Annals of Plant Sciences
ISSN: 2287-688X
OPEN ACCESS
www.annalsofplantsciences.com

Original Research Article

PHYSIOCHEMICAL PROPERTIES AND COOKING QUALITIES OF TRADITIONAL RICE CULTIVARS

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Received: May 07, 2015;
Revised: June 05, 2015;
Accepted: June 12, 2015.

Abstract: Present study was aimed to study the physicochemical and cooking quality of traditioal rice cultivars grown in the farmer's field. Among the cultivars, Kichadi Sona and Salem Sanna recorded higher milling yield (66.0% and 65.0%) and head rice recovery (58.5% and 58.30%), respectively. The highest protein content (14.67%) was recorded in Nagabatha. The cultivars Moroda and D. Basumathi showed highest (26.09 ppm) zinc content. Kanadathumba (81.84 ppm) and Sannamallige (81.48ppm) recorded highest Iron content. Therefore, these cultivars could be utilized in the breeding programme is the need of the today towards the 'hidden hunger' free world.

Key words: Traditional rice cultivars; milling; cooking; nutrition

INTRODUCTION

Rice is an important cereal usually consumed as a whole grain after cooking and in a regular Asian diet, can contribute for 40 to 80% of the total calorie intake (Cai *et al*., 2011). Being a major cereal grain, evaluating the nutritional and cooking qualities of rice has been given highest priority (Dong *et al*., 2007). Consumers' preference varies based on the type of rice and their origin (Musa *et al*., 2011). It has been opined that variations in physical, biochemical composition, milling and cooking quality of rice is mainly depend on the genetic as well as surrounding environmental factors where they are grown (Giri and Vijaya, 2000).

Traditional rice varieties (TRVs) are often highly variable in appearance, but they are each identifiable morphologically and have a certain genetic integrity. Farmers usually give them local names based on their distinct properties or characteristics. Each TRV has a reputation for adaptation to specific ecosystem, but most important, they are genetically diverse. Owing to their adaptation to a wide range of agro-ecological conditions, TRVs provides tremendous genetic variability not found in modern varieties. They may provide the genetic diversity needed to diversify the gene pool of improved rice varieties. Further, the farmers are familiar with local varieties because these have many positive characteristics-taste, price, and milling value are better than that of the high yielding varieties, though yield is less (Nandini, 2013). Therefore TRVs can be exploited significantly to enhance rice productivity in marginal upland areas (Florence *et al.* 2010).

MATERIALS AND METHODS

The seeds of 15 traditional rice varieties produced at Zonal Agricultural Research Staion, and Agricultural Research Station, Ponnampet were dried to safe level of seed moisture (<13 %), graded using seed grader (Lab model Sr. No. S6707- 282) with top and bottom screen size 2.5 and 1.8 mm and used for the study (Table 1).

a) Milling quality (%): Milling quality of selected genotypes was analyzed at the Post Harvest Technology Scheme, Gandhi Krishi Vijnana Kendra, Bengaluru. About 200 gram of seed sample from each genotype was milled using paddy sheller/husker (Satake type) to get brown rice and husk fractions and these fractions were weighed separately. Further, 100 gram of brown rice polished by using rice polisher (Model NF 268). The weight of polished rice and bran obtained from polisher were weighed separately. Then, the weight of the head rice and weight of brokens were determined by using rice-sizing machine (Model-NF 268), which separates the polished rice into bold and broken grains. Finally the different milling quality parameters were computed by using the following formulae:

$$\textbf{1. Milling yield (\%)} = \frac{\text{Weight of total milled rice}}{\text{Weight of paddy sample}} \times 100$$

$$\textbf{2. Husk (\%)} = \frac{\text{Weight of husk}}{\text{Weight of paddy sample}} \times 100$$

$$\textbf{3. Head yield (\%)} = \frac{\text{Weight of Head rice}}{\text{Weight of paddy sample}} \times 100$$

$$\textbf{4. Broken (\%)} = \frac{\text{Weight of polished rice - Weight of Head rice}}{\text{Weight of polished rice}} \times 100$$

b) Cooking quality: The method suggested by Sidhu *et al.* (1975) and Oka *et al.* (2012) was followed to evaluate the cooking quality of traditinal rice genotypes.

Cooking time (min): To recored cooking time, weighed sample (2g) was taken in 50 ml beakers containing water (30 ml) and heated upto required level and period. Then few kernels were pressed between two slides frequently taken from the cooking test tube and noting the time when opaque core had just disappeared determined optimum time of cooking.

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Elongation ratio: The elongation ratio was obtained by cooking presoaked rice (15 min) for 15 minutes in boiling water and then dividing the cumulative length of 20 cooked kernels by respective length of raw kernels.

Gel Consistency (GC): This test differentiates the consistency of milled rice paste (IRRI, 1980). This was determined based on the consistency of milled rice paste that has been gelatinized by boiling in dilute alkali for 15 minutes and then cooled to room temperature. Tubes were laid horizontally on a table lined with millimeter graph paper and total length of the gel measured in millimeters (Oka *et al*., 2012).

Gelatinization Temperature (GT): The time required for cooking is determined by gelatinization temperature. Gelatinization temperature is estimated by the extent of alkali spreading test (Little *et al*., 1958). The degree of spreading of individual milled rice kernel in a weak alkali solution (1.7% KOH) at room temperature (32±2℃) was evaluated on a 7-point numerical scale (IRRI, 1980). Each test was conducted three times, each time, 10 intact milled grains were placed on a petri dish to which 15 ml of 1.7% KOH was added. The grains were carefully separated from each other and incubated at ambient temperature for 23 hrs to allow spreading of the grains (Table 2 and Table 3).

Alkali spreading value (ASV): After 23 hours of soaking, grains swollen to the extent of a cottony center and a cloudy collar were given an alkali spread value (ASV) score 4 and used as check for scoring the rest of the samples in the population. Grains that were un-affected were given ASV of 1 and grains that were dispersed and disappeared completely were given a score of 7. A low ASV corresponds to a high gelatinization temperature and high ASV indicates a low GT (IRRI, 1980).

Table 2: Seven-point scale to measure alkali spreading value

S.No.	Nature of the grain after treating with alkali solution	Scale
1.	Grain not affected	1
2.	Grain swollen	2
3.	Grain swollen, collar incomplete and narrow	3
4.	Grain swollen, collar complete and wide	4
5.	Grain split or segmented, collar complete and wide	5
6.	Grain dispersed, merging with collar	6
7.	Grain completely dispersed and intermingled	7

Table 3: Alkali spreading value corresponds to gelatinization temperature as per IRRI (1980)

S.No.	ASV Scale	GT	
1.	1-2	74.5-80^{o}c	High
2.	3		High to Intermediate
3.	4-5	70-74^{o}C	Intermediate
4.	6-7	<70^{o}C	Low

c) Estimation of nutritional quality: Near infrared reflectance spectroscopy (NIR system, FOSS, Denmark) system was used for the estimation of crude protein, amylose, iron and zinc content. NIR is a fast and non – destructive technique that provides multi -constituent estimates. It works on the principle of detection and measurement of chemical composition of biological materials was based on vibrational responses of chemical bonds to NIR radiations.

d) Analysis of data: The data obtained were statistically analyzed by using suitable ANOVA as per the methods outlined by Sunderaraj *et al.* (1972). Critical difference (CD) values were computed at 5 per cent level wherever 'F' test was significant.

RESULTS AND DISCUSSION

Physical properties: Physical properties of a rice variety are evaluated to provide important facts in determining their appropriate uses (Majzoobi *et al*., 2008). Results on the 1000-kernel weight of different rice cultivars analysed in this study showed significant differences. The cultivars which were classified as bold *viz*., Bilimundaga showed highest (34.40g) test weight followed by Byranella (30.8g), Nagabatha (30.2g) and lowest in Jeerige Sanna (12.3g) and Gandasale (12.4g). Determining the rice grain shape and width are highly essential as both, cooking and eating properties are strongly influenced by these (McKenzie *et al*., 1983). Cultivar Byranella recorded highest (2.28 mm) seed thickness and Jeerige Sanna (1.73 mm), Rathna chudi (1.73 mm) as lowest. The analysis (l/b ratio) was performed to determine the shape of individual rice grains. A length to breadth ratio of above 3 is generally considered as slender (IRRI, 1980). The highest L/B ratio was noticed in D. Basumathi (5.14) and lowest in Byranella (2.37) and Bilimundaga (2.51). In this study also, most of the traditional genotypes can be judged as slender (Table 4).

Table 1: List of traditional rice varieties used for the study

S.No.	Variety	Source of collection	S.No.	Variety	Source of collection
1	Billiraja mudi	ARS, Ponnampet	9	Salem sanna	ZARS, VC Farm Mandya
2	Ratnachudi	ARS, Ponnampet	10	Bilimundaga	ZARS, VC Farm Mandya
3	Jeerige sanna	ARS, Ponnampet	11	Morada	ARS, Ponnampet
4	Gandasale	ZARS, VC Farm Mandya	12	Nagabatha	ZARS, VC Farm Mandya
5	Byranalla	ARS, Arsikere	13	Kichidi sona	ZARS, VC Farm Mandya
6	Karimundaga	ZARS, VC Farm Mandya	14	Sirlagageshwari	ZARS, VC Farm Mandya
7	Sannamallige	ZARS, VC Farm Mandya	15	Kanadatumba	ARS, Ponnampet
8	Deharadun Basumathi	ZARS, VC Farm Mandya			

Table 4: Physical quality of traditional rice varieties

S. No.	Variety	Test weight (g)	Seed length (mm)	Seed breadth (mm)	Seed thickness (mm)	L/B Ratio
1	Billiraja mudi	16.6	8.01	2.16	1.75	3.70
2	Ratnachudi	16.3	7.83	2.59	1.73	3.02
3	Jeerige sanna	12.3	6.66	2.28	1.74	2.92
4	Gandasale	12.4	6.47	2.35	1.78	2.76
5	Byranalla	30.8	7.88	3.32	2.28	2.37
6	Karimundaga	20.1	7.67	2.84	2.01	2.70
7	Sannamallige	22.3	7.21	2.39	1.71	3.01
8	D.Basumathi	20.1	10.14	1.97	1.76	5.14
9	Salem sanna	14.2	7.86	2.25	1.71	3.49
10	Bilimundaga	34.4	8.49	3.38	2.33	2.51
11	Morada	24.3	8.64	2.99	1.88	2.89
12	Nagabatha	30.2	8.92	3.08	2.18	2.90
13	Kichidi sona	16.3	7.61	2.40	1.75	3.17
14	Sirlagageshwari	16.5	7.77	2.43	1.87	3.20
15	Kanadatumba	24.1	9.44	2.31	1.96	4.08
	Mean	**20.70**	**8.04**	**2.58**	**1.90**	**3.19**
	SEm±	**1.00**	**0.60**	**0.15**	**0.03**	**0.706**
	CD@5%	**2.92**	**1.32**	**0.96**	**0.67**	**0.251**
	CV (%)	**2.10**	**5.51**	**3.30**	**3.51**	**3.810**

Milling quality: In the present study, milling quality varied among traditional rice cultivars (Table 5). The cultivars Kichadi Sona and Salem Sanna recorded higher milling yield (66.0% and 65.0%) and head rice (58.5% and 58.30%), respectively. High milling percentage of these varieties may be due to higher head rice recovery. Rita and Sarawgi (2008) reported that more than 80 value milling percentage is preferred and if the milling percentage increases the head rice recovery also increased. As per Shobha Rani *et al.* (2006) the head rice recovery may vary from as low as 25% to as high as 65%. On contrary, in the present study, none of the entries were recorded more than 65 per cent head rice recovery indicating the genotypic difference for milling quality. The lowest hull per cent was noticed in Ratnachudi and Gandasale (32.0%) and highest in Byranella and Sannamallige (41.0%). The variation in the milling quality may due to genotypic differences. A similar difference for milling quality was also reported by Pramila *et al.* (2011) and Ravindra Babu *et al* (2013) in rice. The cultivar Bilirajamudi showed less broken rice (3.1%) followed by Ratnachudi (3.2%) and highest broken rice was noticed in D. Basumathi (9.7%). The milling breakage in rice genotypes is an indicative of poor milling quality and the breakage may be due to either genetic characteristics or improper drying after harvest (Seetanum and De Datta; 1973 and Manisha *et al.* 1992) or may be due to grain length and presence of more of immature grains (Aruna *et al.*, 1999).

Cooking quality: Cooking time varied from 22 minute to 35 minute among traditional cultivars (Table 6). Due to hard nature, the genotype Nagabatha took significantly more cooking time (35 min), whereas Salem sanna due to smaller thickness (1.57 mm) took least time for cooking (22 min) than those with larger thickness and coarser surfaces (Mohapatra and Bal, 2006). Linear elongation of rice on cooking is one of the major characteristics of good rice. Some varieties expand more in size than others upon cooking. Length-wise expansion without increase in girth is considered as highly desirable trait of high quality rice (Sood and Sadiq, 1979). The highest grain elongation was recorded in D. Basumathi (3.3 mm) and least in Salem Sanna (0.4 mm). This finding is consistent with a previous report on local rice variety (Danbaba *et al.*, 2011). However, grain elongation on cooking is also dependent on genetic factors as well as the degree of milling. Cooked rices with hard GC harden faster than those with a soft one. Rice with soft GC cook tender, and remain soft even upon cooling (Juliano 1979). Rices with soft GC are prefered by most rice consumers. Grains with high gel consistency (GC) exhibit a higher degree of tenderness on cooking which is one of the most preferred characteristics among the grain quality parameters (Ravindra Babu, 2013). The GC was maximum (4.3 cm) in Ratnachudi indicating the hard nature, whereas Byranalla with soft nature recorded lower gel consistency (2.2 cm).

In the present study, the gelatinization temperature ranged from low to high. The variation in the gelatinization temperature could be traced to its cooking time since cooking time positively determines the gelatinization temperature of rice. It has been asserted that the higher the value of gelatinization temperature, the longer time it takes to cook rice (Bhattacharya and Sowbhagya, 1971). The genotypes *viz*., Jeerige Sanna (34.0 min), Byranella (34.0 min), Morada (34.0 min) and Nagabatha (35) with high gelatinization temperature took more time to cook. Alkali spreading value is also one of the important cooking quality traits and its intermediate scores (4-5) indicate intermediate amylose content. Alkali spreading value ranges from 1.0 to 7.0 of the tested varieties confirming the results of Rathi *et al.* (2010). In the present study, high alkali spreading value (7.0) corresponded to low gelatinization temperature (7.0) was recorded in Salem sanna and Sirlageshwari. These results are in confirmity with the results of Perez and Juliano (1979).

Nutritional quality: Rice is a major source of food protein in Asia and other countries where the daily intake of rice is high, its value as a protein source is enhanced by its high lysine content compared to other cereal grains. However, the main limitation of rice as a protein source is its less protein content (6 to 8%). As such protein deficiency is predominant in rice consuming population. An increase in protein content would result in substantial increase in protein intake by a large number of consumers provided the quality of protein is not impaired (Nandini, 2013). Protein content varied from 8.46 to 14.67% in traditional rice genotypes. The highest protein content (14.67%) was recorded in Nagabatha. On the basis of nutritional value all the varieties contained sufficient amount of protein except Billirajamudi (8.46%) in which protein content remain comparitively low (Fig. 1). The protein content of fine grain rice is usually lower (Kaul, *et al.,* 1982; Dutta *et al.,* 1998) which is consistent with the findings of the present study. The cultivar D. Basumathi showed highest carbohydrate content (30.71%) followed by Sirlagalageshwari (30.08%). Whereas, cultivar Morada (18.34%) showed lowest carbohydrate content (Fig 2) followed by Gandasale (20.10%). This clearly indicates the existence of wide genetic variability for carbohydrate content in rice (Chandel *et al.,* 2005). Whereas, Pomeranz (1992) reported difference in the rice composition might be due to the variety and processing method used.

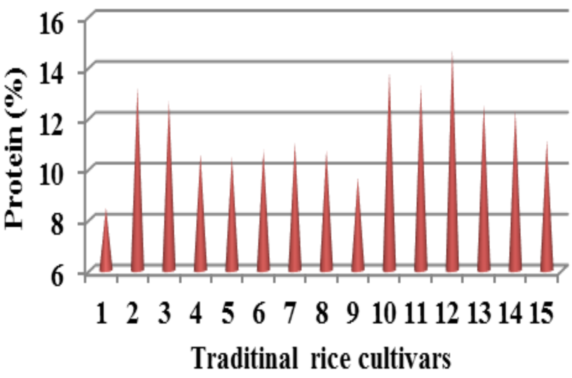

Fig.1: Protein content of traditional rice cultivars

Table5. Milling quality of traditional rice varieties

Sl. No.	Variety	Milling yield (%)	Husk (%)	Head rice (%)	Broken (%)
1	Billiraja mudi	57	33	55.2	3.1
2	Ratnachudi	59	32	54.8	3.2
3	Jeerige sanna	60	40	54.9	5.3
4	Gandasale	58	32	53.3	5.1
5	Byranalla	60	41	54.8	5.2
6	Karimundaga	60	40	55.1	4.8
7	Sannamallige	60	41	54.8	5.0
8	D.Basumathi	65	36	55.6	9.7
9	Salem sanna	65	35	58.3	7.1
10	Bilimundaga	60	40	54.8	5.2
11	Morada	60	40	55.2	4.7
12	Nagabatha	60	40	55.0	4.8
13	Kichidi sona	66	36	58.5	7.1
14	Sirlagageshwari	65	36	58.2	7.2
15	Kanadatumba	60	32	57.5	2.8
	Mean	**61.06**	**36.84**	**55.7**	**5.4**
	SEm±	**3.101**	**0.322**	**0.901**	**0.066**
	CD@5%	**0.881**	**1.441**	**2.752**	**2.135**
	CV (%)	**2.801**	**2.600**	**2.301**	**3.801**

Table 6. Cooking quality of traditional rice varieties

Sl.No	Variety	Cooking time (min)	Elongation ratio (mm)	GC (cm)	Amylose content (%)	ASV	GT
1	Billiraja mudi	31	0.6	4.1	12.23	6	Low
2	Ratnachudi	30	1.3	4.3	12.67	6	Low
3	Jeerige sanna	34	1.0	3.4	12.51	1	High
4	Gandasale	30	0.7	3.5	11.74	1	High
5	Byranalla	34	0.8	2.2	12.89	2	High
6	Karimundaga	32	0.6	2.6	12.96	5	Intermediate
7	Sannamallige	25	1.2	3.5	12.63	1	High
8	D.Basumathi	30	3.3	3.4	11.98	6	Low
9	Salem sanna	22	0.4	3.7	11.88	7	Low
10	Bilimundaga	25	0.8	3.0	12.22	6	Low
11	Morada	34	0.9	2.3	12.73	2	High
12	Nagabatha	35	0.6	3.3	13.51	1	High
13	Kichidi sona	23	1.0	3.5	11.95	3	High to Intermediate
14	Sirlagageshwari	30	0.5	2.7	12.24	7	Low
15	Kanadatumba	33	0.6	2.3	12.21	1	High
	Mean	**28.83**	**0.930**	**3.191**	**12.42**		
	SEm±	**0.815**	**0.048**	**0.099**	**0.072**		
	CD@5%	**1.091**	**0.290**	**0.286**	**1.014**		
	CV (%)	**2.098**	**1.08**	**5.35**	**1.051**		

Amylose content can play a significant role in determining the overall cooking, eating and pasting properties of a rice variety (Adu-Kwarteng *et al.*, 2003, Asghar *et al.*, 2012). It is an indicator of volume expansion and water absorption during cooking and correlates with hardiness, whiteness and dullness of cooked rice. Most of the basmati type lines and non-aromatic varieties have high amylose content (Juliano, 1993). In the present study, the Amylose content of the tested entries ranges >11% (Fig 3). The cultivar Nagabatha recorded highest amylose content (13.51%) and it was lowest in Gandasale (11.74 %) and Salem Sanna (11.88 %). Most of the short grained aromatic lines have intermediate amylose content and cooks fluffy and remains soft on cooling and is the most preferred one. Similar results have also been found by Anonymous (1997). The cultivars Moroda and D. Basumathi showed highest (26.09 ppm) zinc content and Kichadi Sanna (19.01 ppm) showed lowest zinc content (Fig 4). The results for zinc content are in line with earlier findings reported by Eppendorfer *et al.* (1983) and Sotelo *et al.* (1990) who reported higher zinc contents in traditional rice cultivars. Highest iron content (Fig 5) in the present study was recorded in Kanadathumba (81.84 ppm) and Sannamallige (81.48ppm). These results are in agreement with the findings of (Anjum *et al.* 2007). Therefore, these cultivars must be given more attention by the rice breeders to use in their hybridization programmes.

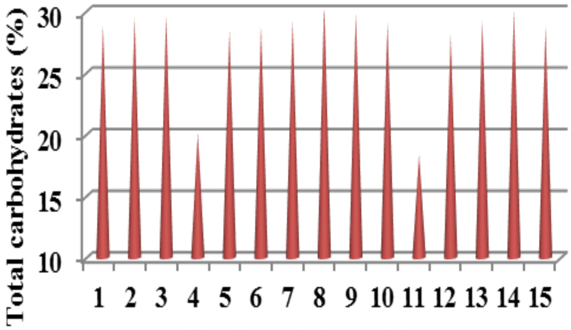

Fig. 2: Total carbohydrates of traditional rice cultivars

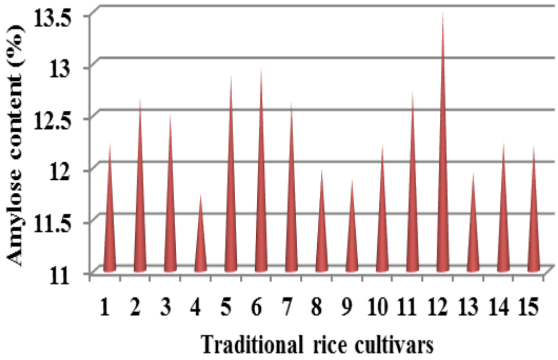

Fig. 3: Amylose content of traditional rice cultivars

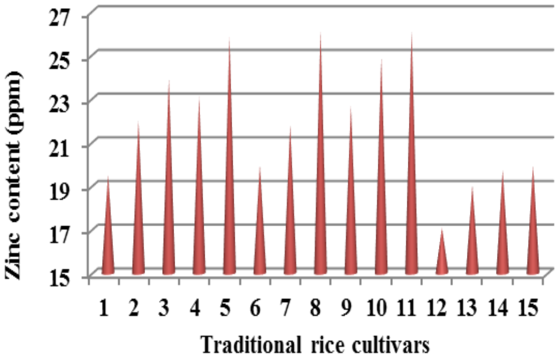

Fig. 4: Zinc content of traditional rice cultivars

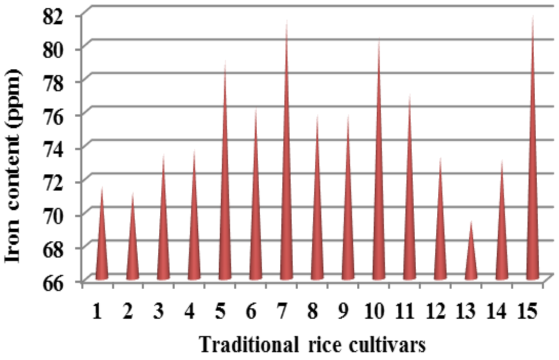

Fig. 5: Iron content of traditional rice cultivars

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CITE THIS ARTICLE AS:

Gangadharaiah S, Babu HN Ramesh, Prasad S Rajendra, Pramila CK and Vishwanath K. Physiochemical Properties and Cooking Qualities of Traditional Rice Cultivars. *Annals of Plant Sciences* 4.8 (2015): 1173-1178.

Source of support: Nil
Conflict of interest: None Declared