Journal of Tropical Agriculture 58 (1): 33-43, 2020

Nutritional composition of selected traditional rice varieties of Kerala

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Received 08 August 2019; received in revised form 25 May 2020; accepted 05 June 2020

Abstract
Biochemical and mineral composition of 13 traditional rice varieties of Kerala was studied in comparison to two popular high yielding varieties under cultivation, *viz.,* Jyothi and Kanchana. Results showed that traditional varieties Thavalakannan and Rakthasali had significantly higher crude protein, crude lipids and insoluble dietary fibre content, making them nutritionally superior among tested varieties. High protein content (> 11 %) was found in traditional varieties Thavalakannan (11.84 %), Rakthasali (11.79 %) and Velutha Navara (11.27%), whereas Chitteni had the highest ash content (1.94%). The amylose content ranged from 20.02 to 30.90%. Kattamodan had the highest carbohydrate (74.47%) and amylose (30.90%) contents. Mineral analysis revealed that traditional varieties Thekkan, Kattamodan, Chettadi and Gandhakasala had the highest potassium (334.2 mg/100g), calcium (26.74 mg/100g), copper (0.62 mg/100g) and manganese (3.48 mg/100g) contents whereas the highest iron content was observed in high yielding variety Kanchana (3.31 mg/100g). Highest zinc content was found in traditional variety Kuttadan (3.63 mg/100g). Traditional varieties proved to be a good source of nutrients and hence can be utilized in future breeding programmes for developing nutritionally rich rice varieties.

Key words: Amylose, Minerals, Proximate composition, Traditional rice varieties.

Introduction

The state of Kerala is one of the most important biodiversity repositories of rice in the country. Although there are no scientific reports available on the exact number of traditional varieties found in the state, it is documented that nearly 2000 traditional varieties were predominantly cultivated here (Leenakumari, 2012). Nearly 1000 traditional varieties of rice were collected from different parts of the state by Kerala Agricultural University in 1976. These included aromatic, medicinal and organic rice varieties well adapted to different edaphic conditions. Traditionally, many local varieties catered to the nutritional, cultural and ritualistic needs of many tribal communities of the state.

Rice research in the country has mainly focused on developing rice varieties with better yield and pest or disease resistance. Most of the studies on traditional varieties have focused on their varietal characteristics. Not much emphasis has been given to the nutritional quality of these varieties except for a few specialty rice varieties like Navara, which is used in the Indian indigenous system of medicine or Ayurveda for treating various ailments (Deepa et al., 2008). The objective of this study was to compare the biochemical and mineral composition of traditional varieties of rice cultivated in the state of Kerala with two popular high yielding varieties under cultivation.

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Material and Methods

Rice varieties

The paddy samples of 15 different varieties were collected from Regional Agricultural Research Station, Kerala Agricultural University, Mele Pattambi, Kerala and Abhayam, Koppam, Pattambi, Kerala. The samples included 13 traditional rice varieties, namely Chenkazhama, Cheruvellari, Chettadi, Chitteni, Gandhakasala, Jeerakasala, Kattamodan, Kuttadan, Rakthasali, Thavalakannan, Thekkan, Vellari and Velutha Navara and two high yielding varieties released from Kerala Agricultural University, namely Jyothi and Kanchana.

Dried grain samples were collected and stored in airtight containers at 4-6 ^{o}C until use. The samples were manually dehulled so as to avoid any loss of bran and powdered to obtain homogenous rice flour which could pass through 60 mesh sieve.

Morphological features of rice kernel

Shape and size

The length and width of 10 randomly selected rice kernels were measured with Carl Zeiss Stemi 508 stereo microscope and the data obtained was interpreted based on the scale provided by IRRI, (2010).

Thousand kernel weight and Hull percentage

The thousand kernel weight was calculated by counting and weighing 100 randomly selected kernels, dried and expressed on dry weight basis. The weight obtained was then multiplied by 10 to determine the weight of thousand kernels. Hull percentage was determined as the percentage of hull to grain on a weight basis. The results were an average of six determinations.

Chemical composition of rice grains

Official methods of analyses of Association of Official Analytical Chemists (AOAC, 1984) were employed for the determination of moisture, crude lipid and ash. Crude protein content was calculated by multiplying the total nitrogen content obtained by the AOAC Kjeldahl method with a conversion factor of 6.25. Total, soluble and insoluble dietary fibre was analyzed following AOAC method using a commercial assay kit (Sigma- Aldrich). Carbohydrate content was determined by "difference" method (FAO, 1999). Gross energy (kJ per 100 g dry matter) was calculated based on the method of Ekanayake et al. (1999):

Gross energy = (crude protein x 16.7) + (lipid x 37.7) + (carbohydrates x 16.7)

The results were expressed as the mean of six determinations.

Estimation of amylose content

Amylose content was determined following the colorimetric method as described by Juliano (1971). Amylose from potato starch was used as the standard.

Mineral analysis

Energy Dispersive X-Ray Fluorescence (ED- XRF) was performed using a SPECTRO XEPOS following the method of Paltridge et al. (2012). A minimum of three replications from each of the varieties were analyzed. Statistical analysis was done using the software Turbo Quant (2).

Statistical analysis

The results were analyzed by using Analysis of Variance (ANOVA) SPSS version 20. Duncan's Multiple Range Test (DMRT) was performed for comparing means and a probability value of $p < 0.05$ was considered to be statistically significant. Student t-test was done to determine the significant difference between nutrient intake and recommended dietary allowance (RDA).

Results and Discussion

Morphological characteristics

The physical features of the rice kernel, namely length, width, thousand kernel weight and husk

Table 1. Morphological characteristics of rice kernel

Variety	Length (mm)	Width (mm)	Weight of 1000 kernel (g)	Hull %
Cheruvellari	5.86[f]	2.84[bcd]	19.07[i]	27.98[a]
Chenkazhama	6.12[ef]	2.61[cde]	20.83[g]	21.13[f]
Chettadi	6.35[de]	2.80[bcd]	21.00[f]	20.14[i]
Chitteni	6.65[c]	3.09[a]	24.05[b]	21.17[f]
Gandhakasala	4.43[h]	1.97[g]	16.17[k]	19.80[j]
Jeerakasala	5.99[f]	2.42[f]	15.30[m]	20.10[i]
Kattamodan	6.24[de]	2.97[ab]	21.21[e]	23.71[c]
Kuttadan	6.53[cd]	2.99[bc]	21.56[d]	20.87[g]
Rakthasali	5.59[g]	2.15[g]	10.54[n]	22.53[d]
Thavalakannan	6.00[f]	2.69[ef]	15.73[l]	20.58[h]
Thekkan	6.22[de]	2.92[ab]	20.00[h]	22.30[e]
Vellari	6.53[cd]	2.91[bcd]	18.80[j]	24.08[b]
Velutha Navara	6.35[de]	2.71[de]	18.74[j]	20.83[g]
Jyothi	7.24[a]	2.56[ef]	23.21[c]	19.86[j]
Kanchana	6.94[b]	2.53[e]	24.30[a]	17.52[k]
Mean	6.20	2.67	19.36	21.50
CD (0.05)	0.23	0.18	0.11	0.20
CV	2.30	0.35	0.35	0.58

Values with the same letters in a column are not significantly different ($p < 0.05$)

percentage were studied, and are presented in Table 1. Wide variability was observed among rice varieties for these characters. Kernel length varied between 4.43 mm in Gandhakasala to 7.24 mm in Jyothi. Based on the length of the rice kernel, varieties were classified into different categories as extra long (more than 7.5 mm), long (6.6 to7.5 mm), medium (5.51 to 6.5 mm) and short (5.5 or less).

Varieties Jyothi and Kanchana had long grains,whereas grains of traditional variety Gandhakasala were short, and that of all other varieties were medium in size. Significant differences ($p < 0.05$) were observed for length between traditional and high yielding varieties. Among the traditional varieties, Chitteni (6.65 mm), Vellari (6.53 mm) and Kuttadan (6.53 mm) had higher value for length with no statistically significant difference. Grain length is a very stable varietal characteristic and a useful indicator for selection in breeding programmes.

The width of the rice kernels was in the range of 1.97 mm to 3.09 mm. Chitteni had the highest value for width whereas the lowest value was recorded in Gandhakasala. No significant difference ($p < 0.05$) was observed between Jyothi, Kanchana, Velutha Navara, Chenkazhama and Thavalakannan.

Thousand kernel weight is an important indicator of grain size and yield. Significant difference ($p < 0.05$) observed. Kanchana had the highest thousand kernel weight (24.30 g) followed by Chitteni (24.05 g) and Jyothi (23.21 g), whereas the lowest kernel weight was observed in Rakthasali (10.54 g). High yielding varieties had higher thousand kernel weight than most of the traditional varieties. Singh et al. (2005) reported a range of 13.3 to 19.9 g for the thousand kernel weight of milled rice from different cultivars.

Hull percentage is another milling and varietal characteristic which could influence consumer preferences. The hull percentage of the rice varieties ranged from 17.52 to 27.98 %. Cheruvellari had the highest hull percentage (27.98%) followed by Vellari (24.08%) and Kattamodan (23.71%), whereas the lowest value was observed in Kanchana (17.52%). All the traditional varieties except

Table 2. Proximate composition of rice varieties (% dry weight basis)

Popular name	Moisture Content	Crude Protein	Crude lipid	Ash content	Total carbohydrates	Gross energy (kJ per 100 g)
Cheruvellari	10.61^{ef}	7.08^{g}	3.02^{ef}	1.59^{c}	73.86^{ab}	1463.30^{a}
Chenkazhama	10.79^{de}	6.75^{g}	2.55^{g}	1.50^{d}	73.13^{ab}	1434.12^{a}
Chettadi	10.28^{g}	8.01^{e}	3.10^{ef}	1.21^{g}	73.19^{ab}	1468.42^{a}
Chitteni	11.13^{abc}	7.77^{ef}	3.10^{ef}	1.94^{a}	67.39^{bcd}	1367.57^{a}
Gandhakasala	11.17^{ab}	10.67^{bc}	4.05^{b}	1.11^{h}	65.81^{cd}	1423.86^{a}
Jeerakasala	10.87^{bcd}	8.16^{e}	3.95^{bc}	1.48^{d}	65.05^{d}	1366.01^{a}
Kattamodan	9.33^{j}	7.18^{fg}	3.12^{fg}	0.98^{j}	74.47^{a}	1473.02^{a}
Kuttadan	9.63^{i}	9.62^{d}	3.04^{fg}	1.00^{h}	72.07^{abc}	1471.25^{a}
Rakthasali	9.64^{i}	11.79^{a}	3.98^{bc}	0.98^{j}	68.13^{abcd}	1474.15^{a}
Thavalakannan	10.88^{cde}	11.84^{a}	4.78^{a}	1.04^{i}	65.21^{d}	1461.50^{a}
Thekkan	10.45^{fg}	5.30^{h}	3.72^{cd}	1.44^{e}	70.27^{abcd}	1398.39^{a}
Vellari	9.95^{h}	7.98^{e}	3.72^{d}	1.59^{c}	69.28^{abcd}	1420.65^{a}
Velutha Navara	9.23^{j}	11.27^{ab}	3.24^{e}	1.11^{h}	65.20^{d}	1393.56^{a}
Jyothi	11.23^{a}	10.20^{cd}	3.26^{ef}	1.75^{b}	68.43^{abcd}	1427.25^{a}
Kanchana	10.24^{g}	7.96^{e}	2.19^{h}	1.32^{f}	70.96^{abcd}	1395.22^{a}
Mean	10.33	8.77	3.36	1.31	69.78	1431.10
CD(0.05)	0.27	0.61	0.27	0.27	6.68	-
CV	1.60	4.19	4.76	4.76	5.76	4.71

Values with the same letters in a column are not significantly different ($p < 0.05$)

Gandhakasala had significantly ($p < 0.05$) higher hull percentage than the high yielding varieties which could be due to their grain size. In a study by Matsushima (1970), hull percentage of rice varieties was negatively correlated to their grain size. The hull percentage decreased with an increase in the grain size.

Proximate analysis

Proximate composition was studied on brown rice and calculated on a dry weight basis as shown in Table 2. The moisture content of the rice varieties ranged from 9.23 % in Velutha Navara to 11.23 % in Jyothi. A value under 12- 14 % is preferred for moisture content to preserve the quality of rice and for its long term storage.

Protein content is one of the major determinants of nutritive value of rice grain and the second highest component in rice after starch. A target value of 9 to 11% was suggested for rice grain protein based on the bioavailability and RDA (HarvestPlus, 2005). Protein content of the rice varieties varied from 5.30 to 11.84 % with a mean value of 8.77 %. Appreciably high amounts of protein content (> 11%) were found in traditional varieties Thavalakannan (11.84 %), Rakthasali (11.79 %) and Velutha Navara (11.27%). Varieties Gandhakasala (10.67%), Jyothi (10.20%) and Kuttadan (9.62%) also had higher protein content in the range of 9-11%. No significant difference was observed for protein content among varieties Jeerakasala (8.16%), Chettadi (8.01%), Vellari (7.98%), Kanchana (7.96%) and Chitteni (7.77%). The lowest protein content was found in traditional variety Thekkan (5.30 %). The range obtained in the present study was comparable to other studies by Verma and Srivastav (2017), Sompong et al. (2011) and Deepa et al. (2008). The width of the range between the highest and the lowest protein content of the test varieties was 6.54 %. Wide variations were found to exist in protein content among rice varieties (Banerjee et al., 2011) which highlights the need for screening rice germplasm for its nutritive traits.

Crude lipid content of the rice varieties ranged between 2.19 to 4.78 % with a mean value of 3.36%. Traditional varieties Thavalakannan (4.78%), Gandhakasala (4.05 %), Rakthasali (3.98 %), Jeerakasala (3.95%), Thekkan (3.72%) and Vellari (3.72%) had significantly higher lipid content than high yielding variety Jyothi (3.26%) whereas Kanchana had the lowest lipid content of 2.19 % among the rice varieties. Other traditional varieties Velutha Navara, Chettadi, Chitteni, Cheruvellari, Kattamodan and Kuttadan had more than 3 % lipid content. Chenkazhama had the lowest lipid content (2.55%) among traditional varieties. The values obtained in the present study was somewhat comparable to the lipid content of pigmented rice varieties with a range of 3.05- 3.73 (Reddy et al., 2017) and higher than the reported values of Oko et al. (2012) and Sompong et al. (2011). Lipid content in rice is mainly concentrated in the bran and could be extracted as Rice Bran Oil (RBO). RBO is a major source of antioxidants such as gamma oryzanol, tocopherol and tocotrienol (Patel and Naik, 2004). Milling can drastically reduce the content of rice lipids; therefore brown rice could be preferred over milled rice for its maximum health benefits.

Ash content of the test varieties was found to range between 0.98 to 1.94%. Statistically significant difference was observed among traditional and high yielding rice varieties. Chitteni (1.94 %) had the highest ash content followed by Jyothi (1.75 %), Vellari (1.59 %) and Cheruvellari (1.59 %). Varieties Chenkazhama, Jeerakasala, Thekkan and Kanchana had ash content of 1.50, 1.48, 1.44, and 1.32% respectively which was more than the mean value of 1.31% observed for the rice varieties. The lowest ash content was observed in Kattamodan (0.98%) and Rakthasali (0.98%). Ash content of rice varieties obtained in this study was comparable to 269 high yielding Indian rice varieties which ranged between 0.90 to 1.99 % (Longvah et al., 2010). Ash content reflects the mineral constituents in the grain and is mainly concentrated in the bran layer of rice caryopsis (Lamberts et al., 2007). The differences in ash content of rice varieties might have seen due to the mineral content of soil and the water used for irrigation (Shayo et al., 2006).

The total carbohydrate content of the rice varieties varied from 65.05 % to 74.47 % with a mean value of 69.78%. Carbohydrate content of traditional and high yielding varieties did not differ significantly ($p < 0.05$). Among the rice varieties, high carbohydrate content was found in Kattamodan (74.47 %) followed by Cheruvellari (73.86 %), Chettadi (73.19 %), Chenkazhama (73.13%), Kuttadan (72.07%), Kanchana (70.96%), Thekkan (70.27%), Vellari (69.28%), Jyothi (68.43%) and Rakthasali (68.13%) with no significant difference ($p < 0.05$). Lower carbohydrate content was recorded in Jeerakasala (65.05 %), Velutha Navara (65.20%) and Thavalakannan (65.21%). Higher intake of dietary carbohydrate has been associated with a higher incidence of type II diabetes mellitus (Villegas et al., 2007) and therefore rice varieties with low carbohydrate content could be promoted in the daily diet of rice eating population. Rice proves to be a rich source of carbohydrate and similar results were reported by Prasad et al. (2018) and Oko et al. (2012).

The gross energy value of the rice varieties varied between 1366.01 kJ/100g in Jeerakasala to 1474.15 kJ/100g in Rakthasali. No significant differences ($p < 0.05$) were observed in the gross energy content of rice varieties. The values obtained in this study were comparable to the gross energy value of 105 high yielding Indian rice varieties with a range of 1422.56 to 1489.5 kJ/ 100g (Longvah et al., 2010).

Total, insoluble and soluble dietary fibre

The total dietary fibre (TDF) content varied between 4.69 to 6.80 % as shown in Table 3. TDF content was calculated as the sum of Insoluble Dietary Fibre (IDF) and Soluble Dietary Fibre (SDF) of a given rice variety. Significantly ($p < 0.05$) higher TDF content was observed in traditional varieties Jeerakasala (6.80 %), Thavalakannan (6.72 %), Rakthasali (6.59 %), Chettadi (6.20%) and Velutha Navara (5.94%) than the high yielding varieties. Other traditional varieties Gandhakasala, Thekkan, Chitteni, Kuttadan, Cheruvellari, Kattamodan and Vellari had TDF content of 5.33, 5.31, 5.22,

Table 3. Total, insoluble and soluble dietary fibre content of rice varieties (% dry weight basis)

Variety	Total dietary fibre	Insoluble fibre	Soluble fibre
Cheruvellari	5.07^{defg}	4.92^{d}	0.14^{h}
Chenkazhama	4.69^{g}	4.36^{fg}	0.32^{g}
Chettadi	6.20^{bc}	4.56^{def}	1.64^{a}
Chitteni	5.22^{de}	4.51^{defg}	0.72^{d}
Gandhakasala	5.33^{d}	3.86^{h}	1.46^{b}
Jeerakasala	6.80^{a}	5.37^{c}	1.42^{b}
Kattamodan	4.85^{efg}	4.37^{fg}	0.48^{ef}
Kuttadan	5.21^{de}	4.41^{efg}	0.80^{d}
Rakthasali	6.59^{ab}	5.81^{b}	0.78^{d}
Thavalakannan	6.72^{a}	6.31^{a}	0.41^{fg}
Thekkan	5.31^{d}	4.80^{de}	0.50^{e}
Vellari	4.74^{fg}	3.24^{i}	1.50^{b}
Velutha Navara	5.94^{c}	5.46^{bc}	0.48^{ef}
Jyothi	5.10^{defg}	4.60^{def}	0.50^{e}
Kanchana	5.17^{def}	4.11^{gh}	1.06^{c}
Mean	5.52	4.66	0.85
CD (0.05)	0.43	0.43	0.09
CV	4.71	5.53	6.58

Values with the same letters in a column are not significantly different ($p < 0.05$)

5.21,5.07,4.85 and 4.74% which was less than the mean value of 5.52% where as the lowest TDF content was observed in Chenkazhama.

The IDF and SDF content of test varieties were in the range 3.24 – 6.31 % and 0.14 -1.64 % respectively. Thavalakannan (6.31 g/100 g) and Chettadi (1.64%) had significantly higher IDF and SDF content among the rice varieties. IDF content of Jyothi, Kanchana, Cheruvellari, Thekkan, Chettadi, Chitteni, Kuttadan, Kattamodan and Chenkazhama fell within a range of 4-5% whereas Thavalakannan, Rakthasali, Velutha Navara and Jeerakasala had IDF content of more than 5%. Vellari and Gandhakasala had IDF content of less than 4%.

Chettadi, Vellari, Gandhakasala, Jeerakasala and Kanchana had more SDF content than the average value of 0.85% recorded for the varieties. The IDF content of all the rice varieties was found to be significantly higher ($p < 0.05$) than its SDF content whereas coefficient of variation (CV) was higher for SDF.

The TDF, IDF and SDF values in the present study were comparable to other Indian rice varieties (Prasad et al., 2018; Deepa et al., 2008) but lower than Malaysian rice varieties which reported a much higher range for TDF (Thomas et al., 2013). Rice appears to be a moderate source of dietary fibre. Consumption of insoluble fibre from unpolished rice was reported to reduce the risk of cardiovascular diseases in human subjects (Hallfrisch et al., 2003). Milling or polishing significantly reduces the amount of dietary fibre in rice, so brown rice could be preferred over white rice for its physiological health benefits.

Amylose content

Amylose content is one of the major determinants of rice grain quality. It also influences consumer preferences for a rice variety and indirectly affects rice prices in the market. The rice varieties were defatted prior to amylose estimation so as to avoid the formation of lipid - amylose complex. The amylose content of the rice varieties was in the range of 20.02 to 30.90 %. Significant differences ($p < 0.05$) were observed among rice varieties. The highest amylose content was found in Kattamodan (30.90 %) whereas Gandhakasala (20.02 %) had the lowest amylose content.

Based on the amylose content, the rice varieties can be classified as waxy (0 – 5.0 %), very low (5.1 - 12.0 %), low (12.1 - 20.0%), intermediate (20.1-25.0 %) and high (>25 %) (Juliano and Betchel, 1985). Amylose content of the varieties Kattamodan, Thekkan, Kanchana, Cheruvellari, Kuttadan, Thavalakannan and Chenkazhama were found to be 30.90, 30.61, 30.41, 29.98, 27.82, 26.09 and 25.78% respectively and were high amylose varieties, whereas Chitteni, Jeerakasala, Vellari, Velutha Navara, Chettadi, Rakthasali, Jyothi and Gandhakasala were intermediate amylose varieties with amylose content of 24.82, 24.46, 24.08, 22.69, 22.55, 22.33, 20.34 and 20.02% respectively.

Amylose content is one of the major determinants of cooking quality of rice. High amylose rice cooks dry and becomes hard upon cooling whereas intermediate amylose rice cooks moist and tender and does not become hard upon cooling. Intermediate amylose rice varieties were the most preferred by rice consuming countries for their cooking quality (Khush et al., 1979). High amylose content in rice was also associated with low glycemic index and low glycemic load which meant that high amylose varieties could be preferred for prevention and better management of diabetes (Prasad et al., 2018).

Mineral composition of rice varieties

Minerals are micronutrients essential for the normal functioning of the human body and their deficiency could result in poor health, sickness and impaired development in children (Golden, 1991). Rice is a major source of minerals for countries where it is consumed as the staple food.

Among the mineral elements analyzed, potassium content was found to be the highest among rice varieties followed by calcium, manganese, zinc, iron and copper as shown in Table 4. Significant differences ($p < 0.05$) were observed in the mineral composition of the rice varieties. The potassium content ranged from 187.32 to 334.29 mg/100g. Higher potassium content were found in varieties Thekkan (334.29 mg/100g), Chitteni (311.36 mg/100g), Jyothi (310.80 mg/100g), Kanchana (295.26 mg/100g) and Jeerakasala (276.41 mg/100g). Chenkazhama had the lowest potassium content of 187.32 mg/100g. Potassium is an important mineral for the body and therefore potassium rich varieties could be promoted for their beneficial health effects. The values obtained were comparable to the potassium content of other traditional rice varieties of Kerala studied by Deepa et al. (2008).

The manganese content of rice varieties varied between 1.15 mg/100g in Chenkazhama to 3.48 mg/100g in Gandhakasala. Significantly higher manganese content was observed in traditional varieties Gandhakasala (3.48 mg/100g), Jeerakasala (3.31 mg/100g) and Cheruvellari (3.36 mg/100g) than Kanchana (2.74 mg/100g). Manganese content of Jyothi (2.22 mg/100g) was not significantly different from Vellari (2.58 mg/100g), Thekkan (2.33 mg/100g), Thavalakannan (2.18 mg/100g), Kuttadan (2.10 mg/100g), Rakthasali (2.09 mg/100g) and Chitteni (2.08 mg/100g). The values obtained in the present study were similar to the

Table 4. Mineral composition of rice varieties (mg/ 100g)

Rice variety	K	Mn	Ca	Cu	Fe	Zn
Cheruvellari	264.10[bcd]	3.36[ab]	13.56[de]	0.59[a]	3.24[a]	2.64[cde]
Chenkazhama	187.32[e]	1.15[h]	11.51[e]	0.35[cd]	1.57[f]	2.36[de]
Chettadi	227.40[cde]	2.91[bc]	14.17[def]	0.62[a]	1.94[def]	3.41[ab]
Chitteni	311.36[ab]	2.08[ef]	13.20[de]	0.43[bc]	2.38[cde]	3.31[ab]
Gandhakasala	267.40[bcd]	3.48[a]	22.12[ab]	0.39[bcd]	2.92[abc]	2.96[bcd]
Jeerakasala	276.41[abc]	3.31[ab]	22.03[ab]	0.31[de]	2.04[def]	2.32[e]
Kattamodan	188.60[e]	1.39[gh]	26.74[a]	0.40[bc]	2.46[bcd]	2.69[cde]
Kuttadan	261.43[bcd]	2.10[ef]	15.12[c]	0.37[bcd]	2.12[def]	3.63[a]
Rakthasali	219.00[cde]	2.09[ef]	20.19[abc]	0.25[e]	2.91[abc]	2.98[bc]
Thavalakannan	213.12[de]	2.18[ef]	19.04[bc]	0.40[bcd]	1.83[ef]	3.10[abc]
Thekkan	334.29[a]	2.33[de]	10.55[f]	0.45[b]	1.88[def]	2.58[cde]
Vellari	253.85[bcd]	2.58[cde]	11.60[ef]	0.38[bcd]	1.85[ef]	2.60[cde]
Velutha Navara	220.51[cde]	1.70[fg]	15.81[bcd]	0.43[bc]	2.76[abc]	3.31[ab]
Jyothi	310.80[ab]	2.22[e]	18.02[bcd]	0.36[bcd]	3.04[ab]	3.07[abc]
Kanchana	295.26[ab]	2.74[cd]	15.46[bcd]	0.43[bc]	3.31[a]	2.90[bcde]
Mean	255.34	2.37	16.60	0.41	2.41	2.94
CD (0.05)	60.93	0.50	5.67	0.09	0.60	.60
CV	14.31	12.72	23.32	14.95	16.49	14.16

Values with the same letters in a column are not significantly different ($p < 0.05$)

manganese content of 236 Indian high yielding varieties which ranged between 0.75-2.46 mg/100g (Longvah et al., 2010).

Calcium content among rice varieties varied between 10.55 to 26.74 mg/100g with a mean value of 16.60 mg/100g. Significantly ($p < 0.05$) higher amount of calcium were found in traditional varieties Kattamodan (26.74 mg/100g), Rakthasali (20.19 mg/100g), Jeerakasala (22.03 mg/100g), Gandhakasala (22.12 mg/100g) and Thavalakannan (19.04 mg/100g) than the high yielding varieties Jyothi (18.02 mg/100g) and Kanchana (15.46 mg/ 100g). Thekkan had the lowest calcium content (10.55 mg/100g). No significant ($p < 0.05$) difference was observed between Jyothi, Kanchana and Velutha Navara (15.81 mg/100g). A higher mean value of 24.11 mg/100g for calcium content was reported by Adu- Kwarteng et al. (2003) for local rice varieties of Ghana and a much wider range of 1.0 to 65.0 g/ 100g was observed by Kennedy and Burlingame (2003) for 57 different varieties of rice. Calcium is an essential micronutrient required for the growth and bone development; therefore calcium rich varieties could be preferred for its health benefits. Among the minerals analyzed, coefficient of variation was the highest for calcium content. These differences could be attributed to the varietal effects and the location of its cultivation (Wang et al., 2016).

The copper content of rice varieties in the present study was found to be in the range of 0.25 mg/100g to 0.62 mg/100g with a mean value of 0.41 mg/ 100g. Chettadi and Cheruvellari had significantly ($p < 0.05$) higher copper content of 0.62 and 0.59 mg/100g. Varieties Jyothi, Kanchana, Thekkan, Chitteni, Kattamodan, Velutha Navara, Thavalakannan, Gandhakasala, Vellari and Kuttadan had no significant ($p < 0.05$) difference in their copper content. The lowest copper content was found in Rakthasali (0.25 mg/100g). Verma and Srivastav (2017) reported similar results for copper content in aromatic and non aromatic Indian rice accessions.

Most of the studies on mineral composition of rice have focused on its iron (Fe) and zinc (Zn) content as the high prevalence of iron deficiency, anemia, and micronutrient deficiency is evident in rice eating populations. Many international programmes are aimed at exploring the biodiversity of rice with high Fe and Zn content. The targeted content for Fe and Zn in biofortified rice was suggested as 1.5mg /100g and 2.8 mg/100g respectively (Bouis and Welch, 2010).

The iron content of the rice varieties in the present study ranged between 1.57 to 3.31 mg/100g whereas zinc content was in the range 2.32 to 3.63 mg/100g. Depending on the iron content, rice varieties could be categorized into three groups, low (0-5 mg/100g), moderate (5.1 -18.0 mg/100g) and high (>18.0 mg/ 100g). Similarly, rice varieties were grouped under three categories based on the zinc content as low (0.0 – 1.40 mg/100g), medium (1.41-2.4 mg/100g) and high (>2.5) (Brar et al., 2011). Accordingly, all the varieties had low iron content. High yielding variety Kanchana had the highest iron content value of 3.31 mg/100g, not significantly different ($p < 0.05$) than Cheruvellari (3.24 mg/ 100g), Jyothi (3.04 mg/ 100g), Gandhakasala (2.92 mg/100g) and Velutha Navara (2.76 mg/100g). Chenkazhama had the lowest iron content of 1.57 mg/100g among the rice varieties tested. The width between the highest and lowest value for iron content was 1.74 which suggested that preferring rice varieties with high iron content could make a significant difference on the iron intake levels.

All the test varieties had high zinc content except Chenkazhama and Jeerakasala which were moderate zinc varieties. There was no significant ($p < 0.05$) difference among varieties Kuttadan, Chettadi, Chitteni, Velutha Navara, Thavalakannan and Jyothi which had zinc contents of 3.63, 3.41, 3.31, 3.31, 3.10 and 3.07 mg/ 100g respectively. Jeerakasala had the lowest zinc content of 2.32 mg/100g which was not statistically different from Chenkazhama (2.36 mg/100g), Thekkan (2.58 mg/100g), Vellari (2.60 mg/100g), Cheruvellari (2.64 mg/100g),

Table 5. Percentage contribution of rice varieties towards recommended dietary allowance (RDA)

Nutrients	Daily intake[a]	RDA[b]	% of RDA	t	p
Calorie (kcal/d)	615.52 ± 17.34	2730	22.54	472.08	0.000*
Protein (g/d)	15.78 ± 3.59	60	26.30	47.61	0.000*
Visible fat (g/d)	nil	30	nil	-	0.000*
Calcium (mg/d)	29.89 ± 8.35	600	4.98	264.13	0.000*
Iron (mg/d)	4.34 ± 1.03	17	25.53	47.49	0.000*

[a] based on the average daily consumption of rice by Indians – 180g/d
[b]RDA - 60 kg male; moderate work

Kattamodan (2.69 mg/100g) and Kanchana (2.90 mg/100g). The values obtained were comparable to another study on 84 land races of West Bengal where a much wider range of 0.025 to 3.48 mg/100g for iron and 0.085 to 19.53 mg/100g for zinc content was reported (Roy and Sharma, 2014).

Nutrient intake from rice varieties and recommended dietary allowance

The daily nutrient intake from the consumption of test varieties and their share towards recommended dietary allowance (RDA) were calculated as shown in Table 5. RDA was defined as the amount of dietary energy and nutrients considered sufficient for maintaining good health by the people of a country (NIN, 2011). The per capita consumption of rice was taken as 180 g per day (Government of India, 2018) and dietary intake values were calculated accordingly.

The average calorie intake from the rice varieties was 615.52 kcal, which was found to be 22.54 % of RDA. Average protein intake was 15.78 g per day, which accounted for 26.30 % of RDA. Similarly, average calcium (29.89 mg) and iron (4.34 mg) intake were 4.98% and 25.53 % of RDA respectively. Rice had no visible fat, but provided for invisible fat content in the diet. Therefore rice varieties used in the present study provided for 26.30%, 25.53% 22.54% and 4.98% of protein, iron, calories and calcium towards RDA.

The result of this study has found wide nutrient diversity among rice varieties for proximate, amylose and mineral composition. Traditional varieties Thavalakannan, Rakthasali and Velutha Navara had appreciably high (>11%) amount of protein content and provided for 26.30 % of RDA. Thavalakannan and Rakthasali also had a significantly higher content of lipid and insoluble dietary fibre, making them nutritionally rich rice varieties. Traditional varieties Thekkan, Kattamodan, Gandhakasala and Chettadi had the highest content of potassium, calcium, manganese and copper respectively, whereas iron content was the highest in high yielding variety Kanchana. The zinc content of the varieties varied from moderate to high and the highest zinc content was found in traditional variety Kuttadan. Rice varieties had low iron content, but the coefficient of variation was high which suggested that varieties with comparatively high iron content could be identified and incorporated into the daily diet for better nutrition. Large variations among rice varieties for different biochemical parameters provide an opportunity for dieticians, nutritionists and consumers to select rice based on its nutritional profile.

Acknowledgement

This work was funded by the Department of Science and Technology, Ministry of Science and Technology, Government of India through an individual research fellowship (Grant no. 150156). We thank the Associate Director of Research, Kerala Agricultural University for providing samples and necessary data on the agronomical features of the rice varieties. We are also grateful to the Director, Central Sophisticated Instrumentation Facility, University of Calicut for laboratory assistance to conduct ED - XRF studies.

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