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Variability of cooking and nutritive qualities in some popular rice varieties of West Bengal

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ABSTRACT

Twenty one indigenous and popular rice varieties of West Bengal, India including some aromatic rice varieties were evaluated for 15 different grain quality parameters to assess genetic estimates of the traits and genetic divergence of varieties. Wide range of variation was observed in many traits offering scope for selection. Incorporation of gene from aromatic rice to other high yielding varieties stands out to be an important proposition for improving protein content in rice. The low difference between phenotypic and genotypic coefficient of variation have suggested less environmental influence on the genetic control of these quality parameters. Heritability was high for almost all the traits. Head rice recovery (HRR) and volume expansion ratio showed high GCV, PCV, GA with high heritability indicating that selection to be effective if based on these traits. Canonical analysis revealed that protein%, volume expansion ratio, kernel breadth before cooking, HRR% and kernel breadth after cooking were the main contributors towards divergence. The varieties were grouped into 11 clusters through canonical analysis.

Key words: *rice, milling, cooking quality, genetic variability, analysis*

There is a growing concern for quality and nutritious rice for domestic as well as international market. India, a surplus rice producing country is gradually focusing on to step up quality parameters as unattractive grain characteristics poses a serious set-back to the spread of otherwise agronomically superior varieties. Very limited efforts has so far been made on the improvement of grain quality parameters and micronutrient contents of the popular rice varieties. It is an urgent exigency to develop detailed database on all available popular rice varieties of West Bengal with special emphasis on grain quality traits and micronutrient content. The present investigation was aimed at to characterize the milling, cooking and nutritive qualities of some popular rice varieties of West Bengal and also to assess the genetic divergence of these varieties which would further help to generate desirable recombinants in future breeding programmes.

MATERIALS AND METHODS

The physico-chemical and biochemical analysis for twenty one popular rice varieties (including some aromatic types) of West Bengal were carried out in the Quality Laboratory of Rice Research Station, Chinsurah. West Bengal. The experimental materials were grown during the wet season of 2007-08 and the harvested materials were taken for physico-chemical and biochemical studies after four months of ageing. The soil of the location is texturally, sandy clay and is mainly characterized by neutral reaction (pH 6.5-7.8) and normal (less than 1) electrical conductivity (EC). The hulling %, milling % and head rice recovery % (HRR) were analyzed in Dehusker, Miller and Test Rice Grader of Satake, Japan following the method of *Govindaswami and Ghosh*, 1969. The traits namely grain length and breadth were recorded by using dial micrometer (Mitutoyo, Japan). Expansion ratio (ER) was also calculated (Anonymous, 2004).The cooking parameter like volume expansion ratio was measured following the method of Juliano *et al*. (1965). The alkali spreading value and amylose content were estimated as per the method of Little *et al*. (1958) and Juliano (1971), respectively. Protein estimation was done following the method of Lowry *et al.* (1951). The canonical analysis has been made following the software INDOSTAT (Version 6.0).

RESULTS AND DISCUSSION

Milling qualities are of paramount importance for breeding quality rice. A variety is considered as ideal if it possesses a high turnout of whole grain (head rice) and total milled rice (Webb, 1985). The kernel appearance, size, shape, aroma, nutritional value and cooking characteristics are important determinants for ascertaining the quality and preference of rice from one group of consumer to another (Dela Cruz and Khush, 2000 and Sellappan *et al*. 2009). In the present investigation hulling % was highest in Govindabhog (81.34) and lowest in Triguna (69.97) and it incidentally transpired that indigenous aromatic varieties surmounted other cultivars (Table1). Earlier Rita and Sarawgi (2008) reported that hulling percentage over 80 is always preferred and when hulling percentage increases the head rice recovery also increases. The performance of genotypes for milling percentage was similar like hulling percentage as Govindabhog (75.97) and Triguna (62.98) exhibited the highest and lowest value respectively. In general aromatic rice was chacterised with high milling %. HRR was highest in Badsabhog and lowest in Sabita (Table1).

The kernel length before cooking (KLBC) varied from 3.57mm (Govindabhog) to7.15 mm (Kalma 222), while the kernel length after cooking (KLAC) varied from 8.6mm (Satabdi) to 12.73 mm (Patnai 23) (Fig 1). It was noted that IR36 though did not occupy the top position in kernel length after cooking but the rate of elongation after cooking was

Table 1. Mean values of quality attributes of popular rice genotypes of West Bengal

Variety	Hulling %	Milling %	Head rice recovery %	AC %	ASV	GelatinizationTemperature
SatabdiIET-4786	76.23	70.23	55.01	27.00	2.16	High>74^{0}C
Probhat	78.32	73.20	68.002	26.70	5.33	Intermediate(70^{o}C-74^{o}C)
SwarnadhanIET-5656	76.62	70.90	63.06	21.25	2.66	High>74^{0}C
Sabita	76.30	65.21	40.30	30.75	2.66	High>74^{0}C
Sashi	78.68	71.61	63.24	25.00	6.16	Intermediate(70^{o}C-74^{o}C)
IR-64	74.01	70.82	63.68	22.65	2.66	High>74^{0}C
KhitishIET-4094	73.76	64.68	53.54	29.00	2.66	High>74^{0}C
Triguna	69.97	62.98	49.36	24.50	2.16	High>74^{0}C
Tulaipanji	78.77	72.65	56.15	20.50	2.66	High>74^{0}C
Masuri	77.07	70.43	66.43	23.40	2.66	High>74^{0}C
Kalma-222	78.57	73.24	60.90	27.30	2.83	High>74^{0}C
IR-36	76.89	71.19	65.97	26.70	2.83	High>74^{0}C
Ranjit	78.79	73.40	64.62	28.25	3.00	HI (71^{0}C-74^{0}C)
MTU-7029	78.11	74.11	67.60	21.25	3.00	HI (71^{0}C-74^{0}C)
PNR-546	77.64	68.64	46.64	9.75	3.83	HI (71^{0}C-74^{0}C)
Pankaj	74.65	69.14	59.61	27.45	3.16	HI (71^{0}C-74^{0}C)
Patnai-23	78.99	71.74	60.43	22.00	2.83	High>74^{0}C
Lathisail	78.66	70.10	55.31	27.90	3.16	HI (71^{0}C-74^{0}C)
Badsabhog	79.81	74.77	69.21	20.50	2.50	High>74^{0}C
Govindabhog	81.34	75.97	68.33	22.50	1.83	High>74^{0}C
Kalonunia	74.59	66.78	53.00	21.60	2.66	High>74^{0}C
Range	69.97-81.34	62.98-75.97	69.21-40.30	9.75-30.75	1.83-6.16	-
Mean	77.03	70.54	59.54	24.09	3.01	-

ASV -Alkali spreading value, AC-Amylose content

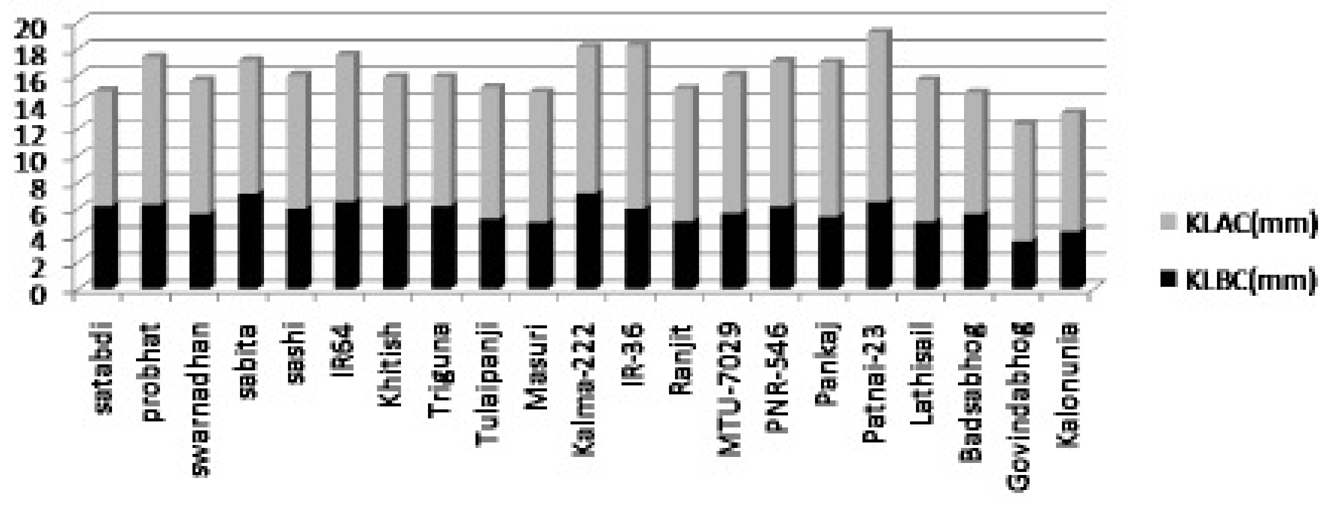

Fig. 1. Graph showing difference between kernel length before cooking and after cooking of indigenous rice varieties

highest. Similarly, high rate of kernel elongation after cooking was also recorded in Patnai 23, Pankag. Lathisail and Govindhabhog. The range of kernel breadth before cooking was from 1.50 mm (Govindabhog) to 2.29mm (Kalma 222) and after cooking the range varied from 1.93mm (Badsabhog) to 3.16mm (Swarnadhan). The length and breadth ratio (L/B ratio) (before cooking) varied from 2.38 mm (Govindabhog) and 4.05 mm (IR64). The ER (elongation ratio) lenghtwise ranged between 1.39 mm (Satabdi) and 2.44 mm (Govindabhog) with an average value of 1.86 mm and ER (Breadth wise) exhibited variation from 1.16 mm (Probhat) to1.80 mm (Tulaipanji). The lengthwise elongation was more in all the varieties (Fig.1). In general cooked rice with higher is preferred to the lower ER by the consumers of India (Shahidullah *et al*. 2009). Out of the 21 popular local landraces, Govindabhog surpassed others with respect to volume expansion ratio while Sabita, a released variety from local selection occupied the bottom position (Table 1).

The biochemical characters, like alkali spreading value (ASV) and gelatinization temperature (GT) were calculated for all the rice varieties included in the study. In the genotypes Govindabhog, Kalonunia, Badsabhog, Satabdi, Swarnadhan, Sabita, IR-64, Khitish, Tulaipanji, Masuri, Kalma-222, Triguna, Patnai and IR-36 expressed low ASV and high GT (Table 1). On the other hand, varieties such as Lathisail, Pankaj, PNR-546, MTU-7029 and Ranjit exhibited low to intermediate ASV and high to intermediate GT. The intermediate ASV and GT were recorded in the varieties Probhat and Sashi. (Table 1). In general cooking time of rice depends on coarseness of the grain. The intermediate ASV indicates the medium disintegration and is also classified as intermediate GT which professes the quality grain (Bansal *et al*. 2006). Out of 21 varieties studied, amylose content (AC) ranged from 9.75 to 30.75 with a mean value of 24.09 (Table 1). The variety Sabita and PNR-546 showed highest and lowest AC, respectively. Most of the local landraces showed intermediate AC content. Out of 21 varieties, 9 varieties showed high amylose % while intermediate amylose % was recorded in 11 varieties and low amylose content was found only in the variety PNR 546. Shahidullah *et al*. (2009) reported that the AC in all grades of rice ranged between 20.7-21.4%. The present finding clearly highlights more variability in the landraces which certainly offers greater scope to plant breeders in breeding program. Amylose in kernels determines the texture of cooked rice and consumers in India and South East Asia prefer rice with intermediate AC as people in this zone do not prefer sticky rice. The protein content ranged from 4.5 to 7.8% with mean percentage of 5.78. The variety Gobindabhog registered highest soluble protein followed by Badsabhog, Masuri and Kalonunia (Table 2). On the contrary, the variety namely MTU-7029 showed a lower value. However, a perfect trend of higher protein % was found in aromatic rice.

Table 2. Mean value of KLBC, KLAC, KBBC, KBAC, L/B, ER (Lengthwise), ER (Breadth Wise), VER, Protein in different rice varieties studied

Variety	Kernel length before cooking (mm)	Kernel breadth before cooking (mm)	L/B Ratio	Kernel length after cooking (mm)	Kernel breadth after cooking (mm)	Elongation ratio(ER) (Length-wise)	ER (Breadth-wise)	Volume Expansion ratio	Protein %
SatabdiIET-4786	6.20	1.67	3.71	08.60	2.10	1.39	1.25	4.50	5.8
Probhat	6.30	1.77	3.55	11.06	2.06	1.76	1.16	4.28	6.2
SwarnadhanIET-5656	5.60	1.94	2.88	10.00	3.16	1.78	1.62	4.67	6.0
Sabita	7.13	1.94	3.67	10.00	2.26	1.40	1.62	2.66	6.1
Sashi	6.00	1.68	3.57	10.00	2.26	1.67	1.34	3.30	4.8
IR-64	6.53	1.61	4.05	11.00	2.06	1.68	1.27	6.28	6.0
KhitishIET-4094	6.20	1.65	3.75	09.67	2.34	1.56	1.41	5.42	5.3
Triguna	6.20	1.60	3.78	09.67	2.26	1.56	1.41	6.34	6.1
Tulaipanji	5.27	1.57	3.35	09.83	2.83	1.86	1.80	5.25	6.1
Masuri	4.80	1.51	3.17	09.73	2.36	2.02	1.56	4.50	6.3
Kalma-222	7.15	2.29	3.13	11.00	2.37	1.83	1.17	3.50	5.9
IR-36	5.87	1.63	3.60	12.27	2.47	2.09	1.51	7.00	5.7
Ranjit	5.06	1.64	3.08	09.93	2.27	1.96	1.38	5.42	5.1
MTU-7029	5.66	2.20	2.57	10.34	2.34	1.92	1.41	4.00	4.5
PNR-546	6.17	1.68	3.67	10.87	2.37	1.76	1.41	4.00	5.8
Pankaj	5.40	1.78	3.03	11.60	2.47	2.14	1.38	6.00	5.2
Patnai-23	6.50	1.88	3.45	12.73	2.53	1.95	1.34	5.11	5.0
Lathisail	5.03	1.89	2.66	10.60	2.37	1.63	1.26	5.75	4.7
Badsabhog	5.62	7.79	3.2	09.06	1.93	2.22	1.32	7.42	6.8
Govindabhog	3.57	1.50	2.38	08.73	2.07	2.44	1.38	7.71	7.8
Kalonunia	4.30	1.52	2.83	08.87	2.33	2.06	1.53	6.00	6.2
Range	3.57-7.15	1.50-2.29	2.38-4.05	8.6-12.73	1.93-3.16	1.39-2.44	1.16-1.80	2.66-7.71	4.5-7.8
Mean	5.75	1.69	3.30	10.23	2.34	1.86	1.41	5.10	5.78

KLBC-Kernel Length Before cooking, KBBC-Kernel Breadth Before cooking, KLAC- Kernel Length after cooking KBAC- Kernel Breadth after cooking, L/B ratio- Length/ Breadth ratio,ER-Elongation ratio,VER-Volume Expansion Ratio.

Selection of parents based on higher genetic divergence in any hybridization program would like to generate desirable segregants in segregating generation (Dasgupta and Das 1985) and so identifying parents on the basis of divergence would be more rewarding in any breeding program. In the present investigation several genetic parameters namely genotypic and phenotypic co-efficient of variation, heritability (%) and genetic advance were estimated for 21 rice cultivars (Table 3). The genotypic and phenotypic coefficient of variation agreed closely with each other indicating that environment plays little role in the genetic expression of quality traits. The Genotypic co-efficient of variation (GCV) and phenotypic co-efficient of variation (PCV) were found to be high for alkali spreading value, volume expansion ratio and amylose content (Table 3) Similar finding was reported by Vanaja and Babu (2006). High heritability was present for almost all the traits. The range of heritability was from 59.61 (KBAC) to 99.98 (kernel length). Comparatively low heritability was recorded for kernel length after cooking (KLAC) and alkali spreading value (ASV) in general, low genetic advance was found for all the traits. Moderately high genetic advance was observed in head rice recovery (Table 3). Head rice recovery exhibited moderately high GCV and PCV, high heritability and thus the present finding emphasizes that there is great scope of improvement in this trait through simple selection as the variability persists for HRR and the trait is likely

Table 3. Mean sum of square along with genotypic and phenotypic coefficient of variation, heritability and genetic advance of popular rice varieties of West Bengal

Character	Mean sum of square			GCV	PCV	Heritability (%)	GA (5%)
	Replication(2)	Variety(20)	Error(40)				
Length	00.75	44.31**	02.34	14.77	14.86	99.98	01.79
Breadth	0.003	02.01**	0.297	10.23	11.38	81.57	00.32
L/B ratio	00.01**	12.38**	0.019	13.76	13.77	99.80	00.93
Length (klac)	00.74	03.80**	0.631	09.98	12.61	62.61	02.00
Breadth (kbac)	00.042	00.23**	0.042	10.68	13.84	59.61	00.40
Volume expansion	00.20**	109.98**	0.084	26.01	26.02	99.45	02.77
ER (lengthwise)	0.004**	04.35**	0.006	14.48	14.49	99.79	00.56
ER (breadthwise)	0.004**	01.50**	0.008	11.22	11.45	96.00	03.09
Alkali spreading Value	0.6723	60.22**	10.32	31.58	35.81	77.78	01.72
Amylose Content	0.828*	1224.85**	04.42	18.73	18.78	99.46	09.27
Protein	01.60**	34.72**	0.080	13.15	13.17	99.65	01.56
Hulling	15.56**	390.26**	7.320	03.29	03.34	97.24	05.13
Milling	09.45**	690.6	4.200	04.81	04.83	99.09	06.98
Head rice recovery	06.72**	370.9**	3.174	13.20	13.21	99.88	16.13

*and**significant at 5% and 1% level respectively.

to be controlled by additive gene action. Similarly, the scope of improvement through selection exists for traits like hulling (%), milling (%) and amylose content.

Canonical analysis was computed to consider the genetic divergence of the 21 indigenous rice varieties for different characters on the basis of three dimensional representation of multidimensional disposition of genotypes. Morphological characters are mostly affected by environmental factors, but it is found that genotype interacts with environment at a very low

Table 4. Estimates of canonical roots and coefficient of first five vectors

Source	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
Root	210671	85634.13	48712.58	36890.84	17637.16
Variation %	48.97422	19.90717	11.32411	8.57593	4.10007
Cumulative variation	48.97422	68.88139	80.2055	88.78143	92.8815
Hulling%	0.00617	0.04767	0.01506	0.10868	0.00452
Milling%	0.01645	0.06526	0.0581	0.13137	-0.03172
HRR%	0.08459	0.29204	0.40904	0.52395	-0.22684
AC	-0.038	-0.04968	0.05611	-0.20923	-0.32296
ASV	-0.07557	0.04674	0.12037	0.34829	0.0264
KLBC	-0.12853	0.06002	-0.30044	-0.20241	-0.31276
KBBC	0.15074	0.37819	-0.73025	0.34413	0.12764
L/B ratio	-0.03458	-0.010781	0.01368	-0.11412	-0.25937
KLAC	-0.26072	0.052455	0.06552	-0.15166	-0.49314
KBAC	0.01458	-0.22544	0.25977	0.21921	0.2719
ER(L)	0.07132	0.16467	-0.09188	0.23183	-0.07415
ER(B)	0.02815	-0.16932	-0.23513	-0.09003	0.12866
VER	0.59357	0.49144	0.21583	-0.45379	0.27932
Protein%	0.7201	-0.34928	-0.07517	0.14165	-0.49392

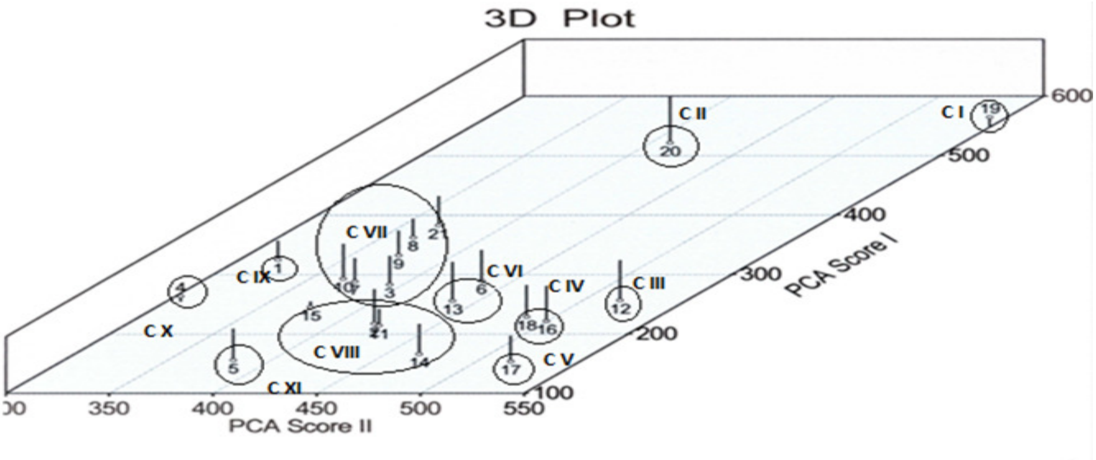

Fig. 2. Three dimensional ordination of 21 rice varieties on principal component axis I and II.

level at least for quality characters. Hence, this multi-location trials may not be undertaken when assessment of quality attributes is done. Canonical analysis revealed that 48.97% of the total variation had been contributed by the first vector and 19.90% and 11.32% by second and third vector respectively. Protein % and volume expansion ratio in the first vector contributed more to the divergence, while volume expansion ratio showed more contribution to divergence in vector two followed by KBBC and HRR % (Table 4). Again volume expansion ratio along with HRR% and KBAC in the third vector contributed more to the divergence. Thus combining the three vectors it appeared that the characters like protein %, volume expansion ratio, KBBC, HRR percentage and KBAC mostly contributed to the high genetic divergence. Head rice recovery and volume expansion ratio showed good promise of improvement from the estimates of the genetic parameters also as these two characters exhibited high GCV, PCV, heritability, GA and thus contributing mostly towards high genetic divergence.

The three dimensional representation of the relative position of the genotypes based on first three principal component roots evinced that the varieties can be grouped into eleven distinct clusters (Fig 2). Cluster VII comprised of six genotypes while cluster VIII, Cluster IV and Cluster VI consisted of four and two genotypes respectively. Bashar (2002) suggested that hybrids with more heterosis mostly belonged to moderate diversity group and extreme diversity sometimes do not produce highly heterotic cross.

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