Mysore J. Agric. Sci., 51 (3) : 726-734, 2017

Cooking Qualities of Traditional Rice Varieties of Karnataka

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Abstract

Evaluation of twenty traditional rice varieties grown in Karnataka, as a dehusked grain was performed with respect to cooking characteristics. Traditional rice varieties varied significantly ($p<0.05$) for cooking characteristics such as gelatinization temperature (67.47-71.14 °C), gel consistency (49.67-95.67 mm), optimum cooking time (19.67-32.33 min), water uptake ratio (2.40-4.60), elongation ratio (1.12-2.71), volume expansion ratio (1.27-3.60) and dispersed solids (1.55-6.33 %). The organoleptic test for cooked traditional rice's were conducted for appearance, cohesiveness, tenderness on touching, tenderness on chewing, taste, aroma, elongation, and overall acceptability on five point hedonic scale. Statistical significant difference were found between the traditional rice varieties for all the sensory attributes except for taste. All the traditional rice varieties studied were recorded good to excellent overall acceptability scores with the mean of 3.47 ± 0.39. Overall, among twenty traditional rice varieties evaluated, Rajmudi (4.05) was most favoured by judges followed by Salem sanna (3.99) and Jeerige sanna (3.95) and least favoured by judges for Krishnaleela (2.76) and Anandi (2.80).

Keywords : Cooking quality, traditional rice varieties, organoleptic

Rice (*Oryza sativa* L.) is one of the major food crop in the world and more than 50 per cent of the world's population depend on rice as their primary calorie source (www.eu.m.wikipedia.org/wiki/rice) and increasingly becoming popular because of its nutritional and beneficial health properties (Saikia *et al.,* 2012). It is usually consumed as a whole grain after processing and cooking and in a regular Asian diet, can contribute for 40 to 80 per cent of the total calorie intake (Hossain *et al.,* 2009 and Cai *et al.,* 2011). Commonly, rice is consumed as polished white rice with the husk, bran, and germ fractions removed. However, consumption of brown rice (hulled rice) is increasing in recent years, due to the increased awareness about its health benefits and good nutritional properties due to higher amounts of proteins, ash, dietary fibre and minerals than white rice (Tan *et al.,* 2009; Mohan *et al.,* 2010 and www.ars.usda.gov/services/docs.htm?docid=8964.u). Through the introduction of modern high yielding varieties, along with new management practices and green revolution has led to a considerable increase in rice production in India as in other Asian countries. This development has led to a gradual erosion of the rice genetic diversity, since thousands of traditional rice varieties were replaced by relatively few high yielding rice varieties (Rahman *et al.,* 2006). Being a major cereal grain, evaluating the cooking qualities of rice has been given highest priority (Dong *et al.,* 2007). Rice grain quality is reported to be influenced by various physico-chemical and cooking characteristics (Bocevska *et al.,* 2009 and Moongngarm, 2010). Amylose content as well as gelatinization temperature and gel consistency can highly influence cooking and eating qualities of rice, which can vary based on the varieties. Providing adequate information on the quality of rice consumed by local population is important for health conscious consumer. Variety with best grain properties remains the most important determinant of market grading and end use qualities. However, studies have not been carried out comprehensively on cooking qualities of traditional rice varieties in Karnataka, India.

Material and Methods

Procurement of traditional paddy rice varieties **:** Twenty traditional rice verities from Karnataka were selected for this study. The samples were procured from All India Coordinated Research Project on Rice, ZARS, V. C. Farm, Mandya.

Cooking characteristics of traditional rice varieties Alkali Spreading Value (ASV) and

Gelatinization Temperature (GT) : Gelatinization temperature (GT) was indexed by 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 (27-30 °C) was evaluated on a 7-point numerical scale. Each test was conducted three times, each time, 10 intact milled grains were placed on a petridish to which 15 ml of 1.7 per cent 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. Grains swollen to the extent of a cottony centre 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 unaffected were given ASV of 1 and grains that were dispersed and disappeared completely were given a score of 10. A low ASV correspond to a high gelatinization temperature, conversely, a high ASV indicates a low GT. The gelatinization temperature of the variety determined from the alkali score by the equation;

$$GT = 74.8 - 1.57 \times ASV$$

GT was classified in to low (55-69 °C); low intermediate (69-70 °C); intermediate (70-74 °C); high (>74 °C).

Gel consistency (GC) : 100 mg of rice flour was taken in test tube (2×19.5 cm), 0.2 ml of ethanol containing 0.25 per cent thymol blue and 2.0 ml of 0.2 N of KOH were added and kept in boiling water-bath for 8 min, cooled, mixed well and kept in ice bath for 20 min. Later the test tubes were laid horizontally for one hr and measurements were made using graph paper. The degree of disintegration of kernel was evaluated using a 7 point scale (Bhattacharya, 1979). The varieties were classified on the basis of gel consistency (gel length) as hard (27–40 mm), medium (41–60 mm), and soft (over 60 mm) gel types (Saikia *et al.,* 2012).

Cooking time : It was determined for each sample by the glass plate white center method of Ranghino (1966). Distilled water (100 ml) was heated to boiling in a 250 ml beaker before 5g of milled rice was added. After 10 min of boiling, samples of 10 grains were withdrawn every minute with a spatula and pressed between two glass plates. Minimum cooking time (MCT) is the time when at least 90 per cent of the pressed grains no longer exhibited opaque or uncooked centers. Optimum cooking time (OCT) equals the minimum cooking time plus two minutes (Juliano *et al.,* 1981).

Water Uptake Ratio (WUR): This was determined by cooking 2.0 g of whole rice kernels from each treatment in 20 ml distilled water for a minimum cooking time in a boiling water bath and draining the superficial water from the cooked rice. The cooked samples were then weighed accurately and the water uptake ratio was calculated as the ratio of final cooked weight to uncooked weight (Oko *et al.,* 2012).

$$\text{Water uptake ratio} = \frac{\text{Weight of cooked rice}}{\text{Weight of uncooked rice sample}}$$

Volume Expansion Ratio (VER) and Elongation Ratio (ER) : 15 ml of water taken in 50 ml graduated centrifuge tubes and 5 g of rice sample was added. Initial volume increase was measured (Y) and soaked for 10 min. Then increase in volume before cooking was noted (Y-15). Rice samples were cooked for 20 min in a water bath. Cooked rice was placed on blotting paper. Then the cooked rice was placed in 50 ml water taken in 100 ml measuring cylinder and increase in volume of cooked rice in 50 ml of water was measured (X). Then the volume raise was recorded (X-50). VER and ER were calculated (Anon, 2004).

To determine elongation ratio, cumulative length of 10 cooked rice kernels was divided by length of 10 uncooked raw kernels and the result was reported as elongation ratio.

Dispersed solids (DS) : This was determined by drying an aliquot of the cooking water in a tarred evaporating dish to evaporate the water as steam (Oko *et al.,* 2012). The weight of the empty petri dish was measured and recorded (W1). This was followed by measuring the weight of the petri dish and aliquot (W2). The weight of the petri dish and the dry aliquot was measured (W3). The amount of solid in cooking water was now calculated as: W3 – W1; where W1 = weight of empty petri dish, W2 = weight of petri dish + aliquot and W3 = weight of petri dish + dry aliquot.

Organoleptic evaluation : Rice samples were soaked for 10 min and cooked in boiling water bath for 20 to 30 min and scored as per panel test performance on 5 point hedonic scale (Anon, 2004).

Statistical analysis : All data were analyzed by the one way Analysis of Variance (ANOVA) procedure. Differences were declared statistically significant when $P < 0.05$. Where significant differences were detected, the means were separated by Duncan's multiple range test (DMRT) at 5 per cent probability level using the MSTAT-C statistical package.

Results and Discussion

The cooking quality of rice is influenced by the gelatinization and retrogradation characteristics of its starch. Statistically significant differences ($p<0.05$) were observed between the varieties for all the cooking characteristics studied (Table I).

Cooking characteristics of traditional rice varieties : Long grain rice varieties showed ASV in the range of 2.67 (Murkan sanna) to 4.67 (Anandi), whereas, medium grain rice varieties showed 2.33 (Karimundaga) to 4.33 (Doddabyranellu). ASV of short grain rice varieties was observed between 2.67 and 4.33. The result established that Anandi (4.67) recorded highest and Karimundaga (2.33) recorded least ASV among all the varieties studied. Among the long grain rice varieties no significant difference was observed for the varieties Murkan sanna (70.61 °C), Krishnaleela (70.09 °C), and Gajagunda (70.09 °C) with respect to GT and these varieties recorded highest value. GT of medium grain rice varieties varied between 68.00 °C and 71.14 °C while, short grain rice varieties showed GT of 68.00 to 70.61 °C. Overall, the medium grain variety Karimundaga (71.14 °C) showed highest GT and lowest was recorded by long grain variety Anandi (67.47 °C). The variety Anandi was determined to have low GT (67.47 °C) with an ASV of 4.67 and the variety Karimundaga was determined to have high GT (71.14 °C) with ASV of 2.33. Differences in gelatinization temperature are governed by amylopectin structure (chain length distribution), which can be influenced by the cultivar, location, and crop year (Singh *et al.,* 2006 and Cameron *et al.,* 2008). GT values in the present study are comparable to the findings of Kibanda and Luzi-Kihupi (2007).

Gel consistency (GC) : Among long grain rice varieties, gel consistency was found significantly lowest in Kagisaale and Gajagunda (55.33 mm) and highest in Anandi (95.67 mm). Among medium grain rice varieties, it varied between 49.67 and 95.67 mm. GC of short grain rice varieties ranged from 55.33 to 75.33 mm. Overall, the least GC was recorded in medium grain variety Karimundaga (49.67 mm). GC reported by Oko *et al.* (2012) ranged from 43 to 54 mm in local and newly introduced rice varieties in Ebonyi State, Nigeria.

Minimum cooking time (MCT) : The cooking time of rice from long grain varieties varied from 17.67 to 24.67 min, in which, the lowest time was found in Nagabatta and highest in Mysore mallige. Among the medium and short grain varieties, cooking time ranged from 18.33 to 30.33 min and 18.33 to 27.33 min, respectively. Irrespective of the grain type, Malgudi sanna (30.33 min) required significantly more cooking time and was on par with Ratnachoodi (30.00 min) which differed significantly than the rest. The long grain variety Nagabatta (17.67 min) required less cooking time. The variation in cooking time could be traced to its gelatinization temperature, which positively determines the cooking time of rice.

Thomas *et al.* (2013) reported minimum cooking time of 10 to 31.67 min in rice varieties marketed in Penag, Malaysia and found brown rice took longest minimal cooking time of 31.67 min. In the present study, similar findings were reported for brown traditional rice varieties. This could be due to the fact that the fibrous bran layer might have not yet been removed, and hence it requires longer time for the starchy endosperm to cook.

Optimum cooking time (OCT) : In the present study, similar trend was observed between minimum cooking time and optimum cooking time among all the rice varieties. Overall, the traditional rice varieties required more optimum cooking time, this might be due to the fact that the fibrous bran layer was not removed. Danbaba *et al.* (2011) indicated that Ofada rice cooks in excess water after a period ranging from 17 to 24 min, and on the average 20.8 min. Lower the

TABLE I

Cooking characteristics of traditional rice varieties

Category	No.	Varieties	ASV	GT (°C)	GC(mm)	MCT (min)	OCT (min)	WUR	ER	VER	DS (%)
Long grain	1	Gamnad batta	3.33^{cde}	69.57^{bcd}	58.67^{fg}	24.33^{cd}	26.33^{cd}	3.48^{cd}	2.63^{b}	1.72^{jkl}	2.73^{l}
	2	Anandi	4.67^{a}	67.47^{f}	95.67^{a}	19.00^{efg}	21.00^{efg}	2.68^{hij}	1.52^{j}	3.60^{a}	6.33^{a}
	3	Krishnaleela	3.00^{def}	70.09^{a}	56.00^{fgh}	19.00^{efg}	21.00^{efg}	2.73^{hi}	2.15^{e}	3.10^{c}	4.64^{d}
	4	Kagisaale	3.67^{bcd}	69.04^{cde}	55.33^{gh}	23.67^{cd}	25.67^{cd}	2.48^{ij}	1.48^{j}	2.80^{d}	3.93^{g}
	5	Murakan sanna	2.67^{ef}	70.61^{ab}	59.00^{fg}	24.33^{cd}	26.33^{cd}	2.65^{hij}	1.90^{g}	1.65^{l}	4.30^{ef}
	6	Mysore mallige	3.33^{cde}	69.57^{bcd}	74.67^{de}	24.67^{cd}	26.67^{cd}	3.77^{bc}	2.66^{ab}	1.75^{ijk}	3.19^{jk}
	7	Nagabatta	3.67^{bcd}	69.04^{cde}	86.00^{bc}	17.67^{gh}	19.67^{gh}	2.61^{hij}	2.09^{ef}	3.30^{b}	3.56^{h}
	8	Gajagunda	3.00^{def}	70.09^{abc}	55.33^{gh}	23.00^{d}	25.00^{d}	2.88^{gh}	2.16^{e}	2.28^{f}	4.10^{fg}
Medium grain	9	Doddabyranellu	4.33^{ab}	68.00^{ef}	87.00^{b}	19.67^{ef}	21.67^{ef}	3.37^{de}	1.86^{g}	2.40^{e}	4.53^{de}
	10	Ratnachoodi	3.33^{cde}	69.57^{bcd}	54.33^{h}	30.00^{a}	32.00^{a}	3.15^{efg}	2.15^{e}	1.48^{m}	3.55^{h}
	11	Malgudi sanna	4.00^{abc}	68.52^{def}	95.67^{a}	30.33^{a}	32.33^{a}	2.40^{j}	2.71^{a}	1.77^{hij}	5.75^{b}
	12	Gowrisanna	3.33^{cde}	69.57^{bcd}	78.33^{d}	18.33^{fgh}	20.33^{fgh}	3.99^{b}	1.71^{h}	1.83^{h}	3.23^{ijk}
	13	Chinna ponni	3.33^{cde}	69.57^{bcd}	58.33^{fg}	24.33^{cd}	26.33^{cd}	2.67^{hij}	2.06^{f}	2.13^{g}	2.93^{kl}
	14	Salem sanna	3.00^{def}	70.09^{abc}	82.67^{c}	27.67^{b}	29.67^{b}	3.29^{def}	1.90^{g}	1.67^{l}	5.18^{c}
	15	Karimundaga	2.33^{f}	71.14^{a}	49.67^{i}	27.00^{b}	29.00^{b}	4.60^{a}	2.30^{d}	3.04^{c}	6.33^{a}
	16	Rajmudi	2.67^{ef}	70.61^{ab}	56.33^{fgh}	25.00^{c}	27.00^{c}	3.05^{fg}	2.53^{c}	1.27^{n}	3.58^{h}
Short grain	17	Rajakaime	4.33^{ab}	68.00^{ef}	75.33^{de}	18.33^{fgh}	20.33^{fgh}	2.73^{hi}	1.87^{g}	1.81^{hi}	1.55^{m}
	18	Jeerige sanna	2.67^{ef}	70.61^{ab}	55.33^{gh}	27.33^{b}	29.33^{b}	2.63^{hij}	1.60^{i}	1.43^{m}	3.40^{hij}
	19	Gandhasaale	3.67^{bcd}	69.04^{cde}	72.67^{e}	19.00^{efg}	21.00^{efg}	2.40^{ij}	1.46^{j}	1.67^{kl}	4.26^{ef}
	20	Kalajeera	2.67^{ef}	70.61^{ab}	59.67^{f}	20.33^{e}	22.33^{e}	2.71^{hi}	1.12^{k}	2.34^{ef}	3.50^{hi}
F test			*	*	*	*	*	*	*	*	*
SEm±			0.325	0.510	1.280	0.596	0.596	0.143	0.027	0.027	0.143
CD at 5 %			0.901	1.414	3.549	1.653	1.653	0.396	0.074	0.075	0.396

* Significant at 5 % level

Note : Means in the same column followed by different superscript letters differ significantly

ASV : Alkali spreading value; GT: Gelatinization temperature; GC: Gel consistency;
MCT: Minimum cooking time; OCT: Optimum cooking time; WUR: Water uptake ratio;
ER: Elongation ratio; VER: Volume expansion ratio; DS: Dispersed solids;

cooking time, the better in terms of fuel and energy consumption during cooking. In this regard the variety Nagabatta in the present study was favoured with less cooking time (19.67 min).

Water uptake ratio (WUR) : In the present study, Mysore mallige (3.77) showed significantly highest water uptake ratio among the long grain rice varieties least was observed in Kagisaale (2.48). WUR of medium grain rice varieties varied between 2.40 (Malgudi sanna) and 4.60 (Karimundaga), whereas for short grain rice varieties, it ranged from 2.40 (Gandhasaale) to 2.73 (Rajakaime). Overall, the medium grain variety Karimundaga (4.60) had highest WUR. Disorganised cellular structure can enhance the probabilities for high water absorption during cooking which is in agreement with Thomas *et al.* (2013) reported highest WUR for brown rice (3.95) and lowest for glutinous rice (2.33). Similar values of WUR were observed in the present study. Factors affecting water absorption of the rice kernels include surface area, amylose, protein levels, and the temperature used for soaking (Bett-Garber *et al.,* 2007). At a higher WU (300 to 570 %), majority of rice showed pasty appearance (Hossain, *et al.,* 2009) which is not favourable for cooking and eating qualities.

Elongation ratio (ER) : Among long grain varieties, no significant difference in elongation ratio was observed between Mysore mallige (2.66) and Gamnad batta (2.63), which had recorded highest ER whereas, lowest ER recorded in Anandi (1.52) and Kagisaale (1.48). Malgudi sanna recorded highest ER (2.71) and lowest was observed in Gowrisanna (1.71) among medium grain varieties. Short grain rice varieties showed significantly lower values for ER compared to long grain and medium grain varieties, which is in contrary to Subudhi *et al.* (2012). Elongation of rice can be influenced by both the L/B ratio and the amylose contents (Danbaba *et al.,* 2011). Some varieties elongate more than others upon hydration and starch gelatinization without increase in girth; this is considered as a desirable cooking quality trait in most high quality rice of the world (Danbaba *et al.,* 2011).

Volume expansion ratio (VER) : In the present study, VER of cooked rice ranged from 1.27 to 3.60. Long grain rice variety Anandi recorded maximum VER of 3.60 and Murkan sanna (1.65) recorded least value. VER ranged from 1.48 to 3.04 among medium grain rice varieties. Short grain rice varieties showed VER ranged between 1.43 and 2.34. Among the selected varieties, Anandi recorded significant difference with highest VER (3.60) followed by Nagabatta (3.30) and least was recorded by Jeerige sanna (1.43). Bhonsle and Sellappan (2010) reported VER ranged from 2.0 to 4.0 in traditional rice varieties, while in high yielding varieties VER was 2.0 to 3.4.

Dispersed solids (%) : Solids released by rice into cooking water ranged from 2.73 to 6.33 per cent (long grain), 2.93 to 6.33 per cent (medium grain) and 1.55 to 4.26 (short grain) among rice varieties with highest value recorded by Anandi and Karimundaga (6.33) and lowest value by Rajakaime (1.55). These results are on par with the observations of Yadav *et al.* (2007), Ravi *et al.* (2012) and Thomas *et al.* (2013). The variation in values may be as a result of the variation in rice consistency seen in the bursting of the grains during and after cooking, as they are of different varieties.

Classification of traditional rice varieties based on gelatinization temperature (GT) and gel consistency (GC) : The results of Table II revealed that, eight varieties such as Murakan sanna, Gajagunda, Salem sanna, Karimundaga, Rajmudi, Jeerige sanna and Kalajeera showed intermediate GT followed by low intermediate (Gamnad batta, Kagisale, Mysore mallige, Nagabatta, Ratnachoodi, Gowri sanna and Gandhasale) and low GT (Anandi, Doddabyranellu, Malgudi sanna, Chinna ponni and Rajakaime). Eleven varieties (Gamnad batta, Krishnaleela, Kagisale, Murakan sanna, Galagunda, Ratnachoodi, Chinna ponni, Karimundaga, Rajmudi, Jeerige sanna and Kalajeera) had medium GC and nine varieties (Anandi, Mysore mallige, Nagabatta, Doddabyrenellu, Malgudi sanna, Gowri sanna, Salem sanna, Rajakaime and Gandhasaale) had soft GC and no varieties reported hard gel among the varieties studied.

Gelatinization Temperature (GT) and Gel Consistency (GC) : Table III depicts the grouping of T.R.V. based on GT and GC. 40.0 per cent of the rice varieties showed intermediate GT when indexed by alkali digestion test. Low and low intermediate GT

TABLE II

Classification of traditional rice varieties based on gelatinization temperature (GT) and gel consistency (GC)

Category	No.	Varieties	GT classification	GC behaviour
Longgrain	1	Gamnad batta	Low intermediate	Medium
	2	Anandi	Low	Soft
	3	Krishnaleela	Intermediate	Medium
	4	Kagisaale	Low intermediate	Medium
	5	Murakan sanna	Intermediate	Medium
	6	Mysore mallige	Low intermediate	Soft
	7	Nagabatta	Low intermediate	Soft
	8	Gajagunda	Intermediate	Medium
Mediumgrain	9	Doddabyranellu	Low	Soft
	10	Ratnachoodi	Low intermediate	Medium
	11	Malgudi sanna	Low	Soft
	12	Gowrisanna	Low intermediate	Soft
	13	Chinna ponni	Low	Medium
	14	Salem sanna	Intermediate	Soft
	15	Karimundaga	Intermediate	Medium
	16	Rajmudi	Intermediate	Medium
Shortgrain	17	Rajakaime	Low	Soft
	18	Jeerige sanna	Intermediate	Medium
	19	Gandhasaale	Low intermediate	Soft
	20	Kalajeera	Intermediate	Medium

GT classification : Low (55-69°C); Intermediate (70-74°C); Low intermediate (69-70°C)
GC behaviour : Hard (27-40 mm); Medium (41-60 mm); Soft (60 mm)

TABLE III

Grouping of traditional rice varieties based on gelatinization temperature (GT) and gel consistency (GC)

Gelatinization temperature	Varieties		Gel consistency behaviour	Varieties	
	N	%		N	%
Low (55-69°C)	5	25.0	Hard (27-40 mm)	0	0.0
Low intermediate (69-70°C)	7	35.0	Medium (41-60 mm)	11	55.0
Intermediate (70-74°C)	8	40.0	Soft (>60 mm)	9	45.0
Total	20	100.0	Total	8	100.0

TABLE IV

Organoleptic evaluation of traditional rice varieties

Sensory attributes	Response (Mean ± SD)	F test	SEm±	CD at 5 %
Appearance	3.68 ± 0.66	*	0.049	0.135
Cohesiveness	3.22 ± 0.81	*	0.115	0.320
Tenderness on touching	4.12 ± 0.60	*	0.123	0.340
Tenderness on chewing	4.27 ± 0.66	*	0.125	0.347
Taste	3.51 ± 0.12	NS	0.288	-
Aroma	4.01 ± 0.90	*	0.404	1.119
Elongation	3.15 ± 0.58	*	0.093	0.258
Overall acceptability	3.47 ± 0.39	*	0.078	0.215

*Significant at 5 % level, NS: Non significant

TABLE V

Organoleptic attribute scores of cooked traditional rice varieties

Varieties	Apprearance	Cohesive-ness	Tenderness on touching	Tenderness on chewing	Taste	Aroma	Elongation	Overall acceptability
Long grains								
Gamnad batta	4.00	3.55	3.55	4.70	3.60	2.80	3.85	3.72
Anandi	4.00	2.35	4.50	1.90	3.55	1.15	2.15	2.80
Krishnaleela	2.50	2.00	3.55	4.50	3.40	1.00	2.40	2.76
Kagisaale	4.00	3.10	3.75	3.65	3.50	2.55	3.70	3.46
Murakan sanna	4.00	3.40	3.70	4.50	3.65	2.75	3.55	3.65
Mysore mallige	4.00	3.25	4.45	4.35	3.65	2.70	3.85	3.75
Nagabatta	4.00	1.55	4.85	4.60	3.60	1.15	2.30	3.15
Gajagunda	2.50	2.65	3.05	4.30	3.60	2.70	2. 85	3.09
Medium grains								
Doddabyranellu	2.40	2.75	3.10	4.15	3.45	2.75	2.80	3.06
Ratnachoodi	4.00	4.15	4.75	4.85	3.20	1.15	3.70	3.69
Malgudi sanna	4.00	3.65	4.45	4.70	3.45	2.65	3.80	3.81
Gowrisanna	4.00	2.85	4.60	4.40	3.45	3.65	3.05	3.71
Chinna ponni	4.00	2.70	4.75	4.10	3.50	2.65	2.90	3.51
Salem sanna	4.00	4.35	4.80	4.80	3.60	2.60	3.80	3.99
Karimundaga	2.20	3.25	3.60	3.75	3.50	1.05	3.30	2.95
Rjamudi	4.00	4.55	4.80	4.75	3.65	2.75	3.85	4.05
Short grains								
Rajakaime	4.00	2.70	4.45	4.55	3.30	1.20	2.30	3.21
Jeerige sanna	4.00	4.50	4.40	4.65	3.55	3.60	2.95	3.95
Gandhasaale	4.00	3.55	3.65	4.50	3.40	2.60	2.95	3.52
Kalajeera	4.00	3.50	3.65	3.75	3.50	3.60	3.00	3.57

was observed in 25.0 and 35.0 per cent rice varieties, respectively. Danbaba *et al.* (2011) classified GT of Ofada rice samples as low (55-69 °C), intermediate (70-74 °C), and high (>74 °C) and 75.0 per cent of the Ofada rice samples showed low GT and remaining rice samples showed intermediate GT as the checks.

Among the traditional rice varieties, the length of the blue gel (gel consistency) was grouped as hard (27-40 mm), medium (41-60 mm) and soft (>60 mm). Medium and soft gel consistency was observed in 55.0 and 45.0 per cent of the traditional rice varieties. The presence of fat could interfere with the retrogradation of starch molecules, especially amylose. Therefore, rice gels with higher fat content showed a softer consistency (Cameron and Wang, 2005). Oko *et al.* (2012) classified newly introduced rice varieties in Ebonyi State, Nigeria based on gel consistency, all the varieties studied could be classified to be medium. For rice varieties with a hard texture, the gel is compact, flowing only a small distance, but for those with a soft texture, the gel is viscous and displaces up to 10 cm within one hour.

Organoleptic evaluation : Statistical significant difference was found between the traditional rice varieties for all the sensory attributes except for taste. The mean score of twenty rice varieties for appearance was 3.68 ± 0.66, which indicated the character in between creamish white / yellow and red streaks. The cohesiveness character of slightly separated to partially separated was observed in rice varieties with the mean score of 3.22 ± 0.81 (Table IV). The texture as measured by tenderness on touching of cooked rice's was moderately soft to soft with the mean score of 4.12 ± 0.60. Similar trend was observed for tenderness on chewing between the rice varieties with a mean score was 4.27 ± 0.66. The taste was observed to be good for all the varieties with a mean value of 3.51 ± 0.12. The average aroma score was 4.01 ± 0.90 and the character was mild to optimal for rice varieties studied. Rice varieties showed good to excellent elongation upon cooking with average score of 3.15 ± 0.58. All the traditional rice varieties studied were recorded good to excellent overall acceptability scores with the mean of 3.47 ± 0.39.

Organoleptic characteristics : The details of organoleptic characteristics of individual rice varieties are presented in Table V. Overall, among twenty traditional rice varieties evaluated, Rajmudi (4.05) was most favoured by judges followed by Salem sanna (3.99) and Jeerige sanna (3.95) and least favoured by judges for Krishnaleela (2.76) and Anandi (2.80). This is mainly because of amylose content, which plays a significant role in determining the overall cooking, eating and pasting properties of a rice variety (Asghar *et al.,* 2012). Apart from the amylose content, the cooking quality of rice can also be influenced by components such as: proteins, lipids or amylopectin (Cai *et al.,* 2011). Bhonsle and Sellappan (2010) conducted an organoleptic test on traditional and high yielding rice varieties and showed that excellent overall acceptability was recorded in the varieties Korgut and Tamde Jyoti.

The results of this study demonstrated a wide range of cooking properties among traditional rice varieties, which provided the basic information for future development of food applications using these varieties. Among twenty traditional rice varieties, Rajmudi was most favoured by judges followed by Salem sanna and Jeerige sanna.

References

Anonymous, 2004, Laboratory manual on rice grain quality procedure. Directorate of Rice Research, Rajendranagar, Hyderabad, India, p. : 1 - 20.

Asghar, S., Anjum, F. M., Amir, R. M. and Khan, M. A., 2012, Cooking and eating characteristics of Rice (*Oryza sativa* L.). *Pak. J. Food Sci.,* **22** (3) : 128 - 132.

Bett-Garber, K. L., Champagne, E. T., Ingram, D. A. and Mcclung, A. M., 2007, Influence of water-to-rice ratio on cooked rice flavour and texture. *Cereal Chem.,* **84**: 614-619.

Bhattacharya, K. R., 1979, Gelatinization temperature of rice starch and its determination. In proceedings of the workshop on chemical aspects of rice grain quality. *Int. Rice Res. Institute*, p. 231 - 249.

Bhonsle, S. J., 2010, Grain quality evaluation and organoleptic analysis of aromatic rice varieties of Goa, India. *J. Agr. Sci.,* **2** (3) : 99 - 107.

BOCEVSKA, M., ALDABAS, I., ANDREEVSKA, D. AND ILIEVA, V., 2009, Gelatinization behaviour of grains and flour in relation to physiochemical properties of milled rice (*Oryza sativa* L.). *J. Food Quality,* **32** : 108 - 124.

CAI, Y., LIU, C., WANG, W. AND CAI, K., 2011, Differences in physicochemical properties of kernels of two rice cultivars during grain formation. *J. Sci. Food Agric.,* **91** : 1977 - 1983.

CAMERON, D. K. AND WANG, Y. J., 2005, A better understanding of factors that affect the hardness and stickiness of long-grain rice. *Cereal Chem.,* **82** : 113 - 119.

CAMERON, D. K., WANG, Y. J. AND MOLDENHAUER, K. A., 2008, Comparison of physical and chemical properties of medium-grain rice cultivars grown in California and Arkansas. *J. Food Sci.,* **73**: C72-C78.

DANBABA, N., ANOUNYE, J. C., GANA A. S., ABO, M. E. AND UKWUNGWU, M. N., 2011, Grain quality characteristics of *Ofada* rice (*Oryza sativa* L.): Cooking and eating quality. *Int. Food Res. J.,* **18** (2) : 629 - 634.

DONG, M. H., SANG, D. Z., WANG, P., WANG, X. M. AND YANG, J. C., 2007, Changes in cooking and nutrition qualities of grains at different positions in a rice panicle under different nitrogen levels. *Rice Sci*., **14** : 141 - 148.

HOSSAIN, M. S., SINGH, A. K. AND FASIH-UZ-ZAMAN, 2009, Cooking and eating characteristics of some newly identified inter sub-specific (*indica / japonica*) rice hybrids. *Sci. Asia.,* **35** : 320 - 325.

JULIANO, B. O., PEREZ, C. M., BARBER, S., BLAKENEY, A. B., IWASAKI, T. A., SHIBUYA, N. AND KENEASTER, K. K., *et al.,* 1981, International cooperative comparison of instruments methods for cooked rice texture. *J. Texture Stud.*, **12** : 17 - 38.

KIBANDA J. M. N. AND A. LUZI-KIHUPI, A., 2007, Influence of genetic and genotype x environment interaction on quality of rice grain, *Afr. Crop Sci. J.,* **15** (4) : 173 - 182.

LITTLE, R. R., HILDER G. B. AND DAWSON, E. H., 1958, Differential effect of dilute alkali on 25 varieties of milled white rice. *Cereal Chem.,* **35** : 111 - 126.

MOHAN, B. H., MALLESHI, N. G. AND KOSEKI, T., 2010, Physico-chemical characteristics and non-starch polysaccharide contents of *indica* and *japonica* brown rice and their malts. *Food Sci. Technol.,* **43** (5) : 784 - 791.

MOONGNGARM, A. AND SAETUNG, N., 2010, Comparison of chemical compositions and bioactive compounds of germinated rough rice and brown rice, *Food Chem.,* **122** (10) : 782 - 788.

OKO, A. O., UBI, B. E. AND DAMBABA, N., 2012, Rice cooking quality and physico-chemical characteristics : A comparative analysis of selected local and newly introduced rice varieties in Ebonyi state, Nigeria. *Food Pub. Health.,* **2** (1) : 43 - 49.

RAHMAN, S., SHARMA, M. P. AND SAHAI, S., 2006, Nutritional and medicinal values of some indigenous rice varieties. *Indian J. Tradit. Know.,* **5** (4) : 454 - 458.

RANGHINO, F., 1966, Evaluation of the resistance of rice to cooking as a function of the time of gelatinization of the grains. *Riso.,* **15** : 117 - 127.

RAVI, U., MENON, L., GOMATHY, G., PARIMALA, C. AND RAJESHWARI, R., 2012, Quality analysis of Indigenous organic Asian Indian rice variety - salem samba. *Indian J. Trad. Know*., **11** (1) : 114 - 122.

SAIKIA, S., DUTTA, H., SAIKIA, D. AND MAHANTA, C. L., 2012, Quality characterization and estimation of phytochemicals content and antioxidant capacity of aromatic pigmented and non-pigmented rice varieties. *Food Res. Int.,* **46** (2) : 334 - 340.

SINGH, N., KAUR, L., SANDHU, K. S., KAUR, J. AND NISHINARI, K., 2006, Relationship between physicochemical, morphological, thermal, rheological properties of rice starches. *Food Hydrocoll.,* **20** : 532 - 542.

SUBUDHI, H. N., SWAIN, D., DAS, S., SHARMA, S. G. AND SINGH, O. N., 2012, Studies on grain yield, physico-chemical and cooking characters of elite rice varieties (*Oryza sativa* L.) in eastern India. *J. Agric Sci*., **4** (12) : 2012 - 2022.

TAN, F., DAI, W. AND HSU, K., 2009, Changes in gelatinization and rheological characteristics of *japonica* rice starch induced by pressure/heat combinations. *J. Cereal Sci.,* **49** (2) : 285 - 289.

THOMAS, R., WAN-NADIAH, W. A. AND BHAT, R., 2013, Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia. *Int. Food Res. J.,* **20** (3) : 1345 - 1351.

YADAV, R. B., KHATKAR, B. S. AND YADAV, B. S., 2007, Morphological, physicochemical and cooking properties of some Indian rice (*Oryza sativa* L.) cultivars. *J. Agric. Technol.,* **3** (2) : 203 - 210.

www.ars.usda.gov/services/docs.htm?docid=8964.u

www.eu.m.wikipedia.org/wiki/rice.

(*Received :* May, 2017 *Accepted :* August, 2017)