IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 9, Issue 4 Ver. II (Apr. 2016), PP 08-12
www.iosrjournals.org

Characterization and variability analysis of Rice genotypes with reference to Cooking Quality Parameters

Baishali Dutta Chowdhury, Anirban Nath And Tapash Dasgupta
Department of Genetics and Plant Breeding, University of Calcutta, India

Abstract: *A study was conducted with 65 rice genotypes during the wet season of 2014 following RCBD with three replications and two checks; cooking quality parameters of the genotypes along with the yield were evaluated. Analysis of variance was conducted to determine GCV, PCV, Heritability and GA of the genotypes with respect to important quality parameters like amylose content, alkali spreading value, gel consistency, elongation ratio, hulling%, milling%, head rice recovery% and yield per plant. Significant variation was observed among the genotypes. Correlation analysis was done for determining the nature of interaction among the characters. A cluster analysis was performed and a dendogram was constructed which evinced the nature of phylogenetic classification among the genotypes of the population.*
Keywords*: Correlation , dendogram, quality parameters, variability*

I. Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops in the world, meeting the daily dietary requirements of the people living in the tropics and sub-tropics. It is consumed mainly in the form of whole grain contributing 20% of daily calories as staple food for a large population throughout the world (Bhattacharjee *et al*. 2002). India is not only a country with self sufficiency in production but also is the second largest exporter of quality rice in the world (Sreedhar *et al.,* 2005). Since the time of adoption of high yielding varieties, rice breeders usually are concerned about improving rice yield along with cooking quality parameters which increase the total economic value of rice. The economic value of rice depends on its cooking and processing quality, which can be measured in terms of grain amylose content, elongation during cooking, processing and milling systems. Hence, breeding objectives are to be augmented giving equal preference for high yield and preferred cooking quality for better consumer acceptance. High magnitude of variability in a population provides the opportunity for selection of varities having desirable characters. Previous results during the past investigations conclude that cooking quality is directly related to the physical and chemical characteristics of the starch in the endosperm; i.e; amylose content, gel consistency, alkali spreading value (Little *et al*., 1958; Webb, 1980; Juliano, 1980; Unnevehr *et al*., 1992; Tan *et al*., 1999). Therefore, one of the major challenges in plant breeding is to develop rice varieties of better cooking quality to satisfy the requirements of the consumers (Lestari *et al*. 2009). Cooking qualities in rice is associated with physico-chemical properties i.e. amylose content (AC), Gel consistency (GC) and gelatinization temperature (GT). Apparently, the amylose content reported for Indica rice varieties ranges from moderately low to intermediate and the level varies according to location and environment as well. Amylose is the linear fraction of starch in the non glutinous varieties. Amylose consists of linearly linked glucose molecules and is relatively resistant to digestion (Oko et.al., 2012). It has a major influence on the characteristics of cooked rice. It correlates negatively with test panel sources for cohesiveness, tenderness, colour and gloss of the boiled rice. Gel consistency (GC) measures viscosity of pastes or gels made from milled rice flour and is a good determining factor of cooked rice texture, especially among rice varieties having a high amylose contents. GC of rice with less than 24% amylose may be soft, medium, or hard. Cooked rice with hard gel consistency hardens faster than those with soft gel consistency. The later also remains tender and soft even upon cooling (Juliano, 1979). Consumer therefore prefers rice with soft to medium gel consistency (Tang et al., 1991). Alkali spreading value (ASV) of whole kernel (milled rice) measures the gel type of rice. It also allows an estimation of the gelatinization temperature and is partly associated with the amylose content of the starch. The gelatinization temperature of the endosperm starch refers to the cooking temperature at which water is absorbed and the starch granule swell irreversibly with a simultaneous loss of crystalline. Alkali spreading value is indirectly correlates with the gelatinization temperature. Keeping in view the above perspectives, the specific objectives of this work is, therefore, to evaluate the grain quality parameters aiming to improve quality rice without compromising the yield.

II. Material & Method

65 genotypes representing various eco-geographical regions were evaluated at Calcutta University Agricultural Farm, Baruipur, 24 pgs (south) in a Randomized Complete Block Design (RCBD) with three

replications along with two checks IR64 and Satabdi in wet season 2014. The seedlings were transplanted 20 cm apart between rows and 15 cm within the row. Five representative plants for each genotype in each replication were randomly selected to record the data of all quality traits under study. Hulling% , Milling% and Head Rice Recovery(HRR) of different cultivars were carried out using a Paddy dehusker (Satake, Japan Model – THU-35B) and milled with a rice miller (Satake, Japan Model – TMO 5C & TM – 05). The yield of brown rice was recorded after hulling and the yield of white rice were recorded after milling. The head rice (HR) recovery was also determined according to the methods of Khush *et al*. (1979) and Adair (1952).

Chemical Characterization of Milled Rice Grains:

Amylose Content: Amylose content of rice flour of different cultivars was determined following the modified method of Juliano (1971). 1ml ethanol (95%) and 9mL of sodium hydroxide (1N) were added to 100mg of rice flour of each cultivar. The samples were heated on a boiling water bath followed by cooling for 1 h, distilled water was added to make the final volume of 100 ml. 1ml of acetic acid (1 N) and 2 ml of freshly prepared iodine solution were added to 5 mL of the stock sample solution (pH 4.5). Absorbance of the solution was measured at 620 nm after 20 min.

Gel Consistency Test: The gel consistency test was performed following the method of Cagampang et al.1973). Rice flour (0.1 g) of different samples was taken in test tubes. Ethanol (0.2 mL; 95%) containing thymol blue (0.025%) and 2 mL of potassium hydroxide (0.2 N) was added to samples. The samples were heated in boiling water bath for 10 min and then cooled in ice water bath for 20 min. Gel consistency was measured by the length of cold gel in test tubes held horizontally on graph paper after 30 min.

Elongation Ratio: Elongation ratio of cooked kernels was determined by dividing the length of cooked kernel to length of uncooked kernel.

Alkali Digestion Test (ASV): This test was done by the method of Bhattacharya and Sowbhagya (1972). The test was conducted in Petri plates containing 6 raw milled rice grains and potassium hydroxide (1.7%) solution. The plates were incubated overnight at room temperature, and the scoring was done (7-point scale) on the basis of degradation of rice grains, which included the amount of residual chalky substance in the degraded grain, the diameter of the collar and the consistency of the collar. The highest score was given for complete degradation of kernels in potassium hydroxide solution and vice versa.

The data were statistically analyzed using the software SPAR.2.0. The analysis of variance revealed that the parameters like phenotypic and genotypic coefficient of variation (PCV and GCV), broad-sense heritability (H2), and genetic advance (GA) suggested by Johnson *et al*. (1955). The dendrogram of 65 genotypes was computed with the help of software Darwin 6.0 version following the method UPGMA.

III. Result & Discussion

ANOVA showed significant variation at 0.01% level of significance among 65 genotypes for all the traits studied. Highest GCV and PCV were observed in gel consistency followed by elongation ratio. The narrow difference between GCV and PCV observed for the traits like hulling%, milling % and HRR indicates a very little environmental effect. So these traits can be improved through simple selection methods. Similar findings were also recorded earlier by (Vanisree et.al; 2013). In the study, heritability was high for all the quality parameters; but a high heritability along with high GA was observed in amylose content and yield per plant which suggests that selection in terms of these two characters will be highly effective. Breeding approaches involving isolation of purelines through direct selection method would be fruitful in this case (Johnson *et al.* 1955). The efficiency and selection for yield mainly depends on the magnitude and direction of association between yield and other components. Correlation analysis (Table No.4) among the traits reveals that significantly positive correlation in terms of both genotype and phenotype at 0.01% level of significance was observed between amylose content with respect to elongation ratio and alkali spreading value; and also between elongation ratio and gel consistency. Amylose content showed significantly negative correlating with gel consistency suggesting that those varieties with high amylose content will result in hard and shorter length of gel than varieties with low amylose content due to retrogradation behavior of amylose during the cooling of gel (Rani *et al*. 2006). Negative correlation between amylose content and gel consistency was also reported earlier (Khatun *et al*. 2003). Also milling % shows a similar positive correlation with respect to HRR. Yield/plant had non-significant association with all the quality parameters reflecting less influence of all these traits upon the final yield. The dendrogram constructed using UPGMA of 65 genotypes and 8 characters showed that 63 genotypes are grouped under 5 clusters at 70% similarity coefficient (Figure: 1). Whereas 2 genotypes were found to be outliers and could not be grouped with the other genotypes. The mean values of the 8 characters were tabulated in Table no: 6 .The cluster analysis suggested that the genotypes present in cluster I, II and IV has intermediate amylose content with a gel consistency greater than 60%. Thus the cooked rice belonging to these three clusters will have a good soft texture and less stickiness. Also the genotypes showed a high grain yield per plant on an average of 20gm. The genotypes of cluster I, II and IV also showed high hulling and milling percentage. In case of cluster III intermediate amylose content with low to intermediate gel consistency was found. The yield per plant was found to be lower than the genotypes belonging to Cluster no. I , II and IV. In cluster I varieties Black gora, Carolina Gold (selection) and Jaldi 6 performed at par with check variety Satabdi. In cluster II Jaldi 13 performed almost equal and in some traits even better than the popular varieties in the same cluster (IR-68 and PNR 519). In group III Japonica variety Azucena outperformed the other genotypes. In group IV the variety Tchibanga was found to be at par with Triguna and IET 20144. Thus the cluster analysis provides some potential parents which can be utilized in future breeding programs for enhancement of cooking quality along with better yield.

IV. Conclusion

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. For successful breeding a genetically diverse germplasm population is required. Thus the following experiment provided a basic idea about the diversity of the population in terms of vital morphological and quality parameters. The correlation analysis provides vital information which can be helpful in alternate selection of characters for development of new lines. The cluster analysis helped in grouping the genotypes into clusters having specific characteristic traits which may be helpful in selecting parents for future breeding programs.

Table: 1: Mean values of cooking quality parameters of 65 rice genotypes

Sl No	Genotypes	Amylose content	Gel Consistency	Elongation Ratio	Alkali Spreading Value	Hulling%	Milling%	Head Rice Recovery%	Yield/Plant (gm)
1	Surjamukhi	16.27	44.33	1.76	3.17	75.67	65.3	51.75	20.57
2	IR68144-2B-2-2-3-1-127	16.17	87.67	1.82	2.8	77	70.2	59.25	26.91
3	IR5882-23-1-3-1	16.79	34	1.83	2.97	75.57	70.33	65.2	26.74
4	Daya	16.87	66.33	1.84	3.7	79.41	69.24	63.61	23.34
5	Patharea	14.67	69.67	1.7	4.7	69.36	63.75	58.69	21.62
6	Nipponbare	16.84	63.33	1.39	3.3	75.46	69.38	59.33	25.55
7	IR 64	20.21	44	2.4	3.57	76.92	70.48	58.66	27.29
8	CN1646-2	17.06	66.33	1.95	2.57	71.4	62.2	51.35	26.27
9	IR 68144-120	17.68	57	1.91	5.57	80.6	73.8	64.77	28.12
10	IR 50	16.31	74.67	1.63	3.3	71.7	61.48	57.64	23.55
11	Ratna	15.02	83.33	1.72	3.1	67.35	59.69	50.3	24.94
12	IR-36	20.31	51	1.69	3.33	77.6	68.6	58.44	26.33
13	ARC 10086	16.44	73.67	2.04	3	74.1	68.96	60.4	25.34
14	Peh-kuh	15.33	25.67	1.97	4.23	77.2	70.2	61.7	26.08
15	PSRBC-68	16.14	50	2.06	3.1	71.54	62.87	55.46	20.25
16	BR-714-35	18.14	58.67	2.17	3.73	70.91	63.25	60.57	30.2
17	CN 915	15.39	77.33	1.62	3.6	77.24	70.06	60.47	25.18
18	PNR 519	17.92	47.33	1.95	5.03	77.66	70.15	63.46	21.05
19	Dular	16.1	55.67	1.7	3.07	76.8	68.09	59.48	27.35
20	Kashalath	19.5	32.33	1.58	3.97	72.77	64.17	57.39	21.3
21	CN 1646-1	20.7	68.33	1.61	3.4	72.28	64.1	57.5	24.58
22	Deokjeokjodo	16.85	94.33	1.87	4.43	75	71.8	67.13	21.73
23	Tequing	14.59	88	1.9	3.2	74.57	67.8	56.74	27.22
24	JALDI 6	20.45	71	2.03	3.77	77.6	69.14	60.15	29.03
25	Rathuwee	19.75	77	2.01	3.53	76.8	71.09	64.6	25.6
26	JALDI 13	23.49	63.67	2.01	5.3	78.52	71.5	60.33	27.37
27	Krishna-Hamsha	16.63	74.33	2.05	4.53	80.86	68.33	64.25	22.85
28	Indo American-1	15.8	71.33	1.92	3.27	70.63	65.08	57.38	28.93
29	Naveen	22.31	38.33	1.78	4.03	74.44	69.75	64.33	25.77
30	Oryzicallonos-5	17.21	62.67	1.7	3.4	70.73	65.52	58.74	26.37
31	Indo American-2	20.91	43	2.01	3.1	74.58	69.37	62.75	29.3
32	Assamlaya	19.76	55.33	1.93	3.97	78.32	70.66	68.39	26.27
33	Carolina gold selection	18.88	81	1.87	3.33	76.63	68.73	60.5	30.5
34	Kalapahar	18.58	88	1.94	3.4	70	66.11	57.5	23.97
35	Gerdeh	19.28	89.33	2.2	3.5	78.33	70.15	65.39	23.83
36	Doble carolina	16.91	92.67	1.64	4.27	78.42	70.11	65.5	26.57
37	Dudheswar	18.21	73	1.8	3.1	74.58	69.66	64.85	22.87
38	Kharbela	15.55	77.67	1.94	5.9	73.3	64.85	59.38	22.6
39	Lemont	17.87	78	1.88	3.6	77.08	70.5	61.73	27.9
40	IR-1552	21.99	76	1.78	4.03	75.41	67.95	60.09	24.4
41	Trembese	17.71	71	2.03	5.6	74.7	66.99	62.46	27.43
42	Badami	17.62	39.67	1.89	3.27	75.2	72.07	59.08	24.77
43	PNR 546	19.94	57.67	1.89	5.03	71.17	63..3	56.34	30.23
44	MTU 1010	17.37	46.33	2	3.07	73.68	68.33	63.2	23.13
45	BonAhu	19.77	46	1.86	3.33	73.69	66.99	60.36	23.5
46	Khittish	23.55	43.67	1.99	3.47	74.9	65.95	55.85	31.17
47	Black gora	19.47	64.67	1.89	3.13	79.86	72.81	69.33	28.47
48	Satabdi	20.05	72.33	1.75	3.6	72.18	65.39	58.71	30.23
49	Padmini	19.28	68.33	1.77	3.77	77	68.74	60.15	25.47
50	Triguna	21.76	90	1.91	4.1	68.9	60.75	51.36	24.07
51	CO 39	17.1	72	1.71	3.37	72.4	67	60.15	22.77
52	I-Zeo-Tze	19.09	75.33	1.99	5.33	74.09	68.77	63.17	27.23
53	Paroma ahu	22.07	95.33	1.89	3.57	76.8	68.9	60.45	23.47
54	IET 20144	16.94	90	1.73	4.4	70.8	61.25	53.66	26.23
55	Phudugey	16.79	68.67	1.49	3.43	71.53	63.65	55.7	20.6
56	Kalinga2	18.32	57	1.91	3.3	76.5	69.9	57.8	29.83
57	Azucena	18.6	67.33	1.83	3.13	69.4	62.5	56.47	19.37
58	ARC 10372	17.22	81.67	1.73	3.67	76.8	67.62	55.38	24.63
59	Tchibanga	19.01	74.67	1.81	3.1	60.2	55.2	48.64	25.3
60	Tondok	16.63	96.33	1.98	3.43	74.65	70.62	59.45	23.57
61	Asse Y Pung	22.61	73.33	2.12	3.5	76.4	70.24	61.76	22.11
62	Khanika	15.42	79.33	1.79	2.87	73.7	68.9	61.5	25.67
63	Pravat	16.09	63	1.8	5.73	79.8	71.25	60.28	28.43
64	Cenit	18.65	39.33	1.86	6.03	70.91	65.2	60.48	22.37
65	Zhenshan-2	16.83	67.32	1.97	3.1	70.95	65.39	60.66	23.23
Mean		14.62	51.88	3.01	1.50	59.61	52.57	45.73	20.52
CD		1.67	9.54	0.54	1.67	3.38	3.02	2.32	3.84
CV (%)		7.08	11.38	11.14	7.08	3.49	3.60	3.14	11.58

Table : 2 Analysis Of Variance (ANOVA)

source	df	MEAN SUM OF SQUARES							
		Amylose content	Gel consistency	Elongation ratio	ASV	Hulling %	Milling %	HRR	Yield/plant
Variety	64	174.183**	275.962**	11.778**	28.408**	274.740**	213.857**	162.574**	339.034**
Replication	2	2.583**	10.181**	0.0252	0.860	0.343	5.189**	4.005**	8.875**
error	128	1.073	1.485	0.016	0.112	1.368	0.483	0.057	1.650

Table: 3 GCV, PCV, Heritability and Genetic Advance

	GCV	PCV	HERITABILITY	GA
Amylose content	11.24	12.99	89.17	15.36
Gel consistency	25.11	26.87	86.33	5.97
Elongation ratio	23.87	27.69	92.70	1.53
ASV	7.96	11.08	85.98	3.29
Hulling %	4.85	5.76	96.34	6.20
Milling %	6.11	6.81	98.60	5.46
HRR	7.49	8.00	97.17	4.77
Yield/plant	9.52	13.84	65.17	20.66

Table: 4 The phenotypic and genotypic coefficient among the traits

		Amylose content	Gel consistency	Elongation ratio	Alkali spreading value	Hulling (%)	Milling (%)	Head rice recovery (%)	Yield/plant
Amylose content	G	1	-0.762*	0.826**	0.878**	0.064	0.033	0.180	0.225
	P	1	-0.709*	0.849**	0.864**	0.087	0.039	0.135	0.127
Gel consistency	G		1	0.906**	-0.758**	-0.084	0.074	0.002	0.052
	P		1	0.974**	-0.604	0.043	0.047	0.011	0.041
Elongation ratio	G			1	0.672*	0.384	0.344	0.211	0.061
	P			1	0.718*	0.118	0.115	0.097	0.057
Alkali spreading value	G				1	0.210	0.107	0.067	0.285
	P				1	0.157	0.103	0.034	0.088
Hulling (%)	G					1	0.920**	0.820**	0.299
	P					1	0.700*	0.674*	0.156
Milling (%)	G						1	0.948**	0.154
	P						1	0.819**	0.110
Head rice recovery (%)	G							1	0.206
	P							1	0.156
Yield/plant	G								1
	P								1

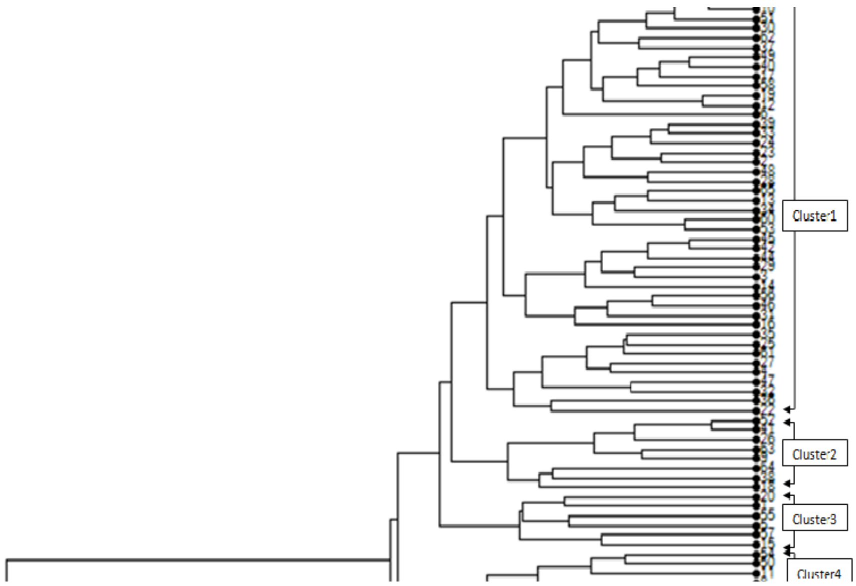

Fig: 1 Dendrogram showing the distribution of 65 genotypes in clusters

Table no: 5 Distribution of 65 genotypes in 4 clusters and 2 outliers

Cluster	Name of the Genotypes
1	2) IR68144-2B-2-2-127, 6) Nipponbare, , 3)IR5882-23-1-3-1 , 10)IR50, 12) IR-36, 4)Daya, 13)ARC10086, 14) Peh-kuh, 16) BR-714-35, 17) CN915, 19) Dular, 21) CN1646-1, 22) IR 64, 23)Tequing, 24)JALDI6, 25) Rathuwee, 27)Krishna-Hamsha, 28) IndoAmerican 1,29) Naveen,30)Oryzicallonos-5, 31)IndoAmerican-2, 32)Assamlaya, 33) Carolina gold sel, 34) Kalapahar,35) Gerdeh, 36)Doble Carolina, 37)Dudheswar, 39) Lemont,40)IR-1552, 42)Badami, ,44) MTU 1010,45) BonAhu,46) Khittish,47) Black gora,48) Satabdi,49) Padmini, 51)CO 39, 53)Paroma ahu, 56)Kalinga2,58) ARC 10372,60) Tondok,61)PNR 546, 62) Khanika,65) Zhenshan-2
2	52)I-Zeo-Tze,41) Trembese ,26) JALDI 13,63) Pravat,9) IR 68144-120,64) Cenit,38) Kharbela,18)PNR 519
3	20)Kashalath,1) Surjamukhi, 55)Phudugey, 5)Patharea,57) Azucena,15)PSRBC-68
4	54)IET 20144,50) Triguna, 11)Ratna,8) CN1646-2, 59)Tchibanga
Outliers	
1	7) Deokjeokjodo
2	43) Asse Y Pung

Table: 6 Mean values of the genotypes of each cluster of 8 traits

No. of clusters / Traits	Cluster 1	Cluster 2	Cluster 3	Cluster4	Outliers 1	Outlier2
Amylose content (%)	18.436	18.273	16.995	17.958	16.85	22.61
Gel consistency	68.053	61.791	55.388	80.866	94.33	73.33
Elongation ratio	1.875	1.936	1.737	1.824	1.87	2.12
Alkali spreading value	3.529	5.561	3.583	3.454	4.43	3.50
Hulling (%)	75.161	76.198	71.712	67.730	75	76.4
Milling (%)	68.498	69.064	63.707	59.818	71.8	70.24
Head rice recovery (%)	60.764	61.791	55.910	51.062	67.13	61.76
Yield/Plant(g)	25.994	25.575	20.618	25.362	21.73	22.11

References

[1] P. Bhattacharjee, R.S. Singhal, and P.R. Kulkarni, Basmati rice: A review. Int. J. Food Sci. Technol. (37), 2002, 1–12

[2] S. Sreedhar, S. Vanisree, N. Kulakarni and M. Ganesh, Gene effects for certain physical quality traits and grain yield in rice, Madras Agricultural Journal, 92(4-6), 2005,183-187.

[3] R.R. Little, G.B. Hilder, and E.H. Dawson,Differential effect of dilute alkali on 25 varieties of milled white rice. Cereal Chemistry 35, 1958, 111-126

[4] B.O. Juliano and C.G.Pascual, Quality characteristics of milled rice grown in different countries. IRRI Res, 1980.

[5] L.J. Unnevehr, B. Duff, and B.O. Juliano, Consumer demand for rice grain quality. Manila, Philippines: IRRI; 1992. p. 159–174.

[6] S. Sreedhar, S. Vanisree, N. Kulakarni and M. Ganesh, Gene effects for certain physical quality traits and grain yield in rice, Madras Agricultural Journal, 92(4-6), 2005,183-187.

[7] Y . Cho, P. Lestari, T.Ham , H. Lee , M. Woo , W. Jiang , S. Chu, S. Kwon, K. Ma, H. Lee,PCR marker based evaluation of the eating quality of Japonica Rice (Oryza sativa L.). J.Agric. Food Chem. 57, 2009, 2754–2762.

[8] A.O. Oko, B. E . Ubi, N. Dambaba, Rice Cooking Quality and Physico-Chemical Characteristics: a Comparative Analysis of Selected Local and Newly Introduced Rice Varieties, Food and Public Health , 2(1), 2012**,** 43-49.

[9] B.O. JULIANO, The chemical basis of rice quality. In Proc. of the workshop on chemical aspects of rice grain quality. IRRI, Manila, Philippines ,1979, 69-90.

[10] S. X. TANG, G. S. KHUSH AND B. O. JULIANO, Genetics of gel consistency in rice (Oryza sativa L.), J. Genet., 70(2), 1991, 69-78.

[11] G.S. Khush, C.M. Paule and N.M. Cruz, Rice grain quality evaluation and improvement at IRRI. In Proceedings of theWorkshop on Chemical Aspects of Rice Grain Quality, IRRI, Los Banos, Philippines, 1979, 21–31.

[12] C.R. Adair, TheMcGill millermethod for determiningthe milling quality of small samples of rice, Rice J, 55, 1952, 21–23.

[13] B.O. Juliano, A simplified assay for milled rice amylose. Cereal Sci. Today, 16, 1971, 334–340.

[14] G.B. Cagampang, C.M. Perez and B.O. Juliano, A gel consistency test for eating quality of rice. J. Sci. Food Agric 24, 1973, 1589–1594.

[15] K.R. Bhattacharya and C.M. Sowbhagya, An improved alkali reaction test for rice quality, Int. J. Food Sci. Technol. 7, 1972, 323–331.

[16] H.W. Johnson, H.F. Robinson and R.E. Comstock, Estimates of genetic and environmental variability in soybean, Agron.J . 47,1955, 477-483.

[17] S. Vanisree, K.Swapna, Ch. Damodar Raju, Ch. Surender Raju and M.Sreedhar, Genetic variability and selection criteria in Rice, Journal of Biological & Scientific Opinion, 4(1), 2013, 341-346

[18] H.F. Johnson and R.E. Comstock, Estimation of genetic and environmental variability in soybean. Argon.J., 47, 1955, 314-18

[19] N.S. Rani, M.K. Pandey, G.S.V. Prasad and I. Sudharshan, Historical significance, grain quality features and precision breeding for improvement of export quality basmati varieties, India. Indian J. Crop Sci.1, 2006, 29–41.

[20] M.M. Khatun, H.M. Ali and D.Q. Dela cruz, Correlation Studies on grain physicochemical characteristics o aromatic rice. Pak. J. Bio. Sci. 6, 2003, 511–512.