International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 1798-1801
© 2020 IJCS
Received: 07-01-2020
Accepted: 09-02-2020

S Muthuramu
Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi, Tamil Nadu, India

T Ragavan
Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi, Tamil Nadu, India

Corresponding Author:
S Muthuramu
Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi, Tamil Nadu, India

Physicochemical and cooking qualities of rainfed rice genotypes

S Muthuramu and T Ragavan

DOI: https://doi.org/10.22271/chemi.2020.v8.i2ab.9022

Abstract
An investigation was carried out at Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi to assess the physicochemical and cooking properties of rainfed rice varieties. The hulling and milling percentage ranged between 55.75 (PMK 3) to 79.75 (PM 16004) and 51.50 (PMK 3) to 74.25 (PM 16004) respectively. Head Rice Recovery Percentage varied from 45.33 (PM 17027) to 72.0 (PM 16003). Correlation was done for determining the nature of interaction among the physicochemical and cooking characters. The hulling percentage was highly significantly associated with milling percentage, head rice recovery and gel consistency. Milling percentage had positive significant association with head rice recovery, breadth wise elongation ratio and gel consistency. The kernel length is highest in Anna 4 (6.9 mm) which shows long grain length and lowest in short grain type PM 17003 (5.0 mm) while the kernel breadth ranged between 1.9 (ADT 45) to 2.7 mm (PM 17025). The Kernel length after cooking ranged from 8.0 mm (PM 17003) to 11.1 mm (Anna 4). The volume expansion ratio in rice cultivars ranged between 3.2 (TKM 13) to 5.0 (PM 16002) and the gel consistency ranged from 50 mm in PMK 3 to 90 mm in PM 17022.

Keywords: Physicochemical, cooking quality, correlation, rainfed rice

Introduction
Rice (*Oryza sativa* L.) is the most important cereal food crop of the world and about 90 per cent of the people of South-East Asia consume rice as staple food. Although production, harvesting and postharvest operations affect overall quality of milled rice, variety remains the most important determinant of market and end-use qualities. Qualities desired in rice vary from one geographical region to another and consumers demand certain varieties and favours specific quality traits of milled rice for home cooking. Quality of rice is not always easy to define as it depends on the consumer and the intended end use for the grain. All consumers want the best quality that they can afford (Pushpa *et al*., 2019) [10]. As countries reach self-sufficiency in rice production, the demand by the consumer for better quality rice has increased. Grain quality is not just dependent on the variety of rice, but quality also depends on the crop production environment, harvesting, processing and milling systems. Rice grain quality is determined by its physical and physicochemical properties. Physical properties include kernel size, shape, milling recovery, degree of milling and grain appearance (Cruz and Khush, 2000) [3]. Physicochemical properties of rice are determined based on amylose content, gel consistency and gelatinization temperature. In rice, eating and cooking qualities are mainly controlled by the physicochemical properties which greatly influence the consumer's affinity (Rohilla, 2000) [12]. Volume expansion over cooking is another quality parameter which influences the edible volume which is the final output after cooking (Rebeira *et al*., 2014) [11]. Therefore, eating and cooking quality can be considered as a vital intrinsic quality component of rice grains that have to be focused in future rice breeding programmes to meet market demands.

Materials and methods
The experimental material comprised with seventeen advanced rice cultures which were evaluated in a randomized block design with three replications at Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi during Rabi 2019-20.

The experimental site is located at 9” 21’ N latitude, 78” 22’ E longitudes and an altitude of 242 m above mean sea level with average annual rainfall of 840 mm. This site has clay loam soil texture with pH of 8.0. Each genotype was raised in 5x2 m plot keeping 15 x 10 cm spacing. The recommended agronomic practices followed to raise good crop stand.

After harvest, samples were cleaned thoroughly and dried in hot air oven up to 12-14% moisture content. The rough rice was cleaned and dehulled with a Laboratory Sheller and hulling percent was calculated. Dehusked kernels were polished to remove bran and milling percent was calculated. Head rice or milling recovery is the estimates of head rice with more than 2/3 rd size and expressed as percentage. Kernel length, kernel breadth and length breadth ratio were measured using graph sheet and the mean was expressed in millimeters (mm). Based on average length, kernels were classified based on Standard Evaluation System (IRRI, 1996) [4].

Milled head rice was cooked for the minimum cooking time as described by (Singh *et al.*, 2005) [13]. Ten unbroken milled kernels were measured for their length and breadth before cooking. The kernels were kept in porous cloth bags, tied and pre soaked in water for 20 minutes. The cooked rice was taken out from the bags and placed on a blotting paper to drain the excess water. Length and breadth of ten cooked rice grains was measured in three replications and expressed in millimeters. The ratio of mean length of cooked rice to mean length of milled rice was computed as linear elongation ratio (Juliano *et al*., 1984). Breadth wise expansion (BER) ratio was computed as the ratio of mean breadth of cooked rice to mean breadth of milled rice. Cooked length–breadth (L/B) ratio was determined by divided the cumulative length of five cooked kernels by the breadth of five cooked kernels. A mean of three replications was reported (Singh *et al.*, 2005) [13].

Gelatinization Temperature was estimated based on Alkali Spreading Value (ASV) of milled rice. Standard Evaluation System (IRRI, 1996) [4] was used to score ASV. Duplicate sets of six whole milled kernel of each entry were placed in Petri dish containing 10 ml of 1.7% potassium hydroxide (KOH) solution. The kernels were arranged in such a way to provide space between kernels for spreading. The plates were covered and incubated at room temperature for 23 hours. The appearance and disintegration of kernels was rated visually based on point numerical spreading scale.

Gel consistency was analyzed based on the method described by (Cagampang *et al*., 1973) [2]. Milled rice flour (50 mg) was weighed in duplicate into the test tubes. Then 0.2 ml of 95% ethanol containing 0.025% thymol blue and 2 ml of 0.2 N KOH were added. Contents were mixed using a vertex genie mixer. The test tubes were covered with glass marbles in order to prevent steam loss and to reflux the samples. The samples were cooked in a vigorously boiling water bath for 8 minutes to make the contents to reach 2/3 rd of the height of the tube. The test tubes were removed from the water bath and kept at room temperature for 5 minutes. The tubes were kept in an ice water bath for 20 minutes and laid horizontally on a table, lined with millimeter graph paper. The total length of the gel was measured in millimeter from the bottom of the tube after one hour. The test classified the rice into three categories as follows, Very flaky rice grains with hard gel consistency (length of gel,40mm or less);(b) Flaky rice grains with medium gel consistency (length of gel, 41 to 60);(c) Soft rice grains with soft gel consistency (length of gel more than 61mm).

Results and Discussion

The hulling percentage varied between 55.75 (PMK 3) to 79.75 (PM 16004). If the hulling percentage is high, then the recovery of rice also increases. Milling out turn is the measure of rough rice recovery during milling. It is one of the important properties to the millers. The rice millers prefer varieties with high milling and head rice recovery, where as consumers preference depends on cooking and eating qualities (Merca and Juliano, 1981) [6]. The milling percentage ranged between 51.50 (PMK 3) to 74.25 (PM 16004). Head rice recovery is the proportion of whole grains in milled rice. It varies depending on the variety, grain type, cultural practices and drying condition (Asish *et al*., 2006) [1]. HRR% is a heritable trait although environmental factors and post harvest handling are known to break the grain during milling. HRR% varied from 45.33 (PM 17027) to 72.0 (PM 16003). The hulling percentage highly significantly associated with Milling percentage, head rice recovery and gel consistency. Milling percentage had positive significant association with head rice recovery, breadth wise elongation ratio and gel consistency (Table.3).

The kernel length is highest in Anna 4 (6.9 mm) which shows long grain length and lowest in short grain type PM 17003 (5.0 mm) while the kernel breadth ranged between 1.9 (ADT 45) to 2.7 mm (PM 17025). Depending on L/B ratio, six genotypes *viz*; PM 17027, PM 18002, PM 18004, ADT 43, ADT 45 and Anna 4 having slender grain type. Other genotypes are having medium grain type. The value for each character for each genotype is given in Table-1. Consumer affinity to size and shape is highly variable. Grain shape, size and appearance are very important characters and determine the consumer’s acceptability.

The Kernel length after cooking ranged from 8.0 mm (PM 17003) to 11.1 mm (Anna 4). Elongation ratio is an important parameter for cooked rice. If rice elongates length wise, it gives finer appearance and it expands girth wise, it gives coarse look. Out of seventeen genotypes tested the highest elongation ratio (1.8) is observed in three genotypes *viz*., PM 16002, PM 16003 and PM 17025. High expansion breadth wise is not a desirable quality attributes in high quality rice required to command premium in the market. The extent of water absorbed during cooking is considered an economic quality as it gives some estimate of the volume increase during cooking. Water uptake shows a positive significant influence on grain elongation. In the present study the volume expansion ratio in rice cultivars ranged from 3.2 (TKM 13) to 5.0 (PM 16002). It is the positive character for lower income group for whom quantity is important criteria. However, more will be volume expansion ratio; less will be energy content per unit volume. The correlation coefficient among the physicochemical and cooking characters is presented in Table 3. Kernel length showed positive and significant association with Kernel length after cooking and L/B ratio. Kernel breath showed positive highly significant association with Kernel breath after cooking while negatively significant with L/B ratio and breath wise elongation ratio. Kernel length after cooking showed positive significant association with LER. These findings were in agreement with those of Mathure *et al.*, 2011, Singh *et al.*, 2012 and Pushpa *et al*., 2019 [7, 14, 10].

Alkali digestion is one of the important indicators of the eating, cooking and processing quality of rice starch (Nishi *et al.*., 2001) [8]. In this study, determination of the alkali digestion classified the rice genotypes into three groups namely; low, intermediate and high alkali digestion. Similar classifications have been reported in Thai rice cultivars

(Prathepha *et al*., 2005) [9]. The alkali digestion value and gelatinization temperature for all the variety were examined and presented in Table 2. The intermediate alkali digestion genotypes are the most preferred worldwide and given their good cooking qualities such as water absorption, moistness, volume expansion and softness upon cooling.

Gel consistency test was developed as an indirect method used in screening cooked rice for its hardness. The gel consistency was measured into soft, medium and hard and it was ranged from 50 mm in PMK 3 to 90 mm in PM 17022. Amylose content is considered to be the single most important characteristic for predicting rice cooking qualities. It is the major factor for eating quality (Juliano *et al*., 1993) [5]. It determines the hardness or stickiness of cooked rice, cohesiveness, tenderness, colour of cooked rice. Higher amylose content (>25.0%) gives non sticky soft or hard cooked rice. Rice varieties having 20-25% amylose content gives soft and flaky cooked rice. It is an indicator of volume expansion and water absorption during cooking. Intermediate amylose content (20-25%) is usually preferred by Indians. In this study, all the tested genotypes are having intermediate amylose content.

Rice grain quality traits encompass the totality of all characteristics and features of rice or the rice products that meets the consumer demands and preference. Development of high yielding varieties accompanied with superior cooking quality is a vital requirement of rice breeding. Breeding for high yield has been quite successful over the years but improvement of the quality parameter along with yield has been lagging due to lack of potential genotypes which can be utilized as parents in hybridization programs. Hence, these germplasms could be used in future breeding programmes for the improvement of valuable grain quality traits.

Table 1: Physicochemical and cooking properties of rainfed rice genotypes

Genotypes	Hulling (%)	Milling (%)	HRR (%)	KL (mm)	KB (mm)	L/B	KLAC (mm)	KBAC (mm)	LER	BER	VER	ASV	GC (mm)
PM 16001	75.75	72.00	69.50	5.3	2.0	2.7	8.2	2.9	1.5	1.5	4.5	4	86
PM 16002	74.37	70.41	67.42	5.1	2.0	2.6	9.3	3.2	1.8	1.6	5.0	3	60
PM 16003	79.33	74.00	72.00	5.2	2.0	2.6	9.5	3.1	1.8	1.6	4.0	3	62
PM 16004	79.75	74.25	69.80	5.9	2.4	2.5	9.1	3.3	1.5	1.4	4.5	4	67
PM 16005	77.35	70.15	66.50	6.4	2.5	2.6	10.0	3.1	1.6	1.2	4.5	3	88
PM 17003	78.90	73.45	68.20	5.0	2.0	2.5	8.0	3.0	1.6	1.5	4.0	2	74
PM 17022	79.50	73.35	69.15	5.5	2.0	2.8	9.2	3.0	1.6	1.5	4.5	2	90
PM 17025	65.66	52.50	53.90	5.8	2.7	2.1	10.5	3.5	1.8	1.3	4.4	3	61
PM 17026	77.50	67.50	64.00	6.0	2.5	2.4	8.5	3.4	1.4	1.4	3.9	3	75
PM 17027	60.33	52.50	45.33	6.3	2.0	3.2	8.9	2.5	1.4	1.3	4.2	2	62
PM 18002	65.33	52.50	46.67	6.5	2.0	3.3	9.2	2.4	1.4	1.2	4.0	4	75
PM 18004	77.50	67.50	49.00	6.8	2.2	3.2	10.8	3.0	1.5	1.4	4.0	3	80
ADT 43	77.50	65.00	59.25	6.3	2.0	3.2	8.2	2.7	1.3	1.4	4.0	3	55
ADT 45	75.33	62.50	60.00	5.7	1.9	3.0	8.6	2.8	1.5	1.5	4.5	2	83
TKM 13	65.33	57.50	56.00	5.4	2.0	2.7	7.5	2.9	1.4	1.5	3.2	3	73
PMK 3	55.75	51.50	47.33	6.4	2.2	2.9	9.2	2.5	1.4	1.1	3.6	4	50
Anna 4	74.60	66.10	62.10	6.9	2.0	3.5	11.1	3.0	1.6	1.5	4.8	3	69
Mean	72.93	64.92	60.36	5.93	2.14	2.79	9.16	2.96	1.54	1.39	4.24	3.00	71.18
CV	10.72	11.19	12.63	10.34	11.10	13.18	11.51	12.04	12.07	10.04	8.54	15.54	17.11
SD	7.06	6.44	7.27	0.67	0.31	0.45	1.23	0.31	0.23	0.14	0.33	0.81	2.24
SE	1.44	1.23	1.44	0.14	0.05	0.08	0.23	0.06	0.04	0.02	0.06	0.16	0.41

HRR: Head Rice Recovery (%), KL: Kernal Length, KB: Kernel breath, L/B: Length breath ratio, KLAC: Kernel length after cooking (mm), KBAC: Kernel breadth after cooking (mm), LER: Linear elongation ratio, BER: Breadth wise elongation ratio, VER: Volume expansion ratio, ASV: Alkali spreading Value, GC: Gel consistency (mm)

Table 2: Alkali digestion value and gelatinization temperature for milled kernel of rainfed rice genotypes

Spreading	Inference	Scale	Inference	GT	Genotypes
Not affected but chalky	Low	1	High	75-79	-
Kernel swollen	Low	2	High	75-79	PM17003, PM17022, PM17025, PM17027, PM18002 & ADT45
Kernel swollen with collar incomplete and narrow	Low to intermediate	3	High to intermediate	70-74	PM 16001, PM 16003 PM 16005, PM 17026, PM 18004, ADT43 & TKM13
Kernel swollen with collar complete and wide	Intermediate	4	Intermediate	70-74	PM 16002, PM 16004 & PMK3
Kernel split or segmented with collar complete and wide	Intermediate	5	Intermediate	70-74	Anna4
Kernel dispersed, merging with collar	High	6	Low	65-69	-
Kernel completely dispersed	High	7	Low	65-69	-

Table 3: Correlation coefficients between various physicochemical and cooking properties of rainfed rice varieties

	H	M	HRR	KL	KB	L/B	KLAC	KBAC	LER	BER	VER	ASV	GC
H	1	0.662**	0.411*	-0.266	0.0856	-0.137	-0.045	0.253	0.050	0.239	0.349	-0.062	0.483*
M		1	0.710**	0.155	0.050	0.287	-0.039	0.101	-0.096	0.508**	-0.152	-0.137	0.474*
HRR			1	-0.002	-0.111	0.279	-0.079	0.085	-0.059	0.654**	-0.294	-0.151	0.321
KL				1	-0.376	0.514**	0.507**	-0.135	-0.134	-0.177	-0.208	0.101	0.077
KB					1	-0.790**	0.231	0.734**	0.169	-0.559**	0.351	0.584**	-0.357
L/B						1	0.002	-0.716**	-0.385	0.260	-0.326	-0.441*	0.257
KLAC							1	0.254	0.723**	-0.023	-0.045	-0.013	-0.02
KBAC								1	0.328	0.146	0.179	0.405*	-0.11
LER									1	0.175	0.010	-0.119	-0.01
BER										1	-0.326	-0.371	0.366
VER											1	0.091	-0.1
ASV												1	-0.32
GC													1

*Significant @ $P<0.05$, **Significant @ $P<0.01$

H: Hulling (%), M: Milling (%), HRR: Head Rice Recovery (%), KL: Kernal Length, KB: Kernel breath, L/B: Length breath ratio, KLAC: Kernel length after cooking (mm), KBAC: Kernel breadth after cooking (mm), LER: Linear elongation ratio, BER: Breadth wise elongation ratio, VER: Volume expansion ratio, ASV: Alkali spreading Value, GC: Gel consistency (mm)

References

1. Asish KB, Kalaiyarasi R, Thiyagarajan K, Manonmani S. Physio-chemical and cooking quality characteristics of promising varieties and hybrids in rice (*Oryza sativa* L.). Indian Journal of Genetics. 2006; 66(2):107-112.
2. Cagampang GB, Perez CM, Juliano BO. A gel consistency test for eating quality of rice. Journal of the Science of Food and Agriculture. 1973, 24:1589-1594.
3. Cruz ND, Khush GS. Rice grain quality evaluation procedures. In: R.K Singh, U.S. Singh and G.S.Khush (Eds). Aromatic rices. Oxford and IBH Publishing Co Pvt. Ltd, New Delhi, 2000, 15-28.
4. IRRI. Standard evaluation system for rice, IRRI, Los Banos, Phlippines, 1996.
5. Juliano BO, Perez CM, Perez FC. Screening For stable high head rice yields in rough rice. Cereal Chemistry, 1993, 70(6):650-655.
6. Merca FE, Juliano BO. Physico-chemical properties of starch of intermediate amylase and starch. Satarke, 1981; 33:253-260.
7. Mathure S, Shaikh A, Renuka N, Wakte K, Jawali N, Thengane R *et al*. Characterization of aromatic rice (*Oryza sativa* L.) germplasm and correlation between their agronomic traits. Euphytica. 2011; 179(2):237-246.
8. Nishi A, Nakamura Y, Tanaka N, Satoh H. Biochemical and genetic analysis of the effects of amylose-extender mutation in rice endosperm. Plant Physiology, 2001; 127:459-472.
9. Prathepha P, Daipolmak V, Samappito S, Baimai V. An assessment of alkali degradation waxy protein and their relation to amylose content in Thai rice cultivars. Science Asia 2005, 31:69-75.
10. Pushpa R, Sassikumar D, Iyanar K, Suresh R, Manimaran R. Study of physicochemical, cooking and nutritional properties of promising rice varieties of Tamil Nadu. Electronic Journal of Plant Breeding, 2019; 10(3):1071-1078.
11. Rebeira SP, Wickramasinghe HAM, Samarasinghe WLG. Diversity of Grain Quality Characteristics of Traditional Rice (*Oryza sativa* L.) Varieties in Sri Lanka. Tropical Agricultural Research. 2014; 25(4):470-478.
12. Rohilla R, Singh VP, Singh US, Singh RK, Khush GS. Crop husbandry and environmental factors affecting aroma and other quality trait, In: Sing, R.K., Sing, U.S. and Khush, G.S. (Ed.). Aromatic rices. Oxford and IBH Publishing Co. Pvt.Ltd. New Delli, India. 2000, 201-216.
13. Singh N, Kaur L, Singh SN, Singh SK. Physicochemical, cooking and textural properties of milled rice from different Indian rice cultivars. Food Chemistry, 2005; 89:253-259.
14. Singh AK, Singh PK, Nandan R, Rao M. Grain quality and cooking properties of rice germplasm. Annals of Plant and Soil Research. 2012; 14(1):52-57.