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GRAIN QUALITY AND COOKING PROPERTIES OF RICE GERMPLASM

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ABSTRACT

An investigation was carried out at Varanasi (U. P.) to assess the grain quality and cooking properties of thirty eight rice germplasm accessions. The competitiveness of locally grown rice can be enhanced by improving physical quality and adopting a marketing strategy that emphasizes the nutritional quality and suitability for specific food. Among the germplasm examined kernel length ranged from 4.07 to 8.91 mm, kernel breadth from 1.74 to 2.50 mm, kernel length after cooking from 6.01 to 11.23 mm, kernel breadth after cooking from 2.31 to 3.02 mm, L/B ratio before cooking from 1.98 to 4.62, L/B ratio after cooking from 2.24 to 4.25 and elongation ratio from 1.18 to 1.57. Germplasm HUBR 40 had highest kernel length before and after cooking and L/B ratio before and after cooking while lowest elongation ratio, and grains were extra-long, slender, scented with intermediate alkali digestion value and gelatinization temperature, where as Adanchini had lowest kernel length, kernel length after cooking and L/B ratio before and after cooking, and grains were short-bold, scented with intermediate alkali digestion value and gelatinization temperature. Kernel length showed positive significant association with kernel length after cooking and L/B ratio before and after cooking while negative one with elongation ratio. The positive significant association also found between kernel breadth and kernel breadth after cooking, kernel length after cooking and L/B ratios, and between L/B ratio before and after cooking. These studies revealed that germplasm accessions HUBR 40 and Adamchini have good grain quality and cooking properties, indicating their potential for consumer preferences.
Keywords: Grain, quality, cooking, properties, rice

INTRODUCTION

Rice (*Oryza sativa* L.) is the only cereal crop cooked and consumed mainly as whole grains, and quality considerations are much more important than for any other food crop (Hossain *et al*., 2009). Although production, harvesting and postharvest operations affect overall quality of milled rice, variety remains the most important determinant of market and end-use qualities. Quality 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 (Azeez and Shafi, 1966). However, in *indica* rice consuming countries, long grain with intermediate gelatinization temperature is preferred since it becomes soft and fluffy after cooking (Hossain *et al*., 2009). The physicochemical characteristics include kernel length, kernel breadth, L/B ratio, kernel size and shape; and cooking quality include alkali digestion value, gelatinization temperature and elongation ratio are important for judging the quality and performance of rice from one group of consumer to another (Sellappan *et al.*, 2009). Kernel size, shape and L/B ratio are important features for grain quality assessment (Rita and Sarawgi, 2008). Aroma, hardness and roughness are depends up on temperature and variety specific which affects the sensory properties of cooked rice (Yau and Huang, 1996). Grain quality is a very wide area encompassing diverse characters that are directly or indirectly related to exhibit one quality type (Siddiqui *et al.*, 2007). Different cultivars showed significant variations in morphological, physicochemical and cooking properties (Yadav *et al.*, 2007). Alkali digestion value and gelatinization temperature are major rice traits, which are directly related to cooking and eating quality. Gelatinization temperature is reasonably high in heritability, although it may vary as much as 10 ^{0}C within a variety in exceptional cases, depending upon environment. High air temperature after flowering raises the gelatinization temperature (which lowers the grain quality) and low air temperature reduces it (Jennings *et al.,* 1979). Individual performance varied, most of the consumers preferred imported rice but differed in their preferences for the local rice (Tomlins *et al.*, 2005). In the present study we have evaluated the grain quality characteristics (physical and cooking) to set up criteria for rice grading which will be eventually applied to the commercial rice.

MATERIALS AND METHODS

The experimental material comprised of thirty eight rice germplasm accessions *viz.* HUR 36, HUR 38B, HUR 3022, HUR 4-3, HUR 105, HUBR 40, HUBR 2-1, IR 64, IR64 Sub1, BPT 5204, IDR 763, MTU 7029, GR 32, Sarjoo 52, Swarna Sub1, Badshahbhog, Gobindbhog, Gopalbhog, Adamchini, Shivani, HUR 38, Pant 10, Pant 12, Pant 16, Jaya 3, Kalanamak, Sonachoor, Motigold, Sonam, Super Aman, Heera, Kanchan, Rupali, Krishna, Vijay, Heena, Moti 360 and Shakti were grown at Agricultural research Farm, Institute of Agricultural Sciences, Banaras Hindu University Varanasi in randomized block design with three replications to assess the grain quality and cooking properties of rice. All the recommended package of practices was followed to raise a good crop. Data pertaining to different quality traits *viz.* kernel length, kernel breadth, kernel length after cooking, kernel breadth after cooking, L/B ratio before and after cooking, size and shape of grain and aroma were recorded on ten randomly selected grains of each replication. Kernel length and width of ten de-husked entire brown rice grains of each replication was measured using dial micrometer. Based on average kernel length and L/B ratio before cooking, size and shape of grains were categorised (Table 1).

Table 1: Classification of thirty eight rice germplasm accessions based on size and shape of kernel

Kernel size				Kernel shape			
Length	Scale	Size	Percentage of germplasm	L/B ratio	Scale	Shape	Percentage of germplasm
> 7.50	1	Extra long	05.26	>3.0	1	Slender	50.00
6.61 to 7.50	2	Long	26.32	2.1-3.0	3	Medium	47.37
5.51 to 6.6	3	Medium	47.37	1.1-2.0	5	Bold	02.63
5.5 or less	4	Short	21.05	<1.1	9	Round	00.00

Aroma: Five g rice samples were taken in a test tube; 15 ml of water added and soaked for 10 minutes. Rice samples were cooked in water bath for 15 minutes and transferred in to a Petri disc and score as per panel test performance (Anonymous, 2004).

Alkali digestion value: The spread of the 6 milled rice kernels in 1.7 % KOH solution for a period of 23 hours was rated as per Standard Evaluation System for Rice (IRRI, 1996). Six milled kernels were placed in 10 ml of 1.7 % KOH solution in Petri dish and arranged in a manner so that they do not touch each other and were allowed to stand for 23 hours at 30 ^{0}C to score spreading on 1-7 scale (Table 4).

RESULTS AND DISCUSSION

During cooking, rice kernels absorb water and increase in volume through increase in length or breadth (Table 2). Breadth wise increase is not desirable, whereas, length wise increase without increase in girth is desirable characteristic in high quality premium rice (Hossain *et al.*, 2009). The range of mean performance of kernel length varied from 4.07 to 8.91 mm and kernel length after cooking ranged from 6.01 to 11.23 mm. The germplasm HUBR 40 and Adamchini recorded highest and lowest kernel length before and after cooking, respectively. Some varieties elongate more than others upon hydration and starch gelatinization without increase in girth, this is considered a desirable cooking quality trait in most high quality rice of the world. Kernel breadth ranged from 1.74 to 2.50 mm and kernel breadth after cooking from 2.31 to 3.02 mm. Sarjoo 52 recorded highest kernel breadth before and after cooking, while Super Aman recorded lowest. High expansion breadth wise is not a desirable quality attributes in high quality rice required to command premium in the market. Similarly, Danbaba *et al.* (2011) reported kernel length before and after cooking of some *Ofada* rice varieties ranging from 6.41 to 9.00 and 9.67 to 13.84 mm respectively, and kernel breadth before and after cooking ranging from 2.66 to 3.21 and 3.56 to 3.89 mm respectively. Among the germplasm accessions studied, L/B ratio before and after cooking ranged from 1.98 to 4.62 and 2.24 to 4.25, respectively. HUBR 40 recorded highest L/B ratio before and after cooking and least was found in Adamchini. Elongation ratio ranged from 1.26 to 1.57. Sonachoor and HUBR 40 recorded highest and lowest elongation ratio, respectively. Similarly, Hossain *et al.* (2009) reported L/B and elongation ratio of cooked rice ranging from 2.39 to 5.07 and 1.51 to 1.82, respectively. Contrary to the observation of Pilaiyar (1988) that elongation ratio is a better index of quality than L/B ratio, Kumar (1989) concluded after studying the genetics of height and cooking quality traits in basmati rice that L/B ratio was a more reliable measure of kernel elongation during cooking, and higher elongation ratio of the cooked rice is preferred than lower elongation ratio (Shahidullah *et al*., 2009). Correlation coefficient among rice grain dimensions are presented in table 3. Kernel length showed positive significant association with kernel length after cooking and L/B ratio before and after cooking, while negative significant with elongation ratio. Kernel breadth showed positive significant association with kernel breadth after cooking, while negative significant with L/B ratio before and after cooking. The positive significant association has been also established between kernel length after cooking and L/B ratio before and after cooking, and L/B ratio before and after cooking. These findings were in agreement with those of Danbaba *et al.* (2011) and Mathure *et al*. (2011).

Based on kernel length and L/B ratio before cooking, the collected germplasm accessions were classified in to four categories (Table 1).

Table 2: Mean performance of various grain dimensions, grain classification and aroma in thirty eight rice germplasm accessions

Germplasm accessions	KL (mean ± SD) (mm)	KB (mean ± SD) (mm)	KLAC (mean ± SD) (mm)	KBAC (mean ± SD) (mm)	L/B (Before cooking)	L/B (After cooking)	ER	Grain classification	Aroma
HUR 36	6.22 ± 0.08	1.97 ± 0.03	8.79 ± 0.07	2.47 ± 0.03	3.16	3.55	1.41	MS	NS
HUR 38B	5.51 ± 0.13	2.12 ± 0.04	7.96 ± 0.15	2.60 ± 0.04	2.60	3.06	1.44	M	NS
HUR 3022	7.36 ± 0.13	2.01 ± 0.04	9.89 ± 0.13	2.62 ± 0.03	3.66	3.78	1.34	LS	NS
HUR 4-3	7.01 ± 0.12	1.94 ± 0.03	9.20 ± 0.10	2.36 ± 0.03	3.61	3.90	1.31	LS	MS
HUR 105	7.20 ± 0.10	2.11 ± 0.06	9.57 ± 0.09	2.65 ± 0.05	3.41	3.61	1.33	LS	S
HUBR 40	8.91 ± 0.10	1.93 ± 0.05	11.23 ± 0.09	2.64 ± 0.05	4.62	4.25	1.26	Ex-LS	S
HUBR 2-1	7.03 ± 0.09	2.00 ± 0.05	9.26 ± 0.09	2.59 ± 0.06	3.52	3.58	1.32	LS	S
IR 64	7.10 ±0.10	2.19 ± 0.07	9.52 ± 0.08	2.75 ± 0.06	3.24	3.46	1.34	LS	NS
IR 64 sub1	7.16 ± 0.10	2.06 ± 0.05	9.65 ± 0.07	2.61 ± 0.06	3.48	3.70	1.35	LS	NS
BPT 5204	6.95 ± 0.12	1.95 ± 0.06	9.58 ± 0.11	2.48 ± 0.06	3.56	3.86	1.38	LS	NS
IDR 763	5.92 ± 0.10	1.87 ± 0.05	8.46 ± 0.07	2.62 ± 0.05	3.17	3.36	1.43	MS	NS
MTU 7029	5.99 ± 0.09	2.32 ± 0.05	8.54 ± 0.06	2.96 ± 0.03	2.58	2.89	1.43	M	NS
GR 32	4.83 ± 0.06	2.12 ± 0.08	7.05 ± 0.06	2.69 ± 0.07	2.28	2.62	1.46	SM	S
Sarjoo 52	6.95 ± 0.12	2.50 ± 0.09	9.11 ± 0.10	3.02 ± 0.06	2.78	3.02	1.31	LM	NS
Swarna sub1	5.92 ± 0.09	2.31 ± 0.08	7.71 ± 0.08	2.90 ± 0.08	2.56	2.66	1.30	M	NS
Badshahbhog	4.53 ± 0.07	2.14 ± 0.07	6.77 ± 0.07	2.82 ± 0.06	2.12	2.40	1.50	SM	S
Gobindbhog	4.50 ± 0.07	1.95 ± 0.07	6.60 ± 0.07	2.57 ± 0.05	2.31	2.57	1.47	SM	S
Gopalbhog	4.58 ± 0.05	1.96 ± 0.10	7.20 ± 0.05	2.59 ± 0.09	2.34	2.78	1.57	SM	NS
Adamchini	4.07 ± 0.05	2.06 ± 0.09	6.01 ± 0.04	2.68 ± 0.08	1.98	2.24	1.48	SB	S
Shivani	5.90 ± 0.07	2.31 ± 0.08	8.09 ± 0.06	2.92 ± 0.07	2.55	2.77	1.37	M	NS
HUR 38	5.95 ± 0.09	2.12 ± 0.13	7.66 ± 0.09	2.80 ± 0.13	2.81	2.74	1.29	M	NS
Pant 10	7.12 ± 0.08	2.11 ± 0.10	9.29 ± 0.06	2.62 ± 0.11	3.37	3.55	1.31	LS	NS
Pant 12	7.09 ± 0.06	2.07 ± 0.05	9.1 ± 0.05	2.64 ± 0.05	3.43	3.45	1.28	LS	NS
Pant 16	6.13 ± 0.07	2.32 ± 0.08	8.09 ± 0.05	2.88 ± 0.08	2.64	2.81	1.32	M	NS
Jaya 3	7.95 ± 0.05	2.12 ± 0.10	10.89 ± 0.05	2.77 ± 0.06	3.75	3.93	1.37	Ex-LS	NS
Kalanamak	5.29 ± 0.07	2.02 ± 0.09	7.01 ± 0.07	2.60 ± 0.09	2.62	2.70	1.33	SM	S
Sonachoor	4.32 ± 0.07	2.01 ± 0.05	6.78 ± 0.05	2.68 ± 0.05	2.15	2.53	1.57	SM	S
Motigold	5.73 ± 0.06	1.95 ± 0.10	7.70 ± 0.06	2.54 ± 0.10	2.94	3.03	1.34	M	NS
Sonam	5.71 ± 0.07	1.77 ± 0.08	7.37 ± 0.07	2.34 ± 0.08	3.23	3.15	1.29	MS	NS
Super Aman	5.42 ± 0.07	1.74 ± 0.10	7.38 ± 0.05	2.31 ± 0.10	3.12	3.20	1.36	SB	NS
Heera	5.86 ± 0.07	1.92 ± 0.06	8.02 ± 0.05	2.55 ± 0.06	3.05	3.15	1.37	MS	NS
Kanchan	6.13 ± 0.08	1.87 ± 0.10	7.79 ± 0.08	2.43 ± 0.11	3.28	3.21	1.27	MS	NS
Rupali	5.87 ± 0.08	1.96 ± 0.09	8.10 ± 0.07	2.56 ± 0.09	2.99	3.16	1.38	MS	NS
Krishna	5.65 ± 0.04	1.89 ± 0.07	7.35 ± 0.04	2.47 ± 0.06	2.99	2.98	1.30	M	NS
Vijay	5.65 ± 0.05	1.91 ± 0.05	7.51 ± 0.06	2.46 ± 0.05	2.96	3.05	1.33	M	NS
Heena	5.74 ± 0.07	1.92 ±0.06	7.68 ± 0.07	2.53 ± 0.05	2.99	3.04	1.34	M	NS
Moti 360	5.83 ± 0.06	1.94 ± 0.05	7.84 ± 0.06	2.50 ± 0.04	3.01	3.14	1.35	M	NS
Shakti	5.80 ± 0.07	1.76 ± 0.06	7.80 ± 0.07	2.38 ± 0.07	3.30	3.28	1.35	MS	NS

KL: Kernel length, KB: Kernel breadth, KLAC: Kernel length after cooking, KBAC: Kernel breadth after cooking, L/B: Kernel length / Kernel breadth, ER: Elongation Ratio, Ex-LS: Extra-long slender, LS: Long slender, LM: Long medium, MS: Medium slender, M: Medium, SM: Short medium, SB: Short bold, S: Scented, MS: Mild-scented, NS: Non-scented and SD: Standard deviation

Most of the germplasms are medium in size and shape. The kernel size-shape of germplasm ranged from extra-long slender (2), long slender (9), long medium (1), medium slender (7), medium (12), short medium (5) and short bold (2) category (Table 3). The grain size and shape of most high yielding rice varieties is long to slender with translucent appearance. Similar results were reported by (Banu *et al.*, 1992). Size and shape are among the grain characteristics that dictate the marketability and commercial viability of rice (Khush *et al.* 1979). Therefore, local varieties can be marketed based on the size and shape preference of consumers. Aroma is another important trait in rice and the aromatic rice has high demand in the market. Germplasm HUR 105, HUBR 40, HUBR 2-1, GR 32, Badshahbhog, Gobindbhog, Adamchini, Kalanamak and Sonachoor showed the presence of aroma, while mild aroma detected in HUR 4-3 (Table 2). The local germplasms studied during this investigation showed the presence of aroma, for which these are preferred by local people for consumption. Similar results were reported by Bhonsle and Sellappan (2010).

Table 3: Correlation coefficient among rice grain dimensions

	KB	KLAC	KBAC	L/B (Before cooking)	L/B (After cooking)	Elongation Ratio (ER)
KL	0.14	0.97**	0.07	0.89**	0.88**	-0.67**
KB		0.17	0.94**	-0.31**	-0.24*	0.02
KLAC			0.12	0.85**	0.90**	-0.46**
KBAC				-0.35**	-0.32**	0.11
L/B (Before cooking)					0.95**	-0.66**
L/B (After cooking)						-0.50**

*** and * Significant at 1 and 5 % level, respectively*

The alkali digestion value and gelatinization temperature for all the germplasms examined are presented in Table 4. The time required for cooking is determined by the gelatinization temperature and it depends on coarseness of the grains. Generally, alkali digestion value was negatively correlated with gelatinization temperature for the samples. As the alkali test is performed on whole-grain milled rice, whereas gelatinization temperature is done on the starch granules, the effect of non-starch constituents, such as cell wall and hemicelluloses, may be important factors in the alkali test (Little and Dawson, 1960). Low alkali digestion value and high gelatinization temperature were detected in HUR 36, Kalanamak, Krishna and Shakti, whereas high alkali digestion value and low gelatinization temperature were recorded in germplasms IR 64 Sub1, GR 32, Gopalbhog, Shivani, HUR 38, Pant 10, Pant 12, Jaya 3, Heera and Heena. The intermediate alkali digestion value and gelatinization temperature were noted in HUR 38B, HUR 4-3, IR64, Swarna sub1, Badshahbhog, Moti 360, HUR 3022, HUR 105, HUBR 2-1, MTU 7029, Gobindbhog, Pant 16, Sonachoor, Rupali, Adamchini, HUBR 40, BPT 5204, IDR 763, Sarjoo 52, Motigold, Sonam, Super Aman, Kanchan and Vijay. Long grain, with an intermediate to high alkali spreading value; tend to have a firm texture when cooked, whereas short and medium grain rice has a low alkali spreading value resulting in softer, stickier cooked rice. The germplasm showed intermediate gelatinization temperature, desired for parboiling purpose (Beachell and Stansel, 1963). The germplasm accessions have intermediate alkali digestion value indicated the medium disintegration and classified as intermediate gelatinization temperature which is highly desirable for quality grain (Bansal *et al.*, 2006 and Bhonsle, 2010).

Table 4: Alkali digestion value and gelatinization temperature for milled kernel of thirty eight rice germplasm accessions

Alkali digestion value			Gelatinization value		Germplasm accessions
Features	Inference	Scale	Inference	GT (^{0}C)	
Not effected but chalky	Low	1	High	75-79	
Swollen	Low	2	High	75-79	HUR 36, Kalanamak, Krishna and Shakti
Swollen with collar incomplete and narrow	Low or Intermediate	3	Intermediate	70-74	HUR 38B, HUR 4-3, IR64, Swarna sub1, Badshahbhog and Moti 360
Swollen with collar incomplete and wide	Intermediate	4	Intermediate	70-74	HUR 3022, HUR 105, HUBR 2-1, MTU 7029, Gobindbhog, Pant 16, Sonachoor, Rupali and Adamchini
Split or segmented with collar complete and wide	Intermediate	5	Intermediate	70-74	HUBR 40, BPT 5204, IDR 763, Sarjoo 52, Motigold, Sonam, Super Aman, Kanchan and Vijay
Dispersed, merging with collar	High	6	Low	65-69	IR 64Sub1, GR 32, Gopalbhog, Shivani, HUR 38, Pant 10, Pant 12, Jaya 3, Heera and Heena
Completely dispersed and clear	High	7	Low	65-69	

The organoleptic test was conducted for the appearance, cohesiveness, tenderness on touching, tenderness on chewing, taste, aroma and overall acceptability of cooked rice and evaluated by trained assessors using the above descriptive analysis in a control panels. It is also emphasized that the training and recruiting the sensory expert panel are important in the process of sensory analysis and organoleptic test (Lefebvre *et al*., 2010). These studies revealed that the rice germplasm accessions *viz.* HUBR 40 and Adamchini with best grain quality, cooking characteristics and consumers preferences. Organoleptic analysis always helps the consumers to select better rice variety for their consumption and use. Hence, these germplasms have potential for consumer preferences and it could be used in future breeding programmes for the improvement of valuable grain quality traits.

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