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RESEARCH PAPER

Study of grain quality of some traditionally cultivated Basmati and Non-Basmati aromatic rices under organic field conditions

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Abstract : Cultivation and selection by farmers for centuries under varied growing conditions has resulted in a myriad of rice varieties. Rice varieties differ from each other in growth duration, photoperiod sensitivity, grain size, shape and colour, and endosperm properties. India possesses an immense wealth of Basmati and non Basmati aromatic rice varieties and land races exhibiting a wide variability in their grain quality and cooking characteristics. Among all scented rices aroma is considered as most important quality parameter of high quality rice. The major aromatic compound responsible for aroma is considered is 2-acetyl-1- pyrroline, which is degraded by excessive nitrogenous fertilizers. To avoid degradation of 2-acetyl-1- pyrroline and ultimately aroma organic field conditions are preferred.In present study 35 varieties/lines of Basmati and Non-Basmati aromatic rices were evaluated for their physical and quality characteristics. Among all quality characteristics aroma is considered as most important quality parameter of high quality rice. In present study aroma ranged from very low to strong. Only one variety *i.e* Kalanamak 3120 show very low aroma. Strong aroma was reported for 11 varieties and remaining 19 varieties showed moderate aroma. The gelatinizing temperature ranged from low to high intermediate category. This was indirectly decided by alkali digestion score which ranged from 7.0 (Kalanamak 3216 and Kalanamak 3319) to 1.75 (Basmati 107). Cooked kernel length was recorded 13.65 mm (Hansraj 3072-2) to 8.40 mm (Kalanamak 3319), while cooked kernel breadth ranged between 2.9 mm (Bindli 3255) to 2.0 mm (Basmati 136, Kalanamak 3121). Elongation ratio was recorded from 2.30 (Kalanamak 3215) to 1.75 (Kalanamak 3319). Most of the parameters of these varieties/lines were compared to premium Dehradun basmati 3020. Based on this study it was revealed that besides Basmati rice other non Basmati aromatic rice varieties should also promoted by scientists and adopted by more and more farmers and traders so the consumers can get better aromatic rice at lower cost and simultaneously we can maintain our traditional non basmati aromatic rice germ plasm.

Key Words : Grain quality, Non-Basmati rice, Amylose content, Gelatinizing temperature, Elongation ratio

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INTRODUCTION

Rice (*Oryza sativa* L.), a semi-aquatic annual grass native to tropical Asia, is the world's single most important food crop and a primary food source for more than a third of world's population. It is an integral part, inter-twined with the socio-religious customs, food habits as well as the economy of the country. More than 90 per cent of the world's rice is grown and consumed in Asia, where 60 per cent of the calories are consumed by 3 billion Asians (Khush, 1997). India is one of the world's largest producers of white rice, accounting for 20 per cent of all world rice production. India stands first in area, second in production, followed and preceded by China on these two aspects. The other major rice growing countries are Indonesia, Vietnam, Bangladesh, Thailand, Myanmar and Philippines among Asian countries. Now these days rice is excessively produced in whole of the world. Rice grain quality is a major factor from consumer as well as marketing point of view. Aromatic rice, which has stronger aroma and kernel elongation than ordinary rice, has more in demand in different

countries of the world. India is one of the largest exporter of basmati rice in world (Husaini *et al.,* 2009) The consumer demand has increased markedly to pay a premium price for fragrance (Louis *et al.,* 2005)

Scented rices grow best and produce finest quality grains under cool, humid conditions, which are common in Himalayan Tarai of U.P. and Uttarakhand and foot hills of Vindhya Hills. Hence, Himalayan Tarai of Uttar Pradesh (U.P.) and Uttarakhand is probably the place of origin of aromatic rices (Khush, 2000). All types of traditional scented rices *viz.*, small and medium grained Non-Basmati and long grained Basmati rices, were once very widely cultivated in these two states. Within these two states different aromatic rices have adopted to specific localities and conditions where their quality traits are expressed best. For example the finest quality Dehradun Basmati is produced in Seola-Majra Belt of Dehradun District of Uttarakhand; Kalanamak is primarily grown by farmers of Siddarthnagar and Basti districts of U.P.

Grain quality has always been an important consideration in rice variety selection and development. Based on the survey of 11 major rice growing countries Juliano and Duff (1991) concluded that grain quality is second only to yield as the major breeding objective. In the future grain quality will be even more important as once the very poor , many of whom depend largely on rice for their staple food become better off and begin to demand higher quality rice (Juliano and Villareal, 1993). Grain quality in rice is very difficult to define with precision as preferences for quality vary from country to country. The cooking quality preferences vary in different countries (Azeez and Shafi, 1966).The concept of quality varies according to the preparations for which grains are to be used. Rice is one cereal that is consumed mainly as whole milled and as boiled grain. The desired properties may vary from one ethnic group or geographical region to another and may vary from country to country (Juliano *et al.,* 1964). Grain quality characters are reported to play important role in genetic divergence too (Singh *et al.,* 2008). Besides grain quality characters, agro-morphological character like plant height, weight of panicle, 1000 grain weight, panicle length also contribute towards genetic divergence (Singh and Singh, 2008). Further both grain quality and agro-morphological characters followed by molecular marker study may be utilized to explore the variability and relatedness among different Basmati and non basmati scented rice lines not only at morpho-physiological and grain quality level but also at molecular level, which can be a positive step towards documentation of our scattered knowledge about germ plasm available in India.

Basmati rice costs 2-3 times more to pocket of consumers than non Basmati rice. It is not possible for each and every person to expend more money for procurement of Basmati rice for their kitchen. On other hand it is not possible to farmers / traders to provide Basmati for each person as production of most of Basmati rice in India is limited to specific area *i.e.* the Himalayan Tarai region. Hence, there is need to explore potential of other non Basmati aromatic rices e.g. Bindli, Tilak Chandan, Kalanamak, Hansraj as substitute of Basmati rice, as these rice varieties/lines can be cultivated in different parts of Uttar Pradesh and Uttarakhand. Keeping in mind these facts, present study was done to generate comparative data of various grain quality characteristics of these varieties/ lines w.r.t Basmati varieties/lines.

MATERIALS AND METHODS

Total 35 varieties/ lines comprising of 08 Basmati, 09 Hansraj, 09 Kalanamak, 06 Bindli, and 03 Tilak Chandan were taken for present study. Dehradun basmati 3020 was taken as standard basmati rice variety. All the lines were grown at seed Production Center (SPC), Pantnagar under G.B.Pant University of Ag. and Tech, Pantnagar under organic field conditions during period of 2004-05 and 2005-06 .Some field observations like plant height and panicle length (Fig. 1) were also taken. Grain samples of all lines were analyzed for different quality characteristics *viz.*, hulling per cent, milling per cent and head rice recovery as described by Ghosh *et al.* (1971), alkali value following the method of Little *et al.* (1978), amylose content (Juliano, 1972) aroma, gel consistency and kernel elongation ratio by method adopted by Azeez and Shafi (1966) were followed.

RESULTS AND DISCUSSION

The mean values of grain quality characters of different aromatic rice varieties/ lines in present study are summarized in Table 1. Among all quality characteristics aroma is considered as most important quality parameter of high quality rice. Aroma development is influenced by both genetic factors and environment. The major aromatic compound responsible for aroma is considered is 2-acetyl-1- pyrroline (Buttery *et al.,* 1983, 1986). In present study aroma ranged from very low to strong. Only one variety *i.e.* kalanamak 3120 show very low aroma, while low aroma was shown by 4 varieties *i.e.* Kalanamak 3215,kalanamak 3259, kalanamak 3114-1 and Bindli 3255. Strong aroma was reported for 11 varieties *i.e* Basmati 370, Dehradun Basmati 3020, Taraori Basmati, Basmati 136, Basmati 127, Hansraj 3072-2, Hansraj 3074, Hansraj 3072-2 U, Hansraj 3074 U and Kalanamak 3131. The remaining 19 varieties showed moderate aroma. According to Lefebvre *et al.,* 2010, the training and recruiting the sensory expert panel are important in the process of sensory analysis and organoleptic tests.

Many cooking and eating characteristics of milled rice are influenced by the ratio of two kinds of starches *i.e* amylose and amylopectin, in rice grain (Rao *et al.*,1952). Amylose content coorelates negatively with taste panel scores for cohesiveness, tenderness, colour and gloss of boiled rice. Among all varieties the amylose concentration ranged from High (01), High-Intermediate (15) to Intermediate (19) category

Table 1: Mean values of grain quality characters of different aromatic rice varieties/lines

Genotype name	PL (mm) L	PB (mm) B	L/B ratio	HR (%)	MR (%)	KL (mm)	KB (mm)	L / B ratio	CKL (mm)	CKB (mm)	ER	GC		GT		AC		Aroma
												GL (mm)	Cat	AS	GT	%	Cat	
Basmati 370	9.75	2.10	4.64	74.25	62.00	6.65	1.75	3.80	12.64	2.15	1.90	63.50	S	4.75	I	25.75	H-I	Strong
Basmati 3054	9.80	2.20	4.45	79.15	55.25	6.75	1.80	3.75	13.48	2.10	2.00	62.00	S	3.50	II-I	24.25	I	Moderate
Basmati 3085	9.25	1.95	4.74	74.00	61.50	6.80	1.75	3.90	13.10	2.20	1.93	91.00	S	2.00	H	24.25	I	Moderate
Dehradun Bas.3020	9.76	2.10	4.64	79.00	65.00	7.00	1.80	3.90	13.10	2.25	1.87	84.50	S	2.25	H	29.50	H-I	Strong
Taraori Basmati	10.10	2.20	4.59	72.50	62.50	7.20	1.80	4.00	14.00	2.25	1.94	82.00	S	4.90	I	30.00	H-I	Strong
Basmati 107	9.70	2.30	4.21	80.00	67.00	7.00	1.80	3.90	12.60	2.05	1.80	83.50	S	1.75	H	27.25	H-I	Moderate
Basmati 136	8.50	2.10	4.05	77.50	66.50	6.25	1.65	3.80	11.25	2.00	1.80	84.50	S	3.00	H-I	26.00	H-I	Strong
Basmati 127	9.45	1.95	4.85	72.00	59.50	6.75	1.70	3.95	12.20	2.05	1.81	47.50	M	4.90	I	22.50	H-I	Strong
Hansraj 3078	10.10	2.10	4.81	76.50	57.50	6.25	1.70	3.67	11.25	2.40	1.80	72.00	S	6.90	L	23.75	I	Strong
Hansraj 3072-2	10.30	2.10	4.90	79.50	58.00	7.20	1.80	4.00	13.65	2.35	1.90	91.50	S	6.75	L	22.75	I	Strong
Hansraj 3072-1	10.15	2.20	4.61	75.50	61.00	7.15	1.75	4.10	13.30	2.05	1.86	39.00	H	6.40	L	22.25	I	Moderate
Hansraj 3067	9.75	2.10	4.64	75.00	60.00	6.45	1.60	4.05	12.50	2.20	1.94	50.00	M	1.95	H	22.75	I	Moderate
Hansraj 3086	9.50	2.10	4.52	76.00	63.50	6.35	1.65	3.85	11.40	2.15	1.80	81.50	S	6.80	L	30.00	H-I	Moderate
Hansraj 3077	9.35	2.00	4.67	75.50	62.75	6.55	1.70	3.85	13.20	2.15	2.00	92.00	S	2.80	H	24.50	I	Moderate
Hansraj 3074	10.10	2.10	4.80	76.00	60.00	6.60	1.65	4.00	12.60	2.15	1.91	42.00	M	2.90	H	21.75	I	Strong
Hansraj 3072-2 U	10.10	2.30	4.40	78.50	61.00	7.10	1.80	3.95	13.40	2.10	1.90	57.00	S	6.30	L	24.25	I	Strong
Hansraj3074 U	9.98	2.10	4.75	73.50	59.50	6.70	1.70	3.95	13.40	2.20	2.00	71.50	S	6.75	L	29.00	H-I	Strong
Kalanamak 3121	7.25	2.10	3.45	77.00	64.50	5.25	1.80	2.90	10.55	2.00	2.01	91.00	S	2.25	H	23.50	I	Moderate
Kalanamak 3215	7.00	2.20	3.18	76.50	66.00	4.40	2.00	2.20	10.10	2.60	2.30	65.00	S	6.50	L	26.50	H-I	Low
Kalanamak 3259	7.10	2.20	3.23	75.50	63.00	4.60	2.00	2.30	10.00	2.80	2.17	65.00	S	6.75	L	23.60	I	Low
Kalanamak 3219	7.00	2.10	3.33	72.00	61.50	5.00	2.00	2.50	9.30	2.40	1.86	60.00	M	6.75	L	23.30	I	Moderate
Kalanamak 3216	6.90	2.15	3.21	74.00	60.50	4.80	1.80	2.67	10.60	2.40	2.21	66.50	S	7.00	L	24.80	I	Moderate
Kalanamak 3120	7.40	2.30	3.22	75.50	63.00	5.60	2.10	2.67	10.80	2.60	1.93	95.00	S	2.50	H	26.80	H-I	Very Low
Kalanamak 3114-1	6.85	2.15	3.19	73.50	61.00	4.90	1.90	2.57	10.60	2.40	2.16	85.00	S	4.50	I	21.70	I	Low
Kalanamak 3131	6.90	2.20	3.14	72.00	59.50	5.00	2.00	2.50	9.40	2.70	1.88	90.00	S	5.00	I	30.80	H	Strong
Kalanamak 3319	6.95	2.15	3.23	73.00	60.00	4.80	1.80	2.67	8.40	2.70	1.75	92.00	S	7.00	L	28.30	H-I	Moderate
Tilak Chandan 3048	7.45	2.30	3.25	81.70	58.50	5.25	1.80	2.90	9.45	2.20	1.80	90.00	S	5.25	I	26.00	H-I	Moderate
Tilak Chandan 3051	7.75	2.60	2.98	79.00	62.50	5.65	2.40	2.35	12.10	2.60	2.14	80.00	S	5.50	I	26.20	H-I	Moderate
Tilak Chandan 3047	7.60	2.60	2.92	77.00	63.00	5.40	2.40	2.25	10.60	2.80	1.96	80.00	S	6.20	L	25.90	H-I	Moderate
Bindli 3193	6.65	2.70	2.46	72.00	65.00	4.40	2.50	1.76	8.80	2.80	2.00	90.0	S	6.50	L	20.60	I	Moderate

Table 1: Contd.....

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Bindli 3192	6.90	2.70	2.56	71.50	63.00	4.60	2.40	1.92	10.60	2.60	2.30	90.0	S	3.50	HI	24.00	I	Moderate
Bindli 3133-2	7.15	2.60	2.75	74.50	64.00	5.10	2.40	2.10	11.00	2.50	2.16	80.0	S	5.25	I	26.00	H-I	Moderate
Bindli 3132-1	6.95	2.65	2.62	71.00	59.50	4.96	2.40	2.00	11.40	2.80	2.30	90.0	S	6.00	L	23.00	I	Moderate
Bindli 3255	6.50	2.70	2.41	68.50	58.00	4.30	2.40	1.80	8.80	2.90	2.05	80.0	S	6.25	L	20.00	I	Low
Bindli 3173	6.95	2.60	2.67	69.00	57.50	4.60	2.40	1.90	8.60	2.80	1.87	80.0	S	6.40	L	24.00	I	Moderate

PB−paddy breadth, HR−hulling recovery, MR−milling recovery, KL−kernel length, KB−kernel breadth, L/B− kernel length/kernel breadth, CKL−cooked kernel length, CKB−cooked kernel breadth, ER=elongation ratio (after cooking), AS=alkali score, GT=gelatinization temperature, GC=gel consistency, GL=gel length, AC=amylose content, cat.=category; L=low; I=intermediate; H-I=high-intermediate; H=high Amylose content codes: I=intermediate (20-25%), H-I=High-Intermediate (25-30%), H=High (>30%),

Aroma codes: Strong (S), Moderate (M), Low (L), Very Low (VL)

Alkali score codes:	Gelatinizing temperature
1	H=High
2	H=High
3	H-I=High-Intermediate
4	I=Intermediate
5	I=Intermediate
6	L–Low
7	L=Low

Gel consistency: Gel length (mm)	Category
0-40	H=hard
41-60	M=Medium
61-100	S=Soft

and it ranged from 30.80 per cent (Kalanamak 3131) to 21.70 per cent (Kalanamak 3114-1). Consumers generally prefer intermediate amylose conc. (20-25 %). The rice varieties are grouped on the basis of their amylose content in to waxy (0-2 %) very low (3-9 %), low (10-19 %), intermediate (20-25 %) and high (>25 %) (Dela Cruz and Khush, 2000). Gel consistency (Fig.4) generally correlates negatively with amylose conc. Gel consistency decides the either rice is soft (gel consistency > 60 mm gel length), flaky (gel consistency 41-60 mm gel length) or hard (gel consistency = 40 mm gel length). Amylose and amyl pectin in kernel determines the texture of cooked rice and consumers prefer rice with intermediate amylose content. Amylose content, starch, gel consistency and non reducing sugars content decreases with elevated temperature (Pandey *et al.*, 2007).In present study it ranged from 95.0 mm (Kalanamk 3120) to 39.0 mm (Hansraj 3072-1). All varieties were grouped in three category *i.e.* soft (30), medium (4) and hard (1) .The gelatinizing temperature of most of varieties/ lines (16) under study was low, remaining were grouped in intermediate (8), high-Intermediate (3) and High (8) gelatinizing temperature Category. This was decided by Alkali Digestion Score (Fig. 3) which ranged from 7.0 (Kalanamak 3216 and Kalanamak 3319) to 1.75 (Basmati 107). Grain quality evaluation of aromatic rice has been reported by Bhonsale (2010) and Bajpai and Singh (2010).

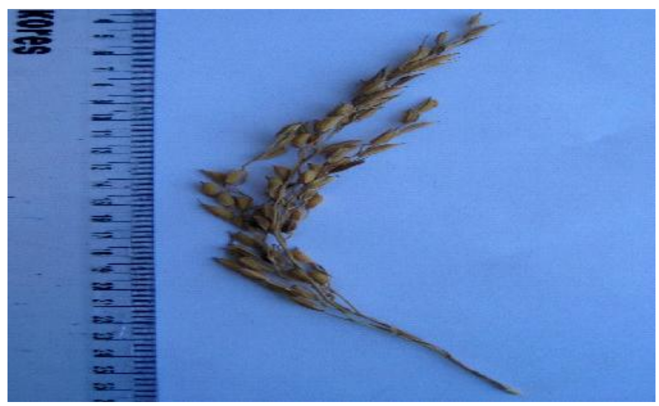

Fig. 1: Panicle size

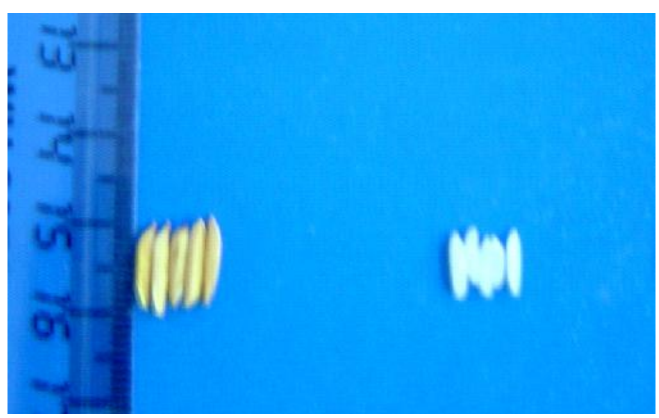

Fig. 2: Cooked kernel elongation

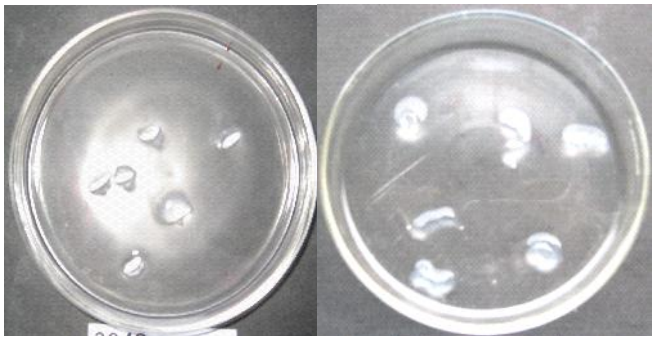

Fig.3: Alkali digestion score analysis

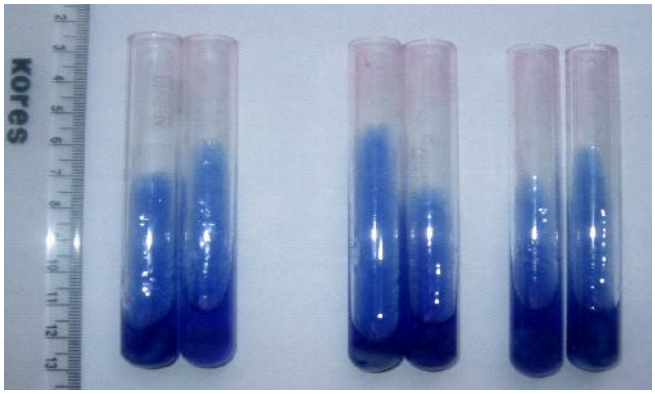

Fig. 4: Gel consistency

The length wise elongation (Fig.2) upon cooking increase in girth is considered most desirable in high quality rice. During cooking rice grains absorb water and increase in length, breadth and volume (Sood, 1978). In present study the kernel length ranged from 7.2 mm (Taraori Basmati) to 4.30 mm (Bindli 3255) and kernel breadth ranged from 2.50 mm (Bindli 3193) to 1.75 mm (Hansraj 3072-1). The L/B ratio of kernel raged from 4.10 (Hansraj 3072-1) to 1.76 (Bindli 3193). According to Dela Cruz and Khush (2000) the L/B ratio decides the shape and category size of rice grain *i.e.* L/B ratio > 3.0 is for slender shape, 2.1 to 3.0 is for medium shape while = 2.0 is called as bold grain. Cooked kernel length was recorded 13.65 mm (Hansraj 3072-2) to 8.40 mm (Kalanamak 3319), while cooked kernel breadth ranged between 2.9 mm (Bindli 3255) to 2.0 mm (Basmati 136, Kalanamak 3121). Elongation ratio was recorded from 2.30 (Kalanamak 3215) to 1.75 (Kalanamak 3319). Milling yield is one of the most important criteria of rice quality especially from marketing point of view. Milling yield of rough rice is the estimate of the quantity of head rice and total milled rice that can be produced from a unit of rough rice. In present study milling yield ranged from 67 per cent (Basmati 107) to55.25 per cent (Basmati 3054). Hulling percentage recorded was 81.70 per cent (Tilak Chandan 3048) to68.50 per cent (Bindli 3255). Paddy length was recorded from 10.30 mm (Hansraj 3072-2) to 6.50 mm (Bindli 3255) and paddy breadth ranged between 2.70 mm (Bindli 3193, Bindli 3192 and Bindli 3255) to 1.95 mm (Basmati 3085, Basmati 107). The L/B ratio of paddy ranged from 4.90 (Hansraj 3072-2) to 2.41 (Bindli 3255). Standard for evaluation of grain length and shape of rice germplasm vary among countries and marketing areas. The quality characterization of newly developed basmati and non-Basmati rice cultivars from cereal chemistry approach and to find correlation between important properties has been recently reported from different parts of India by Bhonsele and Sellappan (2010), Bhonsale, (2010), Bajpai and Singh (2010), and Kaur *et al.* (2011).

The Basmati types are characterized by a harmonious combination of minimum kernel dimensions (kernel length $\geq$ 6.5 mm, length (L) to breadth (B) ratio (L/B ratio) $\geq$ 3), intensity of aroma (medium to strong), texture of cooked rice, high volume expansion during cooking made up by linear kernel elongation ($\geq$ 80%) with minimum breadth-wise swelling, fluffiness, palatability, easy digestibility and longer shelf-life (Singh *et al.,* 2000). The small and medium grain aromatic rices are regarded as separate class Non-Basmati aromatic rices. The Non-Basmati aromatic rices also share one or more of the Basmati characteristics, but not all of them. Generally they have small to medium kernel length but may have similar L/B ratio and kernel elongation rate as that of Basmati types. Many Non-Basmati aromatic rices may surpass Basmati types in all other quality characteristics except kernel length. The Non-Basmati aromatic rices are cultivated in small pockets distributed in different parts of the country particularly in foothills (Singh *et al.,* 2000). Dehradun Basmati is one of the finest quality and most ancient Basmati rice. This variety is still in cultivation in small area comprising of few villages like Seola Kala, Majra, Pithuwala, Bamanwala, Niranjanpur, Seola Khurd, Gangnani and Dudhai Khaddar in district Dehradun. Taraori Basmati is selection from karnal local (HBC 19). It is export quality rice and being cultivated in District Bijnor of U.P. and District U.S. Nagar and Haridwar of Uttarakhand. Hansraj Basmati is a Basmati type and is in cultivation in district Bijnore, Rampur and Pilibhit of U.P. among non-basmati aromatic rices, Kalanamak is the most popular scented rice variety grown in U.P. it is one of the most important scented varieties of India. It derives its name from its black husk. It is grown widely in Tarai area adjoining Nepal. This variety is famous for its taste and aroma. In eastern India it is cooked in honour of guest or given as gift. It is cooking at marriages is considered auspicious and it's smoke is believed to be purifying the atmosphere. Although kalanamak is fast going out of cultivation, it is one indigenous aromatic rice variety which is promoted properly, offers a great promise not only in domestic market but also as an export commodity. It can be boon for farmers of Eastern Uttar Pradesh and Tarai area of Bihar. However, there is need to offer strong research policy and marketing support to promote this cultivar. Tilak Chandan is medium grain variety cultivated in district Bijnore and Rampur of U.P and by few farmers else where for personal consumption. Bindli was once famous aromatic rice variety of

U.P., it is now virtually out of cultivation. Only few farmers grow it as a mixture in plains of Pauri district of Uttarakhand. It can be cultivated under rainfed, irrigated as well as water logged conditions.

Based on this study it was revealed that besides Basmati rice other varieties/ lines in this study *i.e* Hansraj, Kalanamak, Tilak Chandan and Bindli should also promoted by scientists and adopted by more and more farmers and traders so the consumers can get better aromatic rice at lower cost and simultaneously we can maintain our traditional non basmati aromatic rice germplasm.

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REFERENCES

Azeez, M.A. and Shafi, M. (1966). Quality in rice. Department of Agriculture**,** *West Pakistan Technology Bulletin*. No**. 13**: 50**.**

Bajpai, A., Singh, Yogendra (2010). Study of quality characteristics of some small and medium grained aromatic rices of Uttar Pradesh and Uttarakhand. *Agric.Sci.Digest.*,**30** (04): 241-245.

Bhonsale, S.J. (2010). Grain quality evaluation and organoleptic analysis of aromatic rice varieties of Goa, India. *J. Agric. Sci*., **2** (3): 99-107.

Bhonsely, S.J. and Sellappan, K. (2010). Grain quality evaluation of traditionally cultivated rice varieties of Goa, India. *Recent Res. Sci.& Tech.,* **2** (06): 88-97.

Buttery, R.G., Ling, L.C., Juliano, B.O. and Turnbaugh, J.G. (1983). Cooked rice aroma and 2-actyl-1-pyrroline. *J. Agric. Food Chem.,* **31**: 823 - 826.

Buttery, R.G., Ling, L.C. and Mon, T.R. (1986). Quantitative analysis of 2-acetyl-1-pyrroline in rice. *J. Agric. Food Chem.,* **34**: 112-114.

Dela Cruz, N. and Khush, G.S. (2000). In: *Aromatic rices* (Singh, R.K., Singh, U.S. and Khush, G.S., Eds.). Oxford & IBH Publishing Co., NEW DELHI, INDIA. pp. 15-28.

Ghosh, A.K., Nanda, B.B., Govindaswami, S., and Nayak, B.B. (1971). Influence on physiochemical characterstics of rice. *Oryza*. **8**: 87-100.

Husaini, A.M., Parray, G.A., Rather, A.G. and Sanghera, G.S. (2009). Performance of elite basmati rice varieties of sub tropical India under temperate valley conditions of Kashmir, genetic resources. International. Rice Research Notes. pp.117-185.

Juliano, B.O. (1972). Physicochemical properties of starch and protein and their relation to grain quality and nutritional value of rice. In: *Rice breeding*, International Rice Research Institute, Los Banos, Philippines. pp. 389-405.

Juliano, B.O. and Duff, B. (1991). Rice grain quality as an emerging priority in national breeding programs. *In: Rice grain marketing and quality issues*, International Rice Research Institute, Los Banos, Philippines. pp.55-64.

Juliano, B.O. and Villareal, C.P. (1993). *Grain quality evaluation of world rices.* International Rice Research Institute, Los Banos, Philippines. pp.22-31.

Juliano, B.O., Bautista, G.M., Lugay, J.C. and Reyes, A.C. (1964). Studies on the physicochemical properties of rice**.** *J. Agric.Food Chem*., **12**:131-138.

Kaur, S., Panesar, P.S. and Bera, M.B. (2011). Studies on evaluation of grain quality attributes of some basmati and non-Basmati. *J. Food Quality*, **34** (06):435-441.

Khush, G.S. (1997). Origin, dispersal, cultivation and variation of rice. *Plant Mol. Biol.,* **35**: 25 -34.

Khush, G. S. (2000). Taxonomy and origin of rice. In: *Aromatic rices* (Singh R K, Singh U S, and Khush G S, Eds.). Oxford & IBH Publishing Co., NEW DELHI, INDIA. pp. 5-14.

Lefebvre, A., Bassereu, J.F., Pense Lheritier, A.M., Rivere, C., Harris, N. and Duchamp, R. (2010). Recruitment and training of a sensory expert panel to measure the touch of beverage packages: Issues and methods employed. Food Quality & Preferences, **21** (1):156-164.

Little, R. R., Hilder, G.B. and Dawson E.H. (1978). Differential effect of dilute alkali on 25 varieties of milled whole rice. *Cereal.Chem.*, **35**:111-126.

Louis, M.T.B., Robert, J.H., Quinsheng, J., Russell, F.R. and Daniel, L.E.W. (2005). A perfect marker for fragrance genotyping in rice. *Mol. Breed.,* **16**: 279-283.

Pandey, J.P., Archana and Singh, G. (2007). Effect of accelerated aging treatments on physic chemical characterstics of Basmati and non-Basmati rice. *J. Food Sci. & Technol.,* **44** (04): 443-445.

Rao, B. Sanjiva, Vasudeva, A. R. and Subrahmanya, R.S. (1952). The amylose and amylopectin content of rice and their influence on the cooking quality of cereals. *Proc. Indian Acad. Sci*., **368**:70-80.

Singh, Yogendra and Singh,U.S. (2008). Genetic diversity analysis in aromatic rice germplasm using agro- morphological traits. *J. Plant Genet. Res.*, **21** (1):32-37.

Singh, R.K., Singh, U.S., Khush, G.S., Rohilla, R., Singh, J. P., Singh, G. and Shekhar, K.S. (2000). In: *Aromatic rices* (Singh, R K, Singh U S and Khush G S, Eds.). Science Publishers, Inc. Enfield, USA. Oxford & IBH Publishing Co., NEW DELHI, INDIA. pp.155-176.

Singh, Yogendra., Pani, D.R., Pradhan, S.K., Bajpai, A. and Singh U.S. (2008). Divergence analysis for quality traits in some indigenous basmati rice genotypes. *Oryza*, **45**(4): 263-267.

Sood, B.C. (1978). Studies on cooking and nutritive qualities of cultivated rice (*Oryza sativa* L.) with special reference to genetics of kernel elongation, aroma and protein content. Ph. D.Thesis, IARI, NEW DELHI, INDIA.

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