Original Article

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Varietal Differences in Physicochemical and Cooking Quality Characteristics of Selected Rice (*Oryza Sativa L.*) Grains

Vijayalaxmi Kamaraddi*, Jamuna Prakash**

Abstract

Grain quality characteristics of selected rice varieties were analyzed for physicochemical and cooking quality traits and compared with local check Rajamudi. The rice varieties selected for the study were IET 13901, KHP-5, KHP-10, KHP-2 and Rajamudi, released from Agricultural Research Station (Paddy), Mudigere. Length and breadth of reported varieties ranged from 5.63-5.84 and 1.85-2.73. The highest L/B ratio was observed with KHP-2 (3.18) followed by local check Rajamudi (3.13) and medium slender grain IET 13901 (2.53). Kernel elongation ratio ranged between 1.62 (KHP-2) to 1.85 (Rajamudi) and was found to be highest in Rajamudi followed by IET 13901 (1.84). The varieties had alkali degradation score ranging from 4.56 to 5.47 with intermediate gelatinization temperature (69º–74ºC). All the tested varieties had intermediate amylose content including local check ranging between 20.42 (Rajamudi) and 27.18 (KHP-10). The present study revealed that among the ruling varieties tested IET-13901 and KHP-10 showed desirable quality parameters followed by KHP-5 and KHP-2 when compared with local check. These varieties could be effectively utilized in quality improvement program in rice.

Keywords: Length-Breadth Ratio; Amylose Content; Gel Consistency; Alkali Score; Water Uptake Profile; Expansion Characteristics.

Introduction

Rice is life for Asians in general and Indians in particular. Asia cultivates 137 million hectare of rice, of which India's share is 45 million hectare. Rice contributes to 15% annual GDP of India and provides 75% of calorie requirement and 55% of protein requirement for more than 70% of Indians [1]. Rice provides more calories per hectare than any other cereal crop. Its nutritional level is high among cereals and other grains. Though the protein content of the rice is less than that of wheat, the true protein digestibility and biological value of rice protein are the highest among wheat and other cereals. Rice occupies a pivotal place in India's food and livelihood security system. Traditionally, plant breeders concentrated more on breeding for high yields and disease / pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice.

Rice quality is a complex trait comprising many physicochemical characteristics. All consumers want the best quality that they can afford. With many countries achieving self- sufficiency in rice production, the demand by consumer for better quality rice has increased. Milling out turn is one of the important properties to the millers. The rice millers prefer varieties with high milling and head rice out turn, whereas consumer preference depend on physicochemical, cooking and eating qualities [2].

Head rice recovery varies depending on many factors [3]. Size and shape are also important factors for consumers. Preference for grain size and shape vary from one group of consumer to another [4]. The amylose content of rice is the main parameter of cooking and eating qualities [5]. Amylose content, volume expansion and water absorption characteristics influence many of the starch properties of rice [6]. Cooking time is important as it determines tenderness of cooked rice as well as stickiness to a

Author's affiliation: *Department of Food Science and Technology, Agriculture College, Karekere, Hassan 573 225. **Department of Food Science and Nutrition, University of Mysore, Mysore 570006.

Corresponding Author: Jamuna Prakash, Department of Food Science and Nutrition, University of Mysore, Mysore 570006.

E-mail: jampr55@hotmail.com

greater extent. The higher the water imbibition ratio of rice, the lower will be the energy content per unit volume or weight of cooked rice as they will have more water and less solid materials.

Rice production technologies regarding high yielding varieties are now well developed in most of the countries in Asia for maximum production. Hence it is the need of the hour to develop rice varieties with high yield with improved quality. It is urgently needed to characterize the already released varieties and the promising lines in rice with special reference to their physicochemical properties.

Present investigation was undertaken with an objective to characterize five selected rice varieties for physicochemical and cooking quality parameters.

Materials and Methods

The different varieties of rice selected for the study were IET 13901, KHP-5, KHP-10, KHP-2 and Rajamudi. These were procured from Zonal Agricultural Research Station (Paddy), Mudigere, for the study. The local variety, Rajamudi was taken as standard local check for all the traits.

Physical Parameters

Physical parameters like kernel length, breadth, and linear elongation ratio were recorded as per Juliano and Parez, [7]. Gelatinization temperature (GT) was observed based on alkali spreading score (ASS) of milled rice [8]. Estimation of amylose content was done as per simplified procedure of Juliano [9]. Gel consistency was analyzed based on the method given by Cagampang et al., [10]. The details of grading physical parameters are compiled below.

Physical characters: Kernel length and kernel length / breath ratio was used to classify the grains as given below.

Kernel length		Kernel length/breath ratio	
Size	Length (mm)	Shape	L/B ratio
Extra long	>7.50	Slender	>3.0
Long	6.61–7.50	Medium	2.1–3.0
Medium	5.51–6.60	Bold	1.1–2.0
Short	<5.50	Round	<1.0

Cooking quality was determined by linear elongation ratio, which was the ratio of mean length of cooked rice to mean length of milled rice [7].

Chemical characters

Gelatinization temperature (GT) was observed based on alkali spreading score (ASS) of milled rice [8]. The appearance and disintegration of kernels was rated visually based on the following 7 point numerical spreading scale [6]. Kernel with a score of 5.5–7.0 was classified as '*low GT*' (55–69°C), 3.5–5.4 as '*intermediate GT*' (69–74°C), 2.6–3.4 as '*intermediate to high GT*' and 1.0–2.5 as '*high GT*' (74.5–80°C) types.

Score	Spreading	Alkali digestion
1	Kernel not affected	Low
2	Kernel swollen	Low
3	Kernel swollen, collar incomplete or narrow	Low / intermediate
4	Kernel swollen, collar complete or wide	Intermediate
5	Kernel split or segmented, collar complete and wide	Intermediate
6	Kernel dispersed, merged with collar	High
7	Kernel completely dispersed	High

Amylose content

Simplified procedure of Juliano [9] was used for the estimation of amylose content. Based on amylose content rice was classified (5) as follows–

Variety	Amylose content (%)	Description
Waxy (Amylose content <2.0%)	1–2	Waxy
Non-waxy (Amylose content >2.0)	> 2–9	Very low
	>9–20	Low
	>20–25	Intermediate
	>25–33	High

Gel consistency was tested based on the method described by Cagampang et al., [10]. The test classified the rice into two categories**.**

	Length of gel	Description	Gel consistency
1.	<40mm	Very flaky rice	Hard
2.	40-60mm	Flaky rice	Medium
3.	>60mm	Soft rice	Soft

Equilibrium moisture content (EMS-S) on soaking was determined as per Swamy et al., [11]. Rice samples were soaked in distilled water at room temperature. Portions were withdrawn at 0, 15, 30 and 60 min and at 3, 18, and 24 hours. These were pressed thoroughly between filter paper to remove surface moisture and dried in oven at 40° C for 24 hours. The moisture content was determined by repeated weighing.

Statistical Treatment

The data were subjected to Analysis of Variance to determine the level of significance between rice varieties for different parameters. The probability level was fixed at 0.05.

Results and Discussion

Salient features of rice varieties are compiled in Table 1 to indicate the year of release of the crop, the grain type and color, yield of the grain and duration of growing. The grain yield for all released varieties was more than the local check Rajamudi. The number of days for one variety was lesser but two of them required slightly longer time to harvest. On the whole, the characteristics were similar to the local variety with advantage of higher yield.

Table 1: Salient Features of The Selected Rice Varieties

Sl.No.	Variety	Year of release	Grain type	Grain colour	Grain yield Quintal/ hectare	Duration type	No. of days
1.	IET-13901 (Tunga)	2002	Long slender	White	50 –55	Long	155-160
2.	KHP-5	2000	Medium bold	Red	50 –55	Long	170-175
3.	KHP-10	2004	Medium bold	White	50 –50	Long	170-175
4.	KHP-2	1990	Long bold	White	52 –55	Medium	150-155
5.	Rajamudi	Local check	Medium slender	White	40 –42	Medium	155-160

Physical characteristics of raw rice varieties

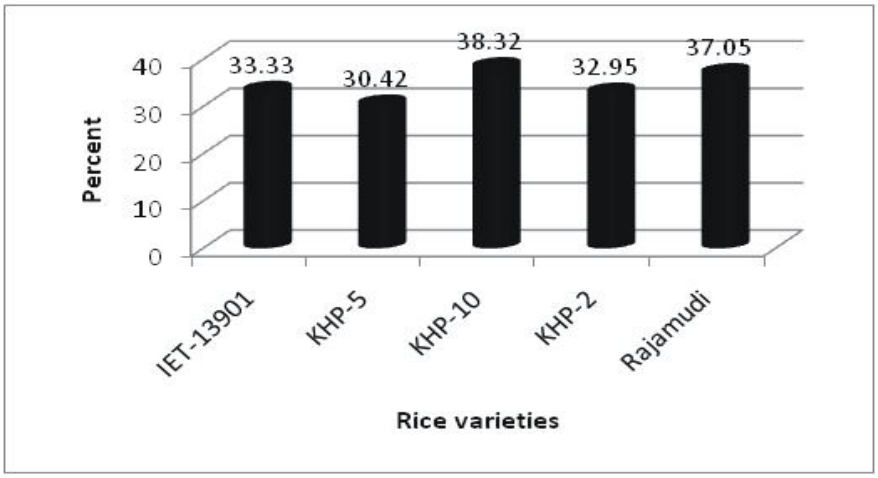
Grain size, shape, length, breadth, thickness and length / breadth ratio were determined based on the consumer preference and these are presented in Table 2. Highest kernel length of 5.84 mm was observed in KHP-5 followed by IET-13901 (5.83) and KHP-2, while lower kernel length was observed in Rajamudi (5.63 mm). Kernel of KHP-5 and KHP-10 were medium bold while those of KHP-5, long bold and IET 13901, long slender followed by Rajamudi as medium slender. Highest length and breadth ratio were observed in KHP-2 (3.18) followed by Rajamudi (3.13) and IET-13901 (2.3). Length and breadth of the genotypes analyzed in the study ranged from 5.63 to 5.84 mm and 1.93 to 2.73 mm respectively. Grain thickness varied from 1.35 mm (Rajamudi) to 1.75 mm (IET-13901). Cultivars differ in the thickness of aleurone layers. Coarser, bolder, short grain cultivars tend to have more thickness than medium and slender long grain varieties.

Equilibrium moisture content (EMC) of tested varieties has been depicted in Fig. 1. EMC of the varieties ranged between 30.42–38.32. The variety, KHP-10 had highest EMC values followed by local check Rajamudi and the lowest values were observed in KHP-5 (30.42).

Table 2: Physical Characteristics of Raw Rice

Characteristics	Rice varieties					F Ratio	P Value
	IET- 1390	KHP-5	KHP-10	KHP-2	Rajamudi		
Length (mm)	5.83 ± 0.038	5.837 ± 0.160	5.797 ± 0.273	5.825 ± 0.037	5.625 ± 0.029	1.51833	0.245^{ns}
Breadth (mm)	2.33 ± 0.038	2.725 ± 0.038	2.53 ± 0.038	1.925 ± 0.379	1.85 ± 0.034	414.707	0.000***
Thickness (mm)	1.75 ± 0.023	1.545 ± 0.017	1.70 ± 0.041	1.475 ± 0.038	1.35 ± 0.034	104.386	0.000***
L/B Ratio	2.527 ± 0.015	2.192 ± 0.009	2.34 ± 0.023	3.177 ± 0.129	3.13 ± 0.047	208.576	0.000***

Fig.1: Equilibrium Moisture Content of Rice Varieties



Cooking Characteristics of Rice Varieties

Elongation ratio of the entries ranged from 1.52–2.01 (Table 3). It is an important parameter for cooked rice. If rice elongates more lengthwise, it gives a finer appearance and if expands girth-wise, it gives a coarse look. The elongation ratio was high in KHP-5 (2.01) followed by Rajamudi (1.85) and (IET-13901 (1.84). Similar results were reported by Biswas et al., and Dipti et al., [12, 13].

The volume expansion ratio of most of the tested varieties was more than 2.5 and it is considered as a positive quality feature especially for the lower income group for whom quality is important criteria. However, higher the volume expansion ratio of rice, lower will be the energy content per unit per volume or unit of cooked rice as they will have more water content and less solid material.

Table 3: Characteristics of Cooked Rice Varieties

Characteristics	Rice varieties					F Ratio	P Value
	IET- 1390	KHP-5	KHP-10	KHP-2	Rajamudi		
Water uptake profile							
Water uptake At 80°C	0.345 ± 0.029	0.25 ± 0.012	0.33 ± 0.012	0.422 ± 0.029	0.462 ± 0.03	49.0251	0.000***
Water uptake At 90°C	2.435 ± 0.040	2.397 ± 0.017	1.638 ± 0.033	2.137 ± 0.026	2.44 ± 0.024	547.419	0.000***
Water uptake Ratio	14.72 ± 0.480	9.835 ± 0.033	19.175 ± 0.044	21.025 ± 0.026	19.04 ± 0.018	1734.32	0.000***
Expansion characteristics							
Kernel elongation ratio	1.84 ± 0.023	2.01 ± 0.009	1.522 ± 0.020	1.62 ± 0.029	1.85 ± 0.024	300.879	0.000***
Volume expansion ratio	2.85 ± 0.042	2.657 ± 0.029	2.522 ± 0.021	2.958 ± 0.043	3.22 ± 0.028	254.636	0.000***
Elongation ratio	2.055 ± 0.097	1.82 ± 0.040	1.525 ± 0.038	1.65 ± 0.024	2.05 ± 0.191	22.5251	0.000***
Elongation index	1.52 ± 0.022	1.125 ± 0.038	1.102 ± 0.071	1.225 ± 0.030	1.312 ± 0.010	72.3584	0.000***

Chemical Characteristics of Varieties

Alkali spreading value of varieties ranged from 4.56-5.47 (Table 4). High alkali spreading value corresponded to low gelatinization temperature. Varieties with intermediate gelatinization temperature are desirable. All the tested varieties exhibited intermediate GT (69–74°C) IET-13901, (4.56); KHP-5, (4.75); KHP-10, (5.24); KHP-2, (4.92) and Rajamudi (5.47). Varieties with high amylose content cook as dry grains, less tender, and become hard upon cooling. In contrast, low amylose content rice varieties cook moist and sticky. Intermediate amylose is most preferred in India. Amylose content of tested varieties ranged from 20.64% to 27.18%. Amylose content is the major factor for eating quality of rice (14). It is an indicator of volume expansion and water absorption during cooking, and correlates with hardness, whiteness and dullness of cooked rice. Intermediate amylose content was observed in three varieties, IET-13901 (24.23), KHP-5 (20.64), KHP-2 (21.23) and Rajamudi (20.42). Highest amylose content was observed in KHP-10 (27.18) (Table 4). Amylose content of the rice determines the hardness or stickiness of cooked rice. Higher amylose content (>25%) gives non-sticky soft or hard cooked rice. Rice varieties with intermediate amylose content (20-25%) gives non-sticky, soft, flaky rice.

Gel consistency of tested varieties ranged from 31.3 to 44.3 (Table 4). Interestingly the result showed that all the varieties exhibited medium gel consistency except KHP-2 (hard gel) indicating that they are flaky rice with medium gel consistently.

Table 4: Amylose Content and Quality Characteristics of Rice Varieties

Characteristics	Rice varieties					F Ratio	P Value
	IET-1390	KHP-5	KHP-10	KHP-2	Rajamudi		
Amylose (g/100g)	24.23 ± 0.206	20.84 ± 0.429	27.18 ± 0.207	21.23 ±0.155	20.42 ± 0.016	578.726	0.000***
Alkali score	4.55 ± 0.029	4.75 ± 0.495	5.23 ± 0.229	4.91 ± 0.009	5.47 ± 0.034	9.06573	0.0006***
Gel consistency (mm)	41.38 ± 0.144	43.3 ± 0.244	44.25 ± 0.289	31.25 ± 0.289	42.03 ± 0.411	1326.46	0.000***

Conclusion

Among the ruling varieties tested, IET-13901 and KHP-10 showed desirable quality parameters followed by KHP-5 and KHP-2 when compared with local variety Rajamudi. These varieties could be effectively utilized in quality improvement program which would be helpful to develop high yielding varieties with better grain quality.

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