mirzag	Ash content (4.10%)
Mushk budji	High sugar (6.56%)
Begumi	High phenols (0.33 g/100g)
Lalbasmati	Low sugar (3.59%)
Bohana dhan	Dietary fibre (9.79%)
Rangdi	Low phytate (0.11 g/100g), high Fe (6.78 mg/100g)
Chittimuthyalu	Low phytate (0.11 g/100g), high Mg (145 mg/100g)
Kalajoha	High Cu (2.1 mg/100 g) and Zn content (8.26 mg/100 g)
Chakhao amubi	High protein (14.3%), high anthocyanin (15.89 mg/g), high total phenol (0.31 g/100g), high CUPRAC (8.1 mg GAE/g)
Chakhao poireiton	High protein (14.1%), total phosphorus (0.74 g/100g); high phytate (2.56 g/ 100g), high CUPRAC (10 mg GAE/g) and high anthocyanin (13.32 mg/g)

Table S1. Total variance explained (Eigen values) and its principal component traits

	PC1	PC2	PC3	PC4	PC5
Total	7.591	3.593	1.742	1.403	1.180
% of Variance	42.170	19.962	9.680	7.794	6.558
Cumulative %	42.170	62.132	71.811	79.605	86.163
Moisture	.642	.403	.471	-.141	-.152
Ash	.131	-.683	-.188	.327	.289
Protein	.853	-.261	.259	.069	.177
CF	-.094	-.625	-.559	.185	-.353
DF	.093	-.251	-.157	-.882	.230
CHOAVL	-.730	.588	.063	.277	-.100
Sugar	.337	.353	-.502	.240	.515
Starch	-.723	.402	.134	.310	-.295
TPhos	.948	.119	.127	.096	-.051
Phytate	.939	.135	.142	.085	-.052
Anthocyanin	.819	.177	-.358	.060	-.003
Total Phenol	.466	.703	-.267	.041	-.006
Phy+Anth+Phe	.954	.223	-.083	.080	-.034
CUPRAC	.865	.123	-.323	.154	-.089
Cu	.763	-.152	.462	-.003	-.079
Zn	.428	-.685	.262	.255	-.159
Fe	-.157	-.761	.203	.241	.217
Mg	-.361	.341	.370	.233	.641

2% can reduce starch digestibility up to 50% (Yoon *et al.*, 1983). It also increases intestinal immunity, and acts as natural anti-oxidant and anti-neoplastic (anti-cancer) agent (Fox and Eberl, 2002; Pacheco *et al.*, 2012; Goufo and Trindade, 2014). Therefore, genotypes containing higher or lower phytic acid can be appropriately used as per need.

The rice landraces with red, black or purple pericarp colors have comparatively higher amount of phenolic compounds, antioxidant activity and anthocyanin content than the light brown or white pericarp colored ones. Various previous studies also have shown that the concentration of bran colour is positively correlated with the antioxidant activity, total phenol and total flavonoids content (Shen *et al.*, 2009; Min *et al.*, 2011; Sutharut and Sudarat, 2012). In a similar study over sevenfold higher total antioxidant capacity and phenolic content was observed in Sri Lankan traditional red rice varieties than improved light brown-grained new-improved varieties (Gunaratne *et al.*, 2013). Several studies indicate that the antioxidant activity is cumulatively effect governed by anthocyanins, members of flavonoids family and other phenolic compounds (Iqbal *et al.*, 2005; Yawadio *et al.*, 2007; Tabart *et al.*, 2009). Anthocyanin also helps in slow release of glucose from rice starch during cooking of parboiled rice (Perera and Jansz, 2000).

Diversity analysis based on Duncan's Multiple Range Test (DMRT) and least significant differences (LSD) indicate that the rice landraces' nutritional diversity within and among the groups did not differ significantly for crude fat, dietary fibre, sugar and Fe content (Table 4 and Supplementary Table 2). Total available carbohydrate was observed as low as 61.2% in Chakhao poireiton which is significantly lower than the reported range of 75-85 % available carbohydrates in brown rice while white milled rice composed of as much as 90% carbohydrates. Higher starch content in the rice is considered as the poor quality food for diabetic patients, because rice starch is usually digested quite rapidly compared to other starch and this leads to a prompt and pronounced increase of the blood glucose level after the ingestion of rice, similar to that of white bread or pure glucose and can induce type II diabetes (i.e. non-insulin dependent diabetes) in adults. Frei and Becker (2003) also reported that rice landraces having slow digestion give a relatively long feeling of satiation.

Clustering analysis (Supplementary Figure 1) of landraces based on their biochemical composition reflects that nutritional parameters are randomly distributed with respect to their quantity among landraces irrespective of their geographical origin or their specialties like aleurone colour, aroma, etc. However, as discussed above each nutritional parameter might have influence of local food preferences or local rituals, etc.

Table S2.Group wise multiple comparisons for least significant differences (LSD) using mean values of biochemical traits.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Moisture	Red rice	Black rice	-2.08*	.79	.01	-3.66	-.51
		White rice	-0.34	0.47	0.47	-1.27	0.60
		Aromatic rice	-0.66	0.57	0.25	-1.81	0.49
		Non-aromatic rice	-0.31	0.44	0.49	-1.20	0.59
		NEH rice	-1.87*	0.57	0.00	-3.03	-0.73
		NWH rice	0	0.49	0.99	-1.00	0.99
	Black rice	Red rice	2.08*	0.79	0.01	0.51	3.66
		White rice	1.74*	0.75	0.02	0.24	3.25
		Aromatic rice	1.42	0.82	0.09	-0.23	3.07
		Non-aromatic rice	1.77*	0.73	0.02	0.30	3.25
		NEH rice	0.2	0.82	0.81	-1.44	1.85
		NWH rice	2.07*	0.77	0.01	0.54	3.62
	White rice	Red rice	0.34	0.47	0.47	-0.60	1.27
		Black rice	-1.74*	0.75	0.02	-3.25	-0.24
		Aromatic rice	-0.33	0.52	0.53	-1.37	0.72
		Non-aromatic rice	0.03	0.37	0.93	-0.72	0.78
		NEH rice	-1.54*	0.52	0.00	-2.59	-0.50
		NWH rice	0.33	0.43	0.45	-0.54	1.20
	Aromatic rice	Red rice	0.66	0.57	0.25	-0.49	1.81
		Black rice	-1.42	0.82	0.09	-3.07	0.23
		White rice	0.33	0.52	0.53	-0.72	1.37
		Non-aromatic rice	0.36	0.50	0.48	-0.65	1.37
		NEH rice	-1.22	0.62	0.06	-2.46	0.03
		NWH rice	0.66	0.55	0.23	-0.44	1.76
	Non-aromatic rice	Red rice	0.31	0.44	0.49	-0.59	1.20
		Black rice	-1.77*	0.73	0.02	-3.25	-0.30
		White rice	-0.03	0.37	0.93	-0.78	0.72
		Aromatic rice	-0.36	0.50	0.48	-1.37	0.65
		NEH rice	-1.57*	0.50	0.00	-2.58	-0.57
		NWH rice	0.3	0.41	0.46	-0.52	1.12
	NEH rice	Red rice	1.87*	0.57	0.00	0.73	3.03
		Black rice	-0.2	0.82	0.81	-1.85	1.44
		White rice	1.54*	0.52	0.00	0.50	2.59
		Aromatic rice	1.22	0.62	0.06	-0.03	2.46
		Non-aromatic rice	1.57*	0.50	0.00	0.57	2.58
		NWH rice	1.87*	0.55	0.00	0.78	2.97
	NWH rice	Red rice	0	0.49	0.99	-0.99	1.00
		Black rice	-2.07*	0.77	0.01	-3.62	-0.54
		White rice	-0.33	0.43	0.45	-1.20	0.54
		Aromatic rice	-0.66	0.55	0.23	-1.76	0.44
		Non-aromatic rice	-0.3	0.41	0.46	-1.12	0.52
		NEH rice	-1.87*	0.55	0.00	-2.97	-0.78
Ash	Red rice	Black rice	0.51	0.68	0.46	-0.86	1.89
		White rice	0.36	0.41	0.38	-0.46	1.17
		Aromatic rice	0.29	0.50	0.57	-0.72	1.29
		Non-aromatic rice	0.24	0.39	0.53	-0.54	1.02
		NEH rice	0.4	0.50	0.42	-0.60	1.41
		NWH rice	-0.08	0.43	0.86	-0.94	0.79
	Black rice	Red rice	-0.51	0.68	0.46	-1.89	0.86
		White rice	-0.15	0.65	0.81	-1.46	1.15
		Aromatic rice	-0.22	0.71	0.76	-1.66	1.21
		Non-aromatic rice	-0.27	0.64	0.67	-1.56	1.02
		NEH rice	-0.11	0.71	0.88	-1.54	1.33
		NWH rice	-0.59	0.67	0.38	-1.93	0.75

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	White rice	Red rice	-0.36	0.41	0.38	-1.17	0.46
		Black rice	0.15	0.65	0.81	-1.15	1.46
		Aromatic rice	-0.07	0.45	0.88	-0.98	0.84
		Non-aromatic rice	-0.12	0.33	0.72	-0.77	0.54
		NEH rice	0.05	0.45	0.92	-0.86	0.96
		NWH rice	-0.43	0.38	0.25	-1.19	0.32
	Aromatic rice	Red rice	-0.29	0.50	0.57	-1.29	0.72
		Black rice	0.22	0.71	0.76	-1.21	1.66
		White rice	0.07	0.45	0.88	-0.84	0.98
		Non-aromatic rice	-0.05	0.44	0.92	-0.92	0.83
		NEH rice	0.12	0.54	0.83	-0.97	1.20
		NWH rice	-0.37	0.48	0.45	-1.32	0.59
	Non-aromatic rice	Red rice	-0.24	0.39	0.53	-1.02	0.54
		Black rice	0.27	0.64	0.67	-1.02	1.56
		White rice	0.12	0.33	0.72	-0.54	0.77
		Aromatic rice	0.05	0.44	0.92	-0.83	0.92
		NEH rice	0.16	0.44	0.71	-0.72	1.04
		NWH rice	-0.32	0.36	0.37	-1.03	0.39
	NEH rice	Red rice	-0.4	0.50	0.42	-1.41	0.60
		Black rice	0.11	0.71	0.88	-1.33	1.54
		White rice	-0.05	0.45	0.92	-0.96	0.86
		Aromatic rice	-0.12	0.54	0.83	-1.20	0.97
		Non-aromatic rice	-0.16	0.44	0.71	-1.04	0.72
		NWH rice	-0.48	0.48	0.32	-1.44	0.47
	NWH rice	Red rice	0.08	0.43	0.86	-0.79	0.94
		Black rice	0.59	0.67	0.38	-0.75	1.93
		White rice	0.43	0.38	0.25	-0.32	1.19
		Aromatic rice	0.37	0.48	0.45	-0.59	1.32
		Non-aromatic rice	0.32	0.36	0.37	-0.39	1.03
		NEH rice	0.48	0.48	0.32	-0.47	1.44
Protein	Red rice	Black rice	-4.28*	1.27	0.00	-6.83	-1.73
		White rice	-0.51	0.75	0.50	-2.03	1.00
		Aromatic rice	-1.67	0.93	0.08	-3.53	0.19
		Non-aromatic rice	-0.4	0.72	0.58	-1.84	1.04
		NEH rice	-3.54*	0.93	0.00	-5.40	-1.68
		NWH rice	0.07	0.80	0.93	-1.54	1.67
	Black rice	Red rice	4.2*	1.27	0.00	1.73	6.83
		White rice	3.76*	1.21	0.00	1.34	6.20
		Aromatic rice	2.61	1.32	0.05	-0.05	5.27
		Non-aromatic rice	3.88*	1.19	0.00	1.50	6.27
		NEH rice	0.74	1.32	0.58	-1.92	3.40
		NWH rice	4.34*	1.24	0.00	1.86	6.83
	White rice	Red rice	0.51	0.75	0.50	-1.00	2.03
		Black rice	-3.76*	1.21	0.00	-6.20	-1.34
		Aromatic rice	-1.16	0.84	0.18	-2.85	0.54
		Non-aromatic rice	0.12	0.60	0.85	-1.10	1.33
		NEH rice	-3.02*	0.84	0.00	-4.72	-1.33
		NWH rice	0.58	0.70	0.41	-0.82	1.98
	Aromatic rice	Red rice	1.67	0.93	0.08	-0.19	3.53
		Black rice	-2.61	1.32	0.05	-5.27	0.05
		White rice	1.16	0.84	0.18	-0.54	2.85
		Non-aromatic rice	1.27	0.81	0.12	-0.36	2.90
		NEH rice	-1.87	1.00	0.07	-3.88	0.14
		NWH rice	1.74	0.88	0.05	-0.04	3.51

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	Non-aromatic rice	Red rice	0.4	0.72	0.58	-1.04	1.84
		Black rice	-3.88*	1.19	0.00	-6.27	-1.50
		White rice	-0.12	0.60	0.85	-1.33	1.10
		Aromatic rice	-1.27	0.81	0.12	-2.90	0.36
		NEH rice	-3.14*	0.81	0.00	-4.77	-1.51
		NWH rice	0.47	0.66	0.48	-0.86	1.79
	NEH rice	Red rice	3.54*	0.93	0.00	1.68	5.40
		Black rice	-0.74	1.32	0.58	-3.40	1.92
		White rice	3.02*	0.84	0.00	1.33	4.72
		Aromatic rice	1.87	1.00	0.07	-0.14	3.88
		Non-aromatic rice	3.14*	0.81	0.00	1.51	4.77
		NWH rice	3.60*	0.88	0.00	1.83	5.38
	NWH rice	Red rice	-0.07	0.80	0.93	-1.67	1.54
		Black rice	-4.34*	1.24	0.00	-6.83	-1.86
		White rice	-0.58	0.70	0.41	-1.98	0.82
		Aromatic rice	-1.74	0.88	0.05	-3.51	0.04
		Non-aromatic rice	-0.47	0.66	0.48	-1.79	0.86
		NEH rice	-3.60*	0.88	0.00	-5.38	-1.83
CF	Red rice	Black rice	1.31	1.14	0.26	-0.99	3.61
		White rice	0.94	0.68	0.17	-0.42	2.30
		Aromatic rice	0.46	0.84	0.58	-1.22	2.14
		Non-aromatic rice	0.73	0.65	0.27	-0.57	2.02
		NEH rice	1.47	0.84	0.08	-0.21	3.15
		NWH rice	-0.32	0.72	0.66	-1.76	1.13
	Black rice	Red rice	-1.31	1.14	0.26	-3.61	0.99
		White rice	-0.37	1.09	0.74	-2.56	1.82
		Aromatic rice	-0.85	1.19	0.48	-3.25	1.55
		Non-aromatic rice	-0.59	1.07	0.59	-2.74	1.56
		NEH rice	0.16	1.19	0.89	-2.24	2.56
		NWH rice	-1.63	1.12	0.15	-3.87	0.61
	White rice	Red rice	-0.94	0.68	0.17	-2.30	0.42
		Black rice	0.37	1.09	0.74	-1.82	2.56
		Aromatic rice	-0.48	0.76	0.53	-2.01	1.04
		Non-aromatic rice	-0.21	0.54	0.69	-1.31	0.88
		NEH rice	0.53	0.76	0.49	-1.00	2.06
		NWH rice	-1.26	0.63	0.05	-2.52	0.01
	Aromatic rice	Red rice	-0.46	0.84	0.58	-2.14	1.22
		Black rice	0.85	1.19	0.48	-1.55	3.25
		White rice	0.48	0.76	0.53	-1.04	2.01
		Non-aromatic rice	0.27	0.73	0.72	-1.20	1.73
		NEH rice	1.01	0.90	0.27	-0.80	2.82
		NWH rice	-0.78	0.80	0.33	-2.37	0.82
	Non-aromatic rice	Red rice	-0.73	0.65	0.27	-2.02	0.57
		Black rice	0.59	1.07	0.59	-1.56	2.74
		White rice	0.21	0.54	0.69	-0.88	1.31
		Aromatic rice	-0.27	0.73	0.72	-1.73	1.20
		NEH rice	0.74	0.73	0.31	-0.72	2.21
		NWH rice	-1.04	0.59	0.09	-2.24	0.15
	NEH rice	Red rice	-1.47	0.84	0.08	-3.15	0.21
		Black rice	-0.16	1.19	0.89	-2.56	2.24
		White rice	-0.53	0.76	0.49	-2.06	1.00
		Aromatic rice	-1.01	0.90	0.27	-2.82	0.80
		Non-aromatic rice	-0.74	0.73	0.31	-2.21	0.72
		NWH rice	-1.78*	0.80	0.03	-3.39	-0.19

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	NWH rice	Red rice	0.32	0.72	0.66	-1.13	1.76
		Black rice	1.63	1.12	0.15	-0.61	3.87
		White rice	1.26	0.63	0.05	-0.01	2.52
		Aromatic rice	0.78	0.80	0.33	-0.82	2.37
		Non-aromatic rice	1.04	0.59	0.09	-0.15	2.24
		NEH rice	1.78*	0.80	0.03	0.19	3.39
DF	Red rice	Black rice	-0.46	1.35	0.74	-3.17	2.25
		White rice	0.37	0.80	0.65	-1.24	1.97
		Aromatic rice	0.88	0.98	0.37	-1.09	2.86
		Non-aromatic rice	-0.06	0.76	0.94	-1.59	1.47
		NEH rice	0.1	0.98	0.92	-1.87	2.08
		NWH rice	0.33	0.85	0.70	-1.37	2.04
	Black rice	Red rice	0.46	1.35	0.74	-2.25	3.17
		White rice	0.82	1.28	0.52	-1.76	3.40
		Aromatic rice	1.34	1.41	0.34	-1.49	4.17
		Non-aromatic rice	0.4	1.26	0.75	-2.13	2.93
		NEH rice	0.56	1.41	0.69	-2.26	3.39
		NWH rice	0.79	1.31	0.55	-1.85	3.43
	White rice	Red rice	-0.37	0.80	0.65	-1.97	1.24
		Black rice	-0.82	1.28	0.52	-3.40	1.76
		Aromatic rice	0.52	0.89	0.57	-1.28	2.32
		Non-aromatic rice	-0.43	0.64	0.51	-1.72	0.86
		NEH rice	-0.26	0.89	0.77	-2.06	1.54
		NWH rice	-0.03	0.74	0.96	-1.52	1.46
	Aromatic rice	Red rice	-0.88	0.98	0.37	-2.86	1.09
		Black rice	-1.34	1.41	0.34	-4.17	1.49
		White rice	-0.52	0.89	0.57	-2.32	1.28
		Non-aromatic rice	-0.94	0.86	0.28	-2.67	0.79
		NEH rice	-0.78	1.06	0.47	-2.92	1.36
		NWH rice	-0.55	0.94	0.56	-2.44	1.33
	Non-aromatic rice	Red rice	0.06	0.76	0.94	-1.47	1.59
		Black rice	-0.4	1.26	0.75	-2.93	2.13
		White rice	0.43	0.64	0.51	-0.86	1.72
		Aromatic rice	0.94	0.86	0.28	-0.79	2.67
		NEH rice	0.16	0.86	0.85	-1.57	1.89
		NWH rice	0.39	0.70	0.58	-1.02	1.80
	NEH rice	Red rice	-0.1	0.98	0.92	-2.08	1.87
		Black rice	-0.56	1.41	0.69	-3.39	2.26
		White rice	0.26	0.89	0.77	-1.54	2.06
		Aromatic rice	0.78	1.06	0.47	-1.36	2.92
		Non-aromatic rice	-0.16	0.86	0.85	-1.89	1.57
		NWH rice	0.23	0.94	0.81	-1.66	2.11
	NWH rice	Red rice	-0.33	0.85	0.70	-2.04	1.37
		Black rice	-0.79	1.31	0.55	-3.43	1.85
		White rice	0.03	0.74	0.96	-1.46	1.52
		Aromatic rice	0.55	0.94	0.56	-1.33	2.44
		Non-aromatic rice	-0.39	0.70	0.58	-1.80	1.02
		NEH rice	-0.23	0.94	0.81	-2.11	1.66
CHOAVL	Red rice	Black rice	5	2.56	0.06	-0.15	10.15
		White rice	-0.81	1.52	0.59	-3.87	2.24
		Aromatic rice	0.7	1.87	0.71	-3.06	4.46
		Non-aromatic rice	-0.21	1.45	0.89	-3.12	2.71
		NEH rice	3.44	1.87	0.07	-0.32	7.20
		NWH rice	0	1.61	1.00	-3.24	3.24

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	Black rice	Red rice	-5	2.56	0.06	-10.15	0.15
		White rice	-5.81*	2.44	0.02	-10.72	-0.91
		Aromatic rice	-4.3	2.67	0.11	-9.67	1.08
		Non-aromatic rice	-5.20*	2.40	0.03	-10.02	-0.39
		NEH rice	-1.56	2.67	0.56	-6.93	3.82
		NWH rice	-5	2.50	0.05	-10.02	0.02
	White rice	Red rice	0.81	1.52	0.59	-2.24	3.87
		Black rice	5.81*	2.44	0.02	0.91	10.72
		Aromatic rice	1.52	1.70	0.38	-1.90	4.93
		Non-aromatic rice	0.61	1.22	0.62	-1.84	3.06
		NEH rice	4.25*	1.70	0.02	0.84	7.67
		NWH rice	0.81	1.41	0.57	-2.02	3.65
	Aromatic rice	Red rice	-0.7	1.87	0.71	-4.46	3.06
		Black rice	4.3	2.67	0.11	-1.08	9.67
		White rice	-1.52	1.70	0.38	-4.93	1.90
		Non-aromatic rice	-0.91	1.64	0.58	-4.20	2.38
		NEH rice	2.74	2.02	0.18	-1.32	6.80
		NWH rice	-0.7	1.78	0.70	-4.28	2.88
	Non-aromatic rice	Red rice	0.21	1.45	0.89	-2.71	3.12
		Black rice	5.20*	2.40	0.03	0.39	10.02
		White rice	-0.61	1.22	0.62	-3.06	1.84
		Aromatic rice	0.91	1.64	0.58	-2.38	4.20
		NEH rice	3.64*	1.64	0.03	0.36	6.94
		NWH rice	0.2	1.33	0.88	-2.47	2.88
	NEH rice	Red rice	-3.44	1.87	0.07	-7.20	0.32
		Black rice	1.56	2.67	0.56	-3.82	6.93
		White rice	-4.25*	1.70	0.02	-7.67	-0.84
		Aromatic rice	-2.74	2.02	0.18	-6.80	1.32
		Non-aromatic rice	-3.64*	1.64	0.03	-6.94	-0.36
		NWH rice	-3.44	1.78	0.06	-7.02	0.14
	NWH rice	Red rice	0	1.61	1.00	-3.24	3.24
		Black rice	5	2.50	0.05	-0.02	10.02
		White rice	-0.81	1.41	0.57	-3.65	2.02
		Aromatic rice	0.7	1.78	0.70	-2.88	4.28
		Non-aromatic rice	-0.2	1.33	0.88	-2.88	2.47
		NEH rice	3.44	1.78	0.06	-0.14	7.02
Sugar	Red rice	Black rice	-0.29	0.70	0.68	-1.69	1.12
		White rice	1.12*	0.41	0.01	0.29	1.95
		Aromatic rice	0.72	0.51	0.16	-0.30	1.75
		Non-aromatic rice	0.58	0.39	0.15	-0.21	1.37
		NEH rice	0.55	0.51	0.28	-0.47	1.58
		NWH rice	0.4	0.44	0.36	-0.48	1.28
	Black rice	Red rice	0.29	0.70	0.68	-1.12	1.69
		White rice	1.41*	0.67	0.04	0.07	2.75
		Aromatic rice	1.01	0.73	0.17	-0.45	2.48
		Non-aromatic rice	0.87	0.65	0.19	-0.44	2.18
		NEH rice	0.84	0.73	0.25	-0.62	2.31
		NWH rice	0.69	0.68	0.32	-0.68	2.06
	White rice	Red rice	-1.12*	0.41	0.01	-1.95	-0.29
		Black rice	-1.41*	0.67	0.04	-2.75	-0.07
		Aromatic rice	-0.4	0.46	0.39	-1.33	0.53
		Non-aromatic rice	-0.54	0.33	0.11	-1.21	0.13
		NEH rice	-0.57	0.46	0.23	-1.50	0.36
		NWH rice	-0.72	0.38	0.07	-1.49	0.05

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	Aromatic rice	Red rice	-0.72	0.51	0.16	-1.75	0.30
		Black rice	-1.01	0.73	0.17	-2.48	0.45
		White rice	0.4	0.46	0.39	-0.53	1.33
		Non-aromatic rice	-0.14	0.45	0.75	-1.04	0.75
		NEH rice	-0.17	0.55	0.76	-1.27	0.94
		NWH rice	-0.32	0.49	0.51	-1.30	0.66
	Non-aromatic rice	Red rice	-0.58	0.39	0.15	-1.37	0.21
		Black rice	-0.87	0.65	0.19	-2.18	0.44
		White rice	0.54	0.33	0.11	-0.13	1.21
		Aromatic rice	0.14	0.45	0.75	-0.75	1.04
		NEH rice	-0.03	0.45	0.96	-0.92	0.87
		NWH rice	-0.18	0.36	0.63	-0.91	0.55
	NEH rice	Red rice	-0.55	0.51	0.28	-1.58	0.47
		Black rice	-0.84	0.73	0.25	-2.31	0.62
		White rice	0.57	0.46	0.23	-0.36	1.50
		Aromatic rice	0.17	0.55	0.76	-0.94	1.27
		Non-aromatic rice	0.03	0.45	0.96	-0.87	0.92
		NWH rice	-0.15	0.49	0.76	-1.13	0.82
	NWH rice	Red rice	-0.4	0.44	0.36	-1.28	0.48
		Black rice	-0.69	0.68	0.32	-2.06	0.68
		White rice	0.72	0.38	0.07	-0.05	1.49
		Aromatic rice	0.32	0.49	0.51	-0.66	1.30
		Non-aromatic rice	0.18	0.36	0.63	-0.55	0.91
		NEH rice	0.15	0.49	0.76	-0.82	1.13
Starch	Red rice	Black rice	4.51	2.37	0.06	-0.25	9.26
		White rice	-0.94	1.40	0.51	-3.76	1.88
		Aromatic rice	0.99	1.73	0.57	-2.48	4.47
		Non-aromatic rice	-0.45	1.34	0.74	-3.14	2.24
		NEH rice	2.92	1.73	0.10	-0.55	6.40
		NWH rice	-0.2	1.49	0.89	-3.19	2.79
	Black rice	Red rice	-4.51	2.37	0.06	-9.26	0.25
		White rice	-5.44*	2.25	0.02	-9.98	-0.92
		Aromatic rice	-3.51	2.47	0.16	-8.48	1.45
		Non-aromatic rice	-4.95*	2.21	0.03	-9.41	-0.51
		NEH rice	-1.58	2.47	0.52	-6.55	3.38
		NWH rice	-4.70*	2.31	0.05	-9.34	-0.07
	White rice	Red rice	0.94	1.40	0.51	-1.88	3.76
		Black rice	5.44*	2.25	0.02	0.92	9.98
		Aromatic rice	1.93	1.57	0.22	-1.23	5.09
		Non-aromatic rice	0.49	1.13	0.67	-1.78	2.75
		NEH rice	3.86*	1.57	0.02	0.71	7.02
		NWH rice	0.74	1.30	0.57	-1.88	3.35
	Aromatic rice	Red rice	-0.99	1.73	0.57	-4.47	2.48
		Black rice	3.51	2.47	0.16	-1.45	8.48
		White rice	-1.93	1.57	0.22	-5.09	1.23
		Non-aromatic rice	-1.44	1.51	0.34	-4.48	1.59
		NEH rice	1.93	1.87	0.31	-1.82	5.68
		NWH rice	-1.19	1.65	0.47	-4.50	2.12
	Non-aromatic rice	Red rice	0.45	1.34	0.74	-2.24	3.14
		Black rice	4.95*	2.21	0.03	0.51	9.41
		White rice	-0.49	1.13	0.67	-2.75	1.78
		Aromatic rice	1.44	1.51	0.34	-1.59	4.48
		NEH rice	3.37*	1.51	0.03	0.34	6.41
		NWH rice	0.25	1.23	0.84	-2.22	2.72

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	NEH rice	Red rice	-2.92	1.73	0.10	-6.40	0.55
		Black rice	1.58	2.47	0.52	-3.38	6.55
		White rice	-3.86*	1.57	0.02	-7.02	-0.71
		Aromatic rice	-1.93	1.87	0.31	-5.68	1.82
		Non-aromatic rice	-3.37*	1.51	0.03	-6.41	-0.34
		NWH rice	-3.12	1.65	0.06	-6.43	0.19
	NWH rice	Red rice	0.2	1.49	0.89	-2.79	3.19
		Black rice	4.70*	2.31	0.05	0.07	9.34
		White rice	-0.74	1.30	0.57	-3.35	1.88
		Aromatic rice	1.19	1.65	0.47	-2.12	4.50
		Non-aromatic rice	-0.25	1.23	0.84	-2.72	2.22
		NEH rice	3.12	1.65	0.06	-0.19	6.43
TPhosg100g	Red rice	Black rice	-.43*	0.12	0.00	-0.67	-0.20
		White rice	0.02	0.07	0.81	-0.12	0.15
		Aromatic rice	-0.03	0.08	0.74	-0.20	0.14
		Non-aromatic rice	-0.03	0.07	0.61	-0.16	0.10
		NEH rice	-.29*	0.08	0.00	-0.47	-0.13
		NWH rice	0.02	0.07	0.77	-0.12	0.17
	Black rice	Red rice	.43*	0.12	0.00	0.20	0.67
		White rice	.45*	0.11	0.00	0.23	0.67
		Aromatic rice	.40*	0.12	0.00	0.17	0.65
		Non-aromatic rice	.40*	0.11	0.00	0.19	0.62
		NEH rice	0.14	0.12	0.25	-0.10	0.38
		NWH rice	.45*	0.11	0.00	0.23	0.68
	White rice	Red rice	-0.02	0.07	0.81	-0.15	0.12
		Black rice	-.45*	0.11	0.00	-0.67	-0.23
		Aromatic rice	-0.04	0.08	0.57	-0.20	0.11
		Non-aromatic rice	-0.05	0.05	0.37	-0.16	0.06
		NEH rice	-.31*	0.08	0.00	-0.47	-0.16
		NWH rice	0	0.06	0.94	-0.12	0.13
	Aromatic rice	Red rice	0.03	0.08	0.74	-0.14	0.20
		Black rice	-.40*	0.12	0.00	-0.65	-0.17
		White rice	0.04	0.08	0.57	-0.11	0.20
		Non-aromatic rice	-0.01	0.07	0.93	-0.15	0.14
		NEH rice	-.26*	0.09	0.00	-0.45	-0.09
		NWH rice	0.05	0.08	0.55	-0.11	0.21
	Non-aromatic rice	Red rice	0.03	0.07	0.61	-0.10	0.16
		Black rice	-.40*	0.11	0.00	-0.62	-0.19
		White rice	0.05	0.05	0.37	-0.06	0.16
		Aromatic rice	0.01	0.07	0.93	-0.14	0.15
		NEH rice	-.26*	0.07	0.00	-0.41	-0.12
		NWH rice	0.05	0.06	0.37	-0.07	0.17
	NEH rice	Red rice	.29*	0.08	0.00	0.13	0.47
		Black rice	-0.14	0.12	0.25	-0.38	0.10
		White rice	.31*	0.08	0.00	0.16	0.47
		Aromatic rice	.26*	0.09	0.00	0.09	0.45
		Non-aromatic rice	.26*	0.07	0.00	0.12	0.41
		NWH rice	.31*	0.08	0.00	0.16	0.48
	NWH rice	Red rice	-0.02	0.07	0.77	-0.17	0.12
		Black rice	-.45*	0.11	0.00	-0.68	-0.23
		White rice	0	0.06	0.94	-0.13	0.12
		Aromatic rice	-0.05	0.08	0.55	-0.21	0.11
		Non-aromatic rice	-0.05	0.06	0.37	-0.17	0.07
		NEH rice	-.31*	0.08	0.00	-0.48	-0.16

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Phytateg100g	Red rice	Black rice	-1.52*	0.40	0.00	-2.34	-0.71
		White rice	0.03	0.24	0.89	-0.45	0.52
		Aromatic rice	-0.1	0.30	0.75	-0.69	0.50
		Non-aromatic rice	-0.14	0.23	0.56	-0.60	0.32
		NEH rice	-1.05*	0.30	0.00	-1.65	-0.46
		NWH rice	0.07	0.25	0.77	-0.44	0.58
	Black rice	Red rice	1.52*	0.40	0.00	0.71	2.34
		White rice	1.55*	0.39	0.00	0.78	2.34
		Aromatic rice	1.42*	0.42	0.00	0.58	2.28
		Non-aromatic rice	1.39*	0.38	0.00	0.63	2.15
		NEH rice	0.47	0.42	0.27	-0.37	1.32
		NWH rice	1.59*	0.39	0.00	0.81	2.39
	White rice	Red rice	-0.03	0.24	0.89	-0.52	0.45
		Black rice	-1.55*	0.39	0.00	-2.34	-0.78
		Aromatic rice	-0.13	0.27	0.63	-0.67	0.41
		Non-aromatic rice	-0.17	0.19	0.38	-0.56	0.22
		NEH rice	-1.08*	0.27	0.00	-1.63	-0.54
		NWH rice	0.04	0.22	0.86	-0.41	0.49
	Aromatic rice	Red rice	0.1	0.30	0.75	-0.50	0.69
		Black rice	-1.42*	0.42	0.00	-2.28	-0.58
		White rice	0.13	0.27	0.63	-0.41	0.67
		Non-aromatic rice	-0.04	0.26	0.88	-0.56	0.48
		NEH rice	-.95*	0.32	0.00	-1.60	-0.31
		NWH rice	0.17	0.28	0.55	-0.40	0.74
	Non-aromatic rice	Red rice	0.14	0.23	0.56	-0.32	0.60
		Black rice	-1.39*	0.38	0.00	-2.15	-0.63
		White rice	0.17	0.19	0.38	-0.22	0.56
		Aromatic rice	0.04	0.26	0.88	-0.48	0.56
		NEH rice	-.91*	0.26	0.00	-1.44	-0.40
		NWH rice	0.21	0.21	0.33	-0.21	0.63
	NEH rice	Red rice	1.05*	0.30	0.00	0.46	1.65
		Black rice	-0.47	0.42	0.27	-1.32	0.37
		White rice	1.08*	0.27	0.00	0.54	1.63
		Aromatic rice	.95*	0.32	0.00	0.31	1.60
		Non-aromatic rice	.91*	0.26	0.00	0.40	1.44
		NWH rice	1.12*	0.28	0.00	0.56	1.69
	NWH rice	Red rice	-0.07	0.25	0.77	-0.58	0.44
		Black rice	-1.59*	0.39	0.00	-2.39	-0.81
		White rice	-0.04	0.22	0.86	-0.49	0.41
		Aromatic rice	-0.17	0.28	0.55	-0.74	0.40
		Non-aromatic rice	-0.21	0.21	0.33	-0.63	0.21
		NEH rice	-1.12*	0.28	0.00	-1.69	-0.56
Anthocyanin	Red rice	Black rice	-1.06*	0.28	0.00	-1.62	-0.51
		White rice	0.31	0.16	0.07	-0.02	0.64
		Aromatic rice	0	0.20	0.98	-0.40	0.41
		Non-aromatic rice	0.1	0.16	0.54	-0.22	0.41
		NEH rice	-0.27	0.20	0.19	-0.67	0.14
		NWH rice	0.06	0.17	0.73	-0.29	0.41
	Black rice	Red rice	1.06*	0.28	0.00	0.51	1.62
		White rice	1.37*	0.26	0.00	0.85	1.90
		Aromatic rice	1.07*	0.29	0.00	0.49	1.65
		Non-aromatic rice	1.16*	0.26	0.00	0.65	1.68
		NEH rice	.80*	0.29	0.01	0.22	1.38
		NWH rice	1.12*	0.27	0.00	0.59	1.67

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	White rice	Red rice	-0.31	0.16	0.07	-0.64	0.02
		Black rice	-1.37*	0.26	0.00	-1.90	-0.85
		Aromatic rice	-0.3	0.18	0.10	-0.67	0.06
		Non-aromatic rice	-0.21	0.13	0.11	-0.48	0.05
		NEH rice	-.57*	0.18	0.00	-0.94	-0.21
		NWH rice	-0.25	0.15	0.11	-0.55	0.06
	Aromatic rice	Red rice	0	0.20	0.98	-0.41	0.40
		Black rice	-1.07*	0.29	0.00	-1.65	-0.49
		White rice	0.3	0.18	0.10	-0.06	0.67
		Non-aromatic rice	0.09	0.18	0.60	-0.26	0.45
		NEH rice	-0.27	0.22	0.22	-0.71	0.17
		NWH rice	0.06	0.19	0.77	-0.33	0.44
	Non-aromatic rice	Red rice	-0.1	0.16	0.54	-0.41	0.22
		Black rice	-1.16*	0.26	0.00	-1.68	-0.65
		White rice	0.21	0.13	0.11	-0.05	0.48
		Aromatic rice	-0.09	0.18	0.60	-0.45	0.26
		NEH rice	-.36*	0.18	0.04	-0.72	-0.01
		NWH rice	-0.04	0.14	0.80	-0.33	0.25
	NEH rice	Red rice	0.27	0.20	0.19	-0.14	0.67
		Black rice	-.80*	0.29	0.01	-1.38	-0.22
		White rice	.57*	0.18	0.00	0.21	0.94
		Aromatic rice	0.27	0.22	0.22	-0.17	0.71
		Non-aromatic rice	.36*	0.18	0.04	0.01	0.72
		NWH rice	0.33	0.19	0.09	-0.06	0.71
	NWH rice	Red rice	-0.06	0.17	0.73	-0.41	0.29
		Black rice	-1.12*	0.27	0.00	-1.67	-0.59
		White rice	0.25	0.15	0.11	-0.06	0.55
		Aromatic rice	-0.06	0.19	0.77	-0.44	0.33
		Non-aromatic rice	0.04	0.14	0.80	-0.25	0.33
		NEH rice	-0.33	0.19	0.09	-0.71	0.06
Total Phenol	Red rice	Black rice	-0.1	0.08	0.21	-0.25	0.06
		White rice	0.09	0.05	0.06	0.00	0.18
		Aromatic rice	0.06	0.06	0.31	-0.06	0.17
		Non-aromatic rice	0.04	0.04	0.40	-0.05	0.12
		NEH rice	0	0.06	0.94	-0.11	0.12
		NWH rice	0.03	0.05	0.52	-0.07	0.13
	Black rice	Red rice	0.1	0.08	0.21	-0.06	0.25
		White rice	.18*	0.07	0.01	0.04	0.34
		Aromatic rice	0.16	0.08	0.06	-0.01	0.32
		Non-aromatic rice	0.14	0.07	0.07	-0.01	0.28
		NEH rice	0.1	0.08	0.21	-0.06	0.26
		NWH rice	0.13	0.08	0.09	-0.02	0.28
	White rice	Red rice	-0.09	0.05	0.06	-0.18	0.00
		Black rice	-.18*	0.07	0.01	-0.34	-0.04
		Aromatic rice	-0.03	0.05	0.54	-0.13	0.07
		Non-aromatic rice	-0.05	0.04	0.16	-0.13	0.02
		NEH rice	-0.09	0.05	0.10	-0.19	0.02
		NWH rice	-0.06	0.04	0.17	-0.14	0.03
	Aromatic rice	Red rice	-0.06	0.06	0.31	-0.17	0.06
		Black rice	-0.16	0.08	0.06	-0.32	0.01
		White rice	0.03	0.05	0.54	-0.07	0.13
		Non-aromatic rice	-0.02	0.05	0.67	-0.12	0.08
		NEH rice	-0.05	0.06	0.38	-0.18	0.07
		NWH rice	-0.03	0.05	0.62	-0.13	0.08

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	Non-aromatic rice	Red rice	-0.04	0.04	0.40	-0.12	0.05
		Black rice	-0.14	0.07	0.07	-0.28	0.01
		White rice	0.05	0.04	0.16	-0.02	0.13
		Aromatic rice	0.02	0.05	0.67	-0.08	0.12
		NEH rice	-0.03	0.05	0.51	-0.13	0.07
		NWH rice	-0.01	0.04	0.89	-0.09	0.07
	NEH rice	Red rice	0	0.06	0.94	-0.12	0.11
		Black rice	-0.1	0.08	0.21	-0.26	0.06
		White rice	0.09	0.05	0.10	-0.02	0.19
		Aromatic rice	0.05	0.06	0.38	-0.07	0.18
		Non-aromatic rice	0.03	0.05	0.51	-0.07	0.13
		NWH rice	0.03	0.05	0.62	-0.08	0.13
	NWH rice	Red rice	-0.03	0.05	0.52	-0.13	0.07
		Black rice	-0.13	0.08	0.09	-0.28	0.02
		White rice	0.06	0.04	0.17	-0.03	0.14
		Aromatic rice	0.03	0.05	0.62	-0.08	0.13
		Non-aromatic rice	0.01	0.04	0.89	-0.07	0.09
		NEH rice	-0.03	0.05	0.62	-0.13	0.08
PhyAnthPhe	Red rice	Black rice	-2.69*	0.65	0.00	-4.00	-1.39
		White rice	0.43	0.38	0.27	-0.34	1.20
		Aromatic rice	-0.03	0.47	0.94	-0.99	0.92
		Non-aromatic rice	0	0.37	1.00	-0.74	0.73
		NEH rice	-1.31*	0.47	0.01	-2.27	-0.36
		NWH rice	0.16	0.41	0.69	-0.66	0.98
	Black rice	Red rice	2.69*	0.65	0.00	1.39	4.00
		White rice	3.12*	0.62	0.00	1.88	4.37
		Aromatic rice	2.65*	0.68	0.00	1.30	4.02
		Non-aromatic rice	2.69*	0.61	0.00	1.47	3.91
		NEH rice	1.37*	0.68	0.05	0.02	2.74
		NWH rice	2.85*	0.63	0.00	1.59	4.13
	White rice	Red rice	-0.43	0.38	0.27	-1.20	0.34
		Black rice	-3.12*	0.62	0.00	-4.37	-1.88
		Aromatic rice	-0.47	0.43	0.28	-1.33	0.40
		Non-aromatic rice	-0.43	0.31	0.17	-1.05	0.19
		NEH rice	-1.74*	0.43	0.00	-2.61	-0.88
		NWH rice	-0.27	0.36	0.46	-0.98	0.45
	Aromatic rice	Red rice	0.03	0.47	0.94	-0.92	0.99
		Black rice	-2.65*	0.68	0.00	-4.02	-1.30
		White rice	0.47	0.43	0.28	-0.40	1.33
		Non-aromatic rice	0.03	0.41	0.94	-0.80	0.86
		NEH rice	-1.28*	0.51	0.02	-2.31	-0.25
		NWH rice	0.2	0.45	0.66	-0.71	1.10
	Non-aromatic rice	Red rice	0	0.37	1.00	-0.73	0.74
		Black rice	-2.69*	0.61	0.00	-3.91	-1.47
		White rice	0.43	0.31	0.17	-0.19	1.05
		Aromatic rice	-0.03	0.41	0.94	-0.86	0.80
		NEH rice	-1.31*	0.41	0.00	-2.15	-0.48
		NWH rice	0.17	0.34	0.63	-0.51	0.84
	NEH rice	Red rice	1.31*	0.47	0.01	0.36	2.27
		Black rice	-1.37*	0.68	0.05	-2.74	-0.02
		White rice	1.74*	0.43	0.00	0.88	2.61
		Aromatic rice	1.28*	0.51	0.02	0.25	2.31
		Non-aromatic rice	1.31*	0.41	0.00	0.48	2.15
		NWH rice	1.47*	0.45	0.00	0.57	2.38

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	NWH rice	Red rice	-0.16	0.41	0.69	-0.98	0.66
		Black rice	-2.85*	0.63	0.00	-4.13	-1.59
		White rice	0.27	0.36	0.46	-0.45	0.98
		Aromatic rice	-0.2	0.45	0.66	-1.10	0.71
		Non-aromatic rice	-0.17	0.34	0.63	-0.84	0.51
		NEH rice	-1.47*	0.45	0.00	-2.38	-0.57
CUPRAC	Red rice	Black rice	-4.81*	1.54	0.00	-7.91	-1.72
		White rice	2.05*	0.91	0.03	0.22	3.89
		Aromatic rice	0.83	1.12	0.46	-1.43	3.09
		Non-aromatic rice	0.68	0.87	0.44	-1.07	2.43
		NEH rice	-1.44	1.12	0.21	-3.70	0.82
		NWH rice	0.45	0.97	0.64	-1.49	2.40
	Black rice	Red rice	4.81*	1.54	0.00	1.72	7.91
		White rice	6.86*	1.47	0.00	3.92	9.82
		Aromatic rice	5.64*	1.61	0.00	2.42	8.88
		Non-aromatic rice	5.49*	1.44	0.00	2.60	8.39
		NEH rice	3.38*	1.61	0.04	0.15	6.61
		NWH rice	5.26*	1.50	0.00	2.25	8.29
	White rice	Red rice	-2.05*	0.91	0.03	-3.89	-0.22
		Black rice	-6.86*	1.47	0.00	-9.82	-3.92
		Aromatic rice	-1.22	1.02	0.24	-3.28	0.83
		Non-aromatic rice	-1.37	0.73	0.07	-2.85	0.10
		NEH rice	-3.48*	1.02	0.00	-5.54	-1.43
		NWH rice	-1.6	0.85	0.06	-3.30	0.10
	Aromatic rice	Red rice	-0.83	1.12	0.46	-3.09	1.43
		Black rice	-5.64*	1.61	0.00	-8.88	-2.42
		White rice	1.22	1.02	0.24	-0.83	3.28
		Non-aromatic rice	-0.15	0.98	0.88	-2.13	1.83
		NEH rice	-2.27	1.21	0.07	-4.71	0.18
		NWH rice	-0.38	1.07	0.73	-2.53	1.78
	Non-aromatic rice	Red rice	-0.68	0.87	0.44	-2.43	1.07
		Black rice	-5.49*	1.44	0.00	-8.39	-2.60
		White rice	1.37	0.73	0.07	-0.10	2.85
		Aromatic rice	0.15	0.98	0.88	-1.83	2.13
		NEH rice	-2.11*	0.98	0.04	-4.09	-0.14
		NWH rice	-0.22	0.80	0.78	-1.83	1.38
	NEH rice	Red rice	1.44	1.12	0.21	-0.82	3.70
		Black rice	-3.38*	1.61	0.04	-6.61	-0.15
		White rice	3.48*	1.02	0.00	1.43	5.54
		Aromatic rice	2.27	1.21	0.07	-0.18	4.71
		Non-aromatic rice	2.11*	0.98	0.04	0.14	4.09
		NWH rice	1.89	1.07	0.08	-0.27	4.04
	NWH rice	Red rice	-0.45	0.97	0.64	-2.40	1.49
		Black rice	-5.26*	1.50	0.00	-8.29	-2.25
		White rice	1.6	0.85	0.06	-0.10	3.30
		Aromatic rice	0.38	1.07	0.73	-1.78	2.53
		Non-aromatic rice	0.22	0.80	0.78	-1.38	1.83
		NEH rice	-1.89	1.07	0.08	-4.04	0.27
Cumg100g	Red rice	Black rice	-.88*	0.35	0.02	-1.59	-0.18
		White rice	-0.23	0.21	0.27	-0.65	0.18
		Aromatic rice	-0.51	0.26	0.05	-1.03	0.00
		Non-aromatic rice	-0.13	0.20	0.53	-0.52	0.27
		NEH rice	-.99*	0.26	0.00	-1.51	-0.48
		NWH rice	-0.02	0.22	0.92	-0.47	0.42

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	Black rice	Red rice	.88*	0.35	0.02	0.18	1.59
		White rice	0.65	0.33	0.06	-0.02	1.32
		Aromatic rice	0.37	0.37	0.32	-0.37	1.10
		Non-aromatic rice	.75*	0.33	0.03	0.10	1.42
		NEH rice	-0.11	0.37	0.76	-0.85	0.62
		NWH rice	.86*	0.34	0.02	0.17	1.55
	White rice	Red rice	0.23	0.21	0.27	-0.18	0.65
		Black rice	-0.65	0.33	0.06	-1.32	0.02
		Aromatic rice	-0.28	0.23	0.23	-0.75	0.19
		Non-aromatic rice	0.11	0.17	0.52	-0.23	0.44
		NEH rice	-.76*	0.23	0.00	-1.23	-0.29
		NWH rice	0.21	0.19	0.28	-0.18	0.60
	Aromatic rice	Red rice	0.51	0.26	0.05	0.00	1.03
		Black rice	-0.37	0.37	0.32	-1.10	0.37
		White rice	0.28	0.23	0.23	-0.19	0.75
		Non-aromatic rice	0.39	0.22	0.09	-0.06	0.84
		NEH rice	-0.48	0.28	0.09	-1.04	0.07
		NWH rice	.49*	0.24	0.05	0.00	0.98
	Non-aromatic rice	Red rice	0.13	0.20	0.53	-0.27	0.52
		Black rice	-.75*	0.33	0.03	-1.42	-0.10
		White rice	-0.11	0.17	0.52	-0.44	0.23
		Aromatic rice	-0.39	0.22	0.09	-0.84	0.06
		NEH rice	-.87*	0.22	0.00	-1.32	-0.42
		NWH rice	0.1	0.18	0.58	-0.26	0.47
	NEH rice	Red rice	.99*	0.26	0.00	0.48	1.51
		Black rice	0.11	0.37	0.76	-0.62	0.85
		White rice	.76*	0.23	0.00	0.29	1.23
		Aromatic rice	0.48	0.28	0.09	-0.07	1.04
		Non-aromatic rice	.87*	0.22	0.00	0.42	1.32
		NWH rice	.97*	0.24	0.00	0.48	1.46
	NWH rice	Red rice	0.02	0.22	0.92	-0.42	0.47
		Black rice	-.86*	0.34	0.02	-1.55	-0.17
		White rice	-0.21	0.19	0.28	-0.60	0.18
		Aromatic rice	-.49*	0.24	0.05	-0.98	0.00
		Non-aromatic rice	-0.1	0.18	0.58	-0.47	0.26
		NEH rice	-.97*	0.24	0.00	-1.46	-0.48
Znmg100g	Red rice	Black rice	-0.65	1.29	0.62	-3.24	1.95
		White rice	-0.07	0.77	0.93	-1.61	1.47
		Aromatic rice	-0.88	0.94	0.35	-2.78	1.01
		Non-aromatic rice	0.14	0.73	0.84	-1.32	1.61
		NEH rice	-1.33	0.94	0.16	-3.23	0.56
		NWH rice	-0.24	0.81	0.77	-1.87	1.39
	Black rice	Red rice	0.65	1.29	0.62	-1.95	3.24
		White rice	0.58	1.23	0.64	-1.89	3.05
		Aromatic rice	-0.23	1.35	0.86	-2.94	2.47
		Non-aromatic rice	0.79	1.21	0.51	-1.63	3.22
		NEH rice	-0.68	1.35	0.61	-3.39	2.02
		NWH rice	0.41	1.26	0.74	-2.12	2.94
	White rice	Red rice	0.07	0.77	0.93	-1.47	1.61
		Black rice	-0.58	1.23	0.64	-3.05	1.89
		Aromatic rice	-0.81	0.86	0.35	-2.54	0.91
		Non-aromatic rice	0.21	0.61	0.73	-1.02	1.45
		NEH rice	-1.26	0.86	0.15	-2.99	0.46
		NWH rice	-0.17	0.71	0.81	-1.60	1.26

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	Aromatic rice	Red rice	0.88	0.94	0.35	-1.01	2.78
		Black rice	0.23	1.35	0.86	-2.47	2.94
		White rice	0.81	0.86	0.35	-0.91	2.54
		Non-aromatic rice	1.03	0.82	0.22	-0.63	2.68
		NEH rice	-0.45	1.02	0.66	-2.50	1.60
		NWH rice	0.65	0.90	0.48	-1.16	2.45
	Non-aromatic rice	Red rice	-0.14	0.73	0.84	-1.61	1.32
		Black rice	-0.79	1.21	0.51	-3.22	1.63
		White rice	-0.21	0.61	0.73	-1.45	1.02
		Aromatic rice	-1.03	0.82	0.22	-2.68	0.63
		NEH rice	-1.48	0.82	0.08	-3.13	0.18
		NWH rice	-0.38	0.67	0.57	-1.73	0.97
	NEH rice	Red rice	1.33	0.94	0.16	-0.56	3.23
		Black rice	0.68	1.35	0.61	-2.02	3.39
		White rice	1.26	0.86	0.15	-0.46	2.99
		Aromatic rice	0.45	1.02	0.66	-1.60	2.50
		Non-aromatic rice	1.48	0.82	0.08	-0.18	3.13
		NWH rice	1.1	0.90	0.23	-0.71	2.90
	NWH rice	Red rice	0.24	0.81	0.77	-1.39	1.87
		Black rice	-0.41	1.26	0.74	-2.94	2.12
		White rice	0.17	0.71	0.81	-1.26	1.60
		Aromatic rice	-0.65	0.90	0.48	-2.45	1.16
		Non-aromatic rice	0.38	0.67	0.57	-0.97	1.73
		NEH rice	-1.1	0.90	0.23	-2.90	0.71
Femg100g	Red rice	Black rice	1.16	1.08	0.29	-1.00	3.33
		White rice	-0.46	0.64	0.47	-1.75	0.82
		Aromatic rice	-0.12	0.79	0.88	-1.70	1.46
		Non-aromatic rice	-0.16	0.61	0.79	-1.39	1.06
		NEH rice	0.1	0.79	0.90	-1.48	1.68
		NWH rice	0.02	0.68	0.97	-1.34	1.39
	Black rice	Red rice	-1.16	1.08	0.29	-3.33	1.00
		White rice	-1.62	1.03	0.12	-3.69	0.44
		Aromatic rice	-1.28	1.12	0.26	-3.54	0.98
		Non-aromatic rice	-1.33	1.01	0.19	-3.35	0.70
		NEH rice	-1.06	1.12	0.35	-3.32	1.20
		NWH rice	-1.14	1.05	0.28	-3.25	0.98
	White rice	Red rice	0.46	0.64	0.47	-0.82	1.75
		Black rice	1.62	1.03	0.12	-0.44	3.69
		Aromatic rice	0.34	0.72	0.63	-1.09	1.78
		Non-aromatic rice	0.3	0.51	0.56	-0.73	1.33
		NEH rice	0.56	0.72	0.44	-0.88	2.00
		NWH rice	0.49	0.59	0.42	-0.70	1.68
	Aromatic rice	Red rice	0.12	0.79	0.88	-1.46	1.70
		Black rice	1.28	1.12	0.26	-0.98	3.54
		White rice	-0.34	0.72	0.63	-1.78	1.09
		Non-aromatic rice	-0.05	0.69	0.95	-1.43	1.34
		NEH rice	0.22	0.85	0.80	-1.49	1.92
		NWH rice	0.14	0.75	0.85	-1.36	1.65
	Non-aromatic rice	Red rice	0.16	0.61	0.79	-1.06	1.39
		Black rice	1.33	1.01	0.19	-0.70	3.35
		White rice	-0.3	0.51	0.56	-1.33	0.73
		Aromatic rice	0.05	0.69	0.95	-1.34	1.43
		NEH rice	0.26	0.69	0.71	-1.12	1.65
		NWH rice	0.19	0.56	0.74	-0.94	1.31

Contd.

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
	NEH rice	Red rice	-0.1	0.79	0.90	-1.68	1.48
		Black rice	1.06	1.12	0.35	-1.20	3.32
		White rice	-0.56	0.72	0.44	-2.00	0.88
		Aromatic rice	-0.22	0.85	0.80	-1.92	1.49
		Non-aromatic rice	-0.26	0.69	0.71	-1.65	1.12
		NWH rice	-0.07	0.75	0.92	-1.58	1.43
	NWH rice	Red rice	-0.02	0.68	0.97	-1.39	1.34
		Black rice	1.14	1.05	0.28	-0.98	3.25
		White rice	-0.49	0.59	0.42	-1.68	0.70
		Aromatic rice	-0.14	0.75	0.85	-1.65	1.36
		Non-aromatic rice	-0.19	0.56	0.74	-1.31	0.94
		NEH rice	0.07	0.75	0.92	-1.43	1.58
Mgmg100g	Red rice	Black rice	9.25	13.64	0.50	-18.16	36.66
		White rice	-7.12	8.09	0.38	-23.38	9.14
		Aromatic rice	-7.44	9.96	0.46	-27.45	12.58
		Non-aromatic rice	-1.86	7.71	0.81	-17.36	13.63
		NEH rice	1.59	9.96	0.87	-18.43	21.61
		NWH rice	1.85	8.57	0.83	-15.38	19.08
	Black rice	Red rice	-9.25	13.64	0.50	-36.66	18.16
		White rice	-16.37	12.99	0.21	-42.48	9.74
		Aromatic rice	-16.68	14.23	0.25	-45.29	11.92
		Non-aromatic rice	-11.11	12.76	0.39	-36.75	14.53
		NEH rice	-7.66	14.23	0.59	-36.26	20.94
		NWH rice	-7.4	13.30	0.58	-34.12	19.33
	White rice	Red rice	7.12	8.09	0.38	-9.14	23.38
		Black rice	16.37	12.99	0.21	-9.74	42.48
		Aromatic rice	-0.31	9.06	0.97	-18.51	17.88
		Non-aromatic rice	5.26	6.50	0.42	-7.79	18.32
		NEH rice	8.71	9.06	0.34	-9.48	26.91
		NWH rice	8.98	7.50	0.24	-6.10	24.05
	Aromatic rice	Red rice	7.44	9.96	0.46	-12.58	27.45
		Black rice	16.68	14.23	0.25	-11.92	45.29
		White rice	0.31	9.06	0.97	-17.88	18.51
		Non-aromatic rice	5.57	8.72	0.53	-11.94	23.09
		NEH rice	9.03	10.76	0.41	-12.60	30.65
		NWH rice	9.29	9.49	0.33	-9.78	28.36
	Non-aromatic rice	Red rice	1.86	7.71	0.81	-13.63	17.36
		Black rice	11.11	12.76	0.39	-14.53	36.75
		White rice	-5.26	6.50	0.42	-18.32	7.79
		Aromatic rice	-5.57	8.72	0.53	-23.09	11.94
		NEH rice	3.45	8.72	0.69	-14.06	20.97
		NWH rice	3.71	7.09	0.60	-10.53	17.96
	NEH rice	Red rice	-1.59	9.96	0.87	-21.61	18.43
		Black rice	7.66	14.23	0.59	-20.94	36.26
		White rice	-8.71	9.06	0.34	-26.91	9.48
		Aromatic rice	-9.03	10.76	0.41	-30.65	12.60
		Non-aromatic rice	-3.45	8.72	0.69	-20.97	14.06
		NWH rice	0.26	9.49	0.98	-18.81	19.33
	NWH rice	Red rice	-1.85	8.57	0.83	-19.08	15.38
		Black rice	7.4	13.30	0.58	-19.33	34.12
		White rice	-8.98	7.50	0.24	-24.05	6.10
		Aromatic rice	-9.29	9.49	0.33	-28.36	9.78
		Non-aromatic rice	-3.71	7.09	0.60	-17.96	10.53
		NEH rice	-0.26	9.49	0.98	-19.33	18.81

Contd.

This study suggest that the high nutritional quality of rice landraces can form a solid basis for changing priorities in rice breeding, putting more emphasis on the grain nutritional value. Combining high yields and high grain nutritional values with the aid of modern conventional breeding techniques, including molecular marker-assisted selection, may be very useful in accelerating the development of more nutritious rice varieties. However, the current prevalence of consuming milled rice may also nullify the efforts, as nutrient rich bran layer is removed in the milling process. Therefore, in addition to developing more nutritious varieties, awareness of the benefits of eating brown rice should be raised among rice consumers. Such a combined approach would ultimately result in a sustainable enhancement of the essential nutrient supply in rice-based diets and also will encourage the traditional farmers to continue and maintain local rice landrace diversity. The nutritional diversity in diverse rice landraces of same crop can be utilized for particular nutrient supply or in favourable combination thereof to improve nutritional status of human society. This will have much impact on the diets of the most economically disadvantaged people which are mainly dependent on rice as the main food crop. These rice landraces which are specialized for at least one or a few particular nutrient components can be utilized for supplying various nutrients as a single source or in combination of more than one specialized landraces to enhance final bioavailability of nutrients to human body. Thus rice bio-fortification appears to be an easy way by combining genetic background of high yielding varieties and nutrient rich rice landraces.

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