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Comparative genetic diversity assessment of some rice genotypes for nutritional and cooking quality parameters

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Abstract
Thirty diverse genotypes of rice (*Oryza sativa* L.) comprising advanced breeding lines, pureline selections, local germplasm, introduction and improved varieties of diverse origin were evaluated for nutritional quality traits and estimation of genetic variability and related parameters was also carried out. The analysis of variation revealed significant variation for all the genotypes under investigation. The maximum genotypic coefficient of variability (GCV) was recorded for water uptake (36.60%) followed by amylose content (21.46%). Heritability estimates were high (>90%) for amylose content, protein content, water uptake, kernel length after cooking, starch content, volume expansion ratio and grain elongation ratio. High heritability with high genetic advance (>50%) was obtained for water uptake (75.17) while high heritability with moderate genetic advance was observed for amylose content.

Keywords: rice**,** nutritional quality, genetic variability

Introduction
Rice (*Oryza sativa* L) is used as a staple crop for 65% of India's population and contributes 20-25% of the agricultural GDP. In India, rice is grown over an area of 43 million hectares with total production of 95 million tonnes amounting to 40% of the total food production [1].

Improvement of quality characters for value addition has been the recent trend in the newly developed rice varieties to meet the demand of end users. The rice quality with respect to nutrition and cooking characteristics has always been a matter of primary importance in rice eating areas of the world. Rice is popular because it is easy to cook and store and very easily digestible, making it ideal for babies and sick people. Utilization of rice, its products and by products has been based on the knowledge of chemical composition of the kernel, which is being increasingly investigated by researchers. Rice has a great diversity in its genetic background especially for amylose content and cooking quality. The cooking quality of rice is dependent to a large extent on the properties of starch, mainly amylose content [2].

Materials and Methods
In the present investigation, 30 diverse genotypes of rice were evaluated for important nutritional and cooking quality characters. The experiment was carried out in a Randomized Block Design with three replications and the harvested seeds were used for estimating the nutritional and cooking quality parameters (Table-1). These parameters were then subjected to analysis of variation followed by determining the genotypic and phenotypic coefficient of variation, heritability (in broad sense) and genetic advance.

Results and Discussion
The analysis of genetic variation revealed significant variation for all the characters among the genotypes (Table 2). The low coefficient of variation indicated negligible sampling error and environmental effect on these characters.

Even after heavy environmental influences, true genetic differences for protein content exist in rice. Rice proteins are nutritionally superior over most of the other principal cereals, but major limitations are that it is available in low quantities and most part of it (7-8%) is lost during milling [3]. The better nutritive value of rice protein is mainly due to better amino acid balance [4]. In the present study, protein content ranged from 6.02 percent in Prafulla to 14.98 percent in Kmj 13A-6-1-2. The other genotypes registering high protein content (>12%) were Luit, Kmj 14S-1-2-17, Kmj13B-1-13-3, Black Rice and IET 21271.

Amylose content of rice grain is considered to be one of the most important compositional indices of rice cooking and processing behaviour.

The varieties having very low amylose (3-10%) content are sticky, moist and tender when cooked. On the other hand, the varieties having a high content of amylose (>25%) become very hard when cooked. As such the intermediate amylose (20-25%) containing varieties, which on cooking remain fluffy and soft, are mostly preferred over other varieties. Amylose is less than 3% in the waxy (glutinous) rice. Such rice does not expand in volume, are glossy and sticky and remain firm when cooked. The result of present investigation revealed that the amylose content ranged from 8.27 percent in Black Rice to 34.4 percent in IET 21850. The amylose content of the genotypes was classed as low (3.1-15.0%) for Black Rice and Kmj 13AB-1-12-3, high (>25.1%) for IET 21850, Betguti 2, Purnendu and Improved Samba Mahsuri and intermediate (15.1-25.0%) for the rest genotypes. The variation in amylose content of the rice grains for different genotypes may be attributed primarily due to the difference in their genetic makeup. It has been reported that methods of rice processing results in significant differences in the amylose content in the grains [5].

Carbohydrates are the important components of storage and structural materials in the plants. Starch is one of the carbohydrates, most widely produced by plants, but there are only a limited number of high starch producing plants that are extensively grown and used for human consumption, viz. cereals, tubers and pulses. Rice starch consists of amylose, a straight unbranched chain of glucose units and amylopectin a highly branched short chain of glucose unit. Starch granules are highly organized structures and are characteristics of plant species. In the present study, considerable variation in starch content ranging from 54.99 per cent in Dhirendra to 87.68 percent in Kmj 14S-1-2-17 was recorded. The other genotypes with high starch content (>80%) were Kmj 13A-6-1-2, Kmj 13AB-1-12-3, Kmj 13B-1-13-3, Kmj 13S-3-1-3, IET 18648, Purnendu and Mahsuri.

In the present investigation the range for water uptake was from 82.67 ml in Black Rice to 395 ml in TTB 303-18-3 and IR 64 Sub 1 which is wide and representative of the genotypes. IR 64 was at par with TTB 303-18-3 and IR 64 Sub 1. The water uptake for Mahsuri (247.33 ml) was at par with Kon Joha T, IET 18648 and Luit. The volume expansion ratio ranged from 1.45 in Black Rice to 3.15 in IET 21850. The volume expansion ratio for most of the genotypes was comparable to Mahsuri (2.55). A high volume expansion ratio is considered as a positive quality feature especially for the lower income group for whom quantity is important criteria. However, higher the volume expansion ratio of rice, lower will be the energy content per unit volume or weight of cooked rice as they will have more water and less solid materials [6]. Kernel length after cooking ranged from 5.95 mm in Betguti 1 to 9.00 mm in Dhirendra and IR 64. Kmj 14S-2-10-10 was at par with Dhirendra and IR 64. Grain elongation is important cooking quality character and their high values are desirable and much preferred by traders and consumers [7]. The grain elongation ratio was the lowest (0.93) in Kmj 13B-1-13-3 and the highest (1.71) in Betguti 2. The grain elongation ratios for Kmj 13A-6-1-2, Tamdao, Kmj 14S-1-2-17, Dhirendra, Prafulla, Betguti 1, Swarna, and Ranjit were at par with Mahsuri (1.40).

Genetic variability refers to the presence of gene differences among the individuals of a plant population. Variability results due to differences either in the genetic constitution of the individuals of a population or in the environment in which they are grown. The existence of variability is essential for resistance to biotic and abiotic factors as well as for wider adaptability. It is only the genetic variation which is heritable. Selection is also effective when there is significant generic variability among the individuals in a population. Hence an insight into the magnitude of genetic variability present in a population is of paramount importance to plant breeder for formulating a breeding programme in any crop including rice. Knowledge on nature and amount of genetic variability present in a gene pool and the heritability of the traits are important for achieving genetic improvement of quantitative traits. Thus, information on genetic parameters such as variance, co-efficient of variation and heritability are useful. Moreover, the environmental influence on the trait can be understood by the estimation of heritability.

The estimates of genetic parameters (Table 3) for the various characters revealed maximum GCV for water uptake (36.60%), followed by amylose content (21.46%). All these estimates were high while most characters showed moderate GCV. The GCV estimates had close agreement with PCV estimates for most of the characters [8-12]. The GCV provides information for comparison of the genetic variability and indicates the validity of the traits for selection. However, it does not provide a clear picture of the genetic gain to be achieved from selection unless the heritable fraction of the variation is known [13], indicating the importance of heritability estimation.

Table 1: Means of the genotypes for the different grain and nutritional quality parameters

Genotype	Protein content (%)	Amylose content, % (AC)	Starch content (%)	Water uptake (ml)	Volume expansion ratio	Kernel length after cooking (mm)	Grain elongation ratio
Kmj 13A-6-1-2	14.98	17.18	83.52	197.67	2.50	8.30	1.47
Kmj 13AB-1-12-3	7.92	13.19	85.37	95.00	2.15	8.35	1.51
Kmj 13B-1-13-3	12.73	16.58	83.16	184.33	2.40	6.30	0.93
Tamdao	10.38	23.48	74.38	297.67	2.55	8.35	1.45
Kmj 13S -3-1-3	10.38	22.98	83.91	120.00	2.45	7.33	1.30
Kmj 14S-1-2-17	12.75	24.82	87.68	167.67	2.70	7.90	1.46
Kmj 14S-2-10-10	8.79	24.95	73.02	320.00	2.75	8.90	1.39
Mitra Sali	9.06	23.84	75.48	277.67	2.65	8.40	1.39
Dhirendra	10.06	22.39	54.99	367.67	2.55	9.00	1.47
Joymoti	11.08	18.36	69.96	130.00	2.45	8.80	1.38
TTB 303-18-3	8.06	21.25	61.69	395.00	2.65	8.70	1.34
Prafulla	6.02	18.77	62.40	232.67	2.50	7.95	1.41
Kon Joha-B	9.35	20.34	78.26	232.50	2.50	6.65	1.57
Kon Joha-T	9.50	20.64	67.27	240.00	2.65	7.40	1.22
Black Rice	12.73	8.27	78.40	82.67	1.45	8.40	1.32
Betguti 1	11.00	23.34	68.52	312.67	2.50	5.95	1.41

Betguti 2	10.23	25.69	75.31	180.00	2.85	6.95	1.71
IET 18648	9.21	24.06	81.95	342.67	2.70	8.00	1.34
IET 21271	12.29	17.28	65.84	182.67	2.50	7.60	1.35
IET 21840	10.29	18.19	75.52	222.67	2.55	8.15	1.54
IET 21850	9.88	34.43	68.23	322.67	3.15	8.40	1.39
Imp Samba Mahsuri	8.25	25.75	56.23	322.67	2.85	7.60	1.37
IR 64	10.06	22.79	77.80	387.33	2.65	9.00	1.48
IR 64 Sub 1	8.13	21.17	75.16	395.00	2.65	6.35	1.00
Swarna	8.77	21.45	60.38	182.67	2.65	8.25	1.47
Swarna Sub 1	9.56	21.12	60.09	137.67	2.65	8.75	1.53
Purnendu	9.06	26.52	80.72	297.67	2.90	8.25	1.54
Luit	13.42	21.27	77.11	240.00	2.65	7.25	1.10
Mahsuri	9.67	22.06	84.53	247.33	2.55	8.05	1.40
Ranjit	9.21	20.08	78.17	330.00	2.45	8.20	1.46
Mean	10.09	21.41	73.50	248.14	2.57	7.92	1.39
SEm±	0.06	0.06	0.69	4.01	0.04	0.05	0.03
$CD_{0.05}$	0.16	0.18	1.97	11.34	0.10	0.16	0.07
CV (%)	0.79	0.42	1.34	2.28	1.94	0.97	2.59

Table 2: ANOVA for the different grain and nutritional quality parameters

SOURCE	DF	MEAN SQUARES						
		Protein content (%)	**Amylose content, % (AC)**	**Starch content (%)**	**Water uptake (ml)**	**Volume expansion ratio**	**Kernel length after cooking (mm)**	**Grain elongation ratio**
Replicate	2	4.1E-04	6.3E-03	4.2E+00	140.90	0.002	0.065*	0.005
Treatments	15	1.1E+01**	6.3E+01**	2.5E+02**	24790.25**	0.233**	2.042**	0.077**
Error	30	9.6E-03	1.2E-02	1.4E+00	48.12	0.004	0.009	0.002

*, ** Significant at p= 0.05 and 0.01, respectively

Table 3: Range, mean, Genotypic coefficient of variability (GCV), Phenotypic coefficient of variability (PCV), Heritability in broad sense (H^2_{Bs}) and Genetic advance as percent of mean (GA as % of mean) of the different grain and nutritional quality parameters for the genotypes.

Character	Range	Mean ± SE_m	GCV%	PCV%	h^2_{bs} (%)	GA as % of mean
Protein content	6.02 - 14.98	10.10 ± 0.06	18.75	18.78	99.73	38.58
Amylose content	8.27 - 34.43	21.41 ± 0.06	21.46	21.47	99.94	44.20
Starch content	54.99 - 87.68	73.50 ± 0.69	12.40	12.51	98.29	25.32
Water uptake	82.67 – 395	248.14 ± 4.01	36.60	36.70	99.42	75.17
Volume expansion ratio	1.45 - 3.15	2.57 ± 0.04	10.74	11.00	95.24	21.59
Kernel length after cooking	5.95 – 9.00	7.92 ± 0.05	10.40	10.47	98.69	21.28
Grain elongation ratio	0.93 - 1.71	1.39 ± 0.03	11.37	11.81	92.67	22.55

High heritability was observed for amylose content, water uptake, volume expansion ratio, kernel length after cooking, grain elongation ratio and starch content. The results are in conformity with the findings of Vanaja and Babu (2006) [14] for amylose content, water uptake, volume expansion ratio, kernel length after cooking, grain elongation ratio, starch content and also with the findings of Amundha and Thiyagarajan (2008) [15] for amylose content, water uptake, volume expansion ratio and kernel length after cooking. High heritability suggests high component of heritable portion of variation that can be exploited by the breeders in the selection of superior genotypes on the basis of phenotypic performance. High to moderate heritability was reported for different quantitative traits studied in rice [16-18].

High heritability combined with high genetic advance is desirable for the selection-based genetic improvement of a character [19]. High heritability accompanied with high genetic advance as per cent of mean was observed for water uptake which was also observed by Vanaja and Babu (2006) [14] and Amundha and Thiyagarajan (2008) [15]. Amylose content showed high heritability with moderate genetic advance. High heritability coupled with moderate to high genetic advance and high genotypic coefficient of variability for characters such as water uptake and amylose content indicate the predominance of additive gene action for these traits. Hence selection based on these traits will be highly rewarding.

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