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Varietal differences in quality characteristics of popped rice

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Rice is a versatile cereal and used for consumption in various forms. The three principal rice products of commercial importance which are traditionally being made in India are popped, puffed and flaked rice. Popped rice is a popular product, especially in Asia, because of its crispness and lightness. Hence an investigation was undertaken to study the varietal suitability of rice for popping quality characteristics. Sample of 15 paddy varieties were procured from ARS, Mugad. The physico-chemical parameters, cooking time and gelatinization temperature (GT) of milled rice and popping quality such as popping yield, expansion ratio of popped rice and flake size of popped rice were studied. Physical characteristics of milled rice varieties varied significantly ($P<0.01$). Among the milled rice varieties, the super fine variety Pusa-basumati had the highest length (7.22 mm) and the lowest in Dodiga (5.33 mm) a common grain variety. The L:B ratio for all the varieties of milled rice ranged from 1.89 to 3.68. In the study the popping yield was positively correlated with thousand kernel weight ($r=0.332$), bulk density ($r=0.605$), head rice yield ($r=0.571$), whereas the popping expansion was positively correlated to L:B ratio ($r=0.527$) and no significant correlation was found between popping expansion and amylose content and gelatinization temperature. The expansion ratio of popped rice of Intan found to be maximum at 27.6 per cent total amylose and 13.4 per cent hot water insoluble amylase. In the present study, it was observed that rice varieties Intan, Dodiga Udarsali, Navali, Abhilash, Jaya, Champakali posses good processing quality, exhibit optimum cooking time (19.00 to 23.50 min), high amylose content (27.6-30.6% db) and intermediate gelatinization temperature (70.09° to 72.45°C). Hence, it can be concluded that the rice varieties with high amylose content and intermediate gelatinization temperature are most suitable for good cooking, eating and processing qualities.

Key Words : Popped rice, Flake size, Expansion ratio, Gelatinization temperature, Amylose

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INTRODUCTION

Rice is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the agricultural commodity with third-highest worldwide production (*https://en.m.wikipedia.org>wik> rice*). Rice is a versatile cereal and used for consumption in various forms like, breakfast cereals, noodles, infant and snack foods made by extrusion cooking and other convenience foods (Houston, 1972). The three principal rice products of any commercial importance and which are traditionally being made in India from centuries and still popular are popped, puffed and flaked rice. Popped rice is produced by puffing of raw paddy, when the uncooked endosperm material is suddenly exploded

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through the husk cover under the pressure of steam and the product is very similar in appearance and properties to popcorn.

Rice is predominantly a starchy cereal. About 90 per cent of its dry weight is starch. Varietal differences observed in puffing quality of cereal grains have been ascribed variously to kernel structure, amount and distribution of protein, starch composition, tightness of glumes enveloping the grains, differences in processing condition. The object of the present study was to screen a varietal differences among 15 rice varieties for its popping quality.

METHODOLOGY

Sample of 15 paddy varieties were procured from Agricultural Research Station, Mugad (Plate 1). All the samples were collected at one lot, cleaned, shade dried, stored in closed bins and used for the entire study. Rice samples were obtained by milling in commercial rice mill. The milled rice samples were studied for different physical characteristics. Colour of the milled rice grains were observed and recorded. One thousand kernels of rice were counted and their weights were noted and the volume of same thousand kernel was measured in a measuring cylinder. Density of grain was calculated from thousand kernel weight and volume (Singh *et al.*, 1998).

Kernel measurement *i.e.*, length (L) and breadth (B) of rice were measured as the average length and breadth of 15 kernels and expressed in mm. L:B ratio was obtained by dividing the length of a single kernel by the corresponding breadth (Lorenz and Kulp, 1991).

Rice grains were pulverized in a laboratory model wiley mill and the whole meal was analysed for starch and its fractions. Starch content was analysed by the method of Basarkar and Srinivasan (1997) by hydrolysing the dried defatted flour in perchloric acid.Total and soluble amylose contents of the isolated starch samples were determined according to the method of Sowbhagya and Bhattacharya (1979). The content of amylopectin was calculated by substracting the total amylose from 100.

Amylopectin (% dry basis) = 100 – total amylose content

Different conventional processing methods commonly used for rice *viz*., milling, popping, puffing, flaking were used to evaluate the suitability of rice varieties for specific end use. Milling is an important primary processing method to identify rice grain quality prior to the secondary processing of paddy. Milling quality in rice is based on yield of head rice and total milled rice.

A known quantity of paddy samples were milled in commercial rice mill. The husk and total milled rice were separated and the weights were recorded. The milled fraction was passed through a opening of 14 mesh sieve. The head rice and broken rice were separated and weighed to determine the yield.

Gelatinization temperature of milled rice:

Alkali spreading value (ASV) was used as an indirect method for estimation of gelatinization temperature (GT). Alkali spreading value was determined by the method of (Bhattacharya *et al.*, 1982) using six whole grains, soaked for overnight in 20ml of 1.4 per cent KOH in a 2.8 diameter petridish at room temperature. The disintegration was given a score between 1 and 7, which was used for the following GT classification; low GT (6-7, GT<70°C) intermediate GT (4-5, GT 70°-74°C), higher intermediate GT (3) and high (2, 74.5-80°C).

The popping of paddy varieties carried out as per the traditional process practiced at the local cottage industry (Bhatti).

Popping quality:

Popping yield:

A known quantity of paddy samples were popped as per the traditional method practiced in a local cottage industry. The husk and unpopped paddy were separated from the popped rice by sieving through a 4 mesh sieve. The popped rice, husk and unpopped rice were weighed to determine the yield and expressed as the percentage of respective sample.

Expansion ratio of popped rice

Expansion ratio was determined by measuring the bulk volume of 10g of the original rice and that of the resulting popped rice in graduated cylinder.

Flake size of popped rice :

The flake size determined by the ratio of volume of the popped rice to that of the number of popped kernels.

The data collected in triplicate for all the quality parameters was statistically analysed by using Completely Randomised Design (CRD). The correlation co-efficient among physical characters and chemical composition were determined (Snedecor and Cochran, 1962).

OBSERVATIONS AND ASSESSMENT

Physical characteristics of milled rice varieties varied significantly (P<0.01). Among the milled rice varieties, the super fine variety Pusa-basumati had the highest length (7.22 mm) and the lowest in Dodiga (5.33 mm) a common grain variety. The L:B ratio for all the varieties of milled rice ranged from 1.89 to 3.68. The L:B ratio of milled rice was higher for super fine varieties. The highest thousand kernel weight (24.40 g) and bulk density (0.87 g/ml) was in common grain variety Dodiga. Whereas the highest thousand kernel volume was in fine grain variety Udarsali (29.00 ml) (Table 1). The significant variation among physical dimensions of paddy and milled rice varieties may be due to influence of genetic factor. Malik (1989) also reported a wide variation in grain length (5.20 to 7.10 mm), breadth (1.70 to 2.20 mm) L:B ratio (1.20 to 2.00 mm) of 25 rice varieties. In the present study, the physical dimensions of milled rice kernel were closely related to those of corresponding paddy varieties however, the mean bulk density of milled rice (0.81 g/ml) was found to be greater than the mean bulk density of paddy varieties (0.52 g/ml). Similar results were also observed by Bhattacharya *et al*. (1982), relating the grain breadth and thickness as well as all dimensions of milled rice to those of the corresponding paddy. They also noticed relationship between the bulk density of rice and paddy to grain shape and found that the density of milled rice increased slightly with milling, possibly due to husk percentage.

The chemical composition with respect to starch and its component varied significantly among rice varieties (P<0.01). The rice variety Dodiga (84.04%) had higher starch content, followed by Udarsali (82.10%), Amurth (78.57%), Abhilash (78.10%) and the lowest in Avinash (73.45%). Ramarathnam and Kulkarni (1988) and Singh *et al*. (1998) also observed wide variation in starch content (65 to 72, 61.76 to 77.95 %) of 17 and 6 rice varieties, respectively (Table 2).

There was a significant variation in total amylose content of rice varieties with a range of 25.43 to 32.30 per cent (Table 2). Rice variety Avinash recorded significantly higher total amylose (32.3%) followed by Pusa-basumati (31.73%), Mugad-basumati (31.53%), K-44-1 (31.26%), Udarsali (30.66%) and the lowest in

Table 1 : Physical characteristics of rice varieties

Variety	Length (mm)	Breadth (mm)	L:B ratio	1000 kernel			Colour
				Weight (g)	Volume (ml)	Bulk density (g/ml)	
Navali	6.26	2.53	2.47	20.59	25.00	0.82	White
Dodiga	5.53	2.91	1.89	24.40	28.00	0.87	White
Prasanna	6.64	2.02	3.29	16.62	20.67	0.80	White
Champakali	7.11	2.48	2.75	23.63	27.67	0.85	White
Rasi	5.93	2.33	2.54	18.24	22.00	0.82	White
Intan	6.35	2.26	2.81	18.06	22.00	0.82	White
Udarsali	15	2.53	2.82	23.58	29.00	0.81	White
K-44-1	6.44	2.60	2.47	21.78	27.00	0.80	White
Pusa-basumati	7.22	1.98	3.65	15.67	21.67	0.72	White
Abhilash	7.11	2.53	2.81	23.34	27.00	0.86	White
Mugad-basumati	6.86	1.86	3.68	15.03	20.00	0.75	White
Avinash	6.30	2.51	2.51	17.79	22.00	0.80	Red
Jaya	5.95	2.53	2.35	18.50	22.00	0.83	White
Amruth	6.20	2.20	2.81	17.43	21.00	0.83	Creamy
MTU-1001	5.93	2.33	2.54	15.52	19.00	0.81	White
Mean	6.46	2.37	2.76	19.35	23.60	0.81	
F value	165.28**	268.73**	171.72**	614.86**	246.85**	13.72**	
S.E.±	0.058	0.023	0.051	0.186	0.297	0.014	
C.D. (P=0.01)	0.14	0.06	0.13	0.47	0.76	0.03	

** - The values are significantly different at P=0.01, point of distribution of F

Prasanna (25.43%). Soluble and insoluble amylose content of rice varieties ranged from 12.41 to 20.12 per cent and 11.26 to 16.37 per cent, respectively.

The amylopectin content of rice varieties varied significantly (P<0.01) and ranged from 67.73 to 74.57 per cent. The highest amylopectin content was observed in Prasanna (74.57%) followed by Intan (72.39%), Champakali (71.77%) and the lowest in Avinash (67.73%). A wide variation in total amylose (17.00 to 23.00%) and amylopectins (77.00 to 84.00%) content of 17 unmilled brown rice varieties was also reported by Ramarathnam and Kulkarni (1988) whereas Chandrasekhar and Chattopadhya (1991) observed wide variation in amylose content of 12 paddy varieties (23.95 to 31.55%) and insoluble amylose content (9.22 to 18.78%). Matsue *et al*. (1997) reported a wide variation in total amylose content (9.70 to 26.40%) of Japanese native red kernel and of white kernel cultivars (15.60 to 20.90%). In the study, the L:B ratio of rice varieties and starch and its fractions did not show any significant relation. The present findings were in line with Juliano *et al*. (1964) who reported, a wide variation in total amylose content (2.9 to 31.8%) in 55 milled samples of rough rice and noted that, the length-width ratio of rice and amylose content were not significantly correlated.

Milling quality of rice indicated by total milling yield or head rice yield is expressed as a percentage of rough rice. Varietal difference of rice in grain form, size and weight affect percentage of brokens after milling, that determines milling recovery, percentage of head rice recovery. In the present study significant variation in total milling yield, head rice yield and broken rice yield and husk content among the paddy varieties was observed. The total milling yield of paddy varieties ranged from 67.05 to 79.30 per cent (Table 3). Maximum total milling yield was in Intan (79.30%) followed by Navali (78.30%), Jaya (76.55%), Udarsali (76.00%) and the minimum in Prasanna (67.05%). The mean total milling yield of paddy varieties was 73.56 per cent. The highest husk content was in Prasanna (32.95%) and the lowest was in Intan (20.70%). The head rice and broken rice yield of paddy varieties ranged from 46.56 to 76.95 per cent and 23.05 to 53.44 per cent, respectively. The highest head rice and broken rice recovery was in variety Intan (76.95%) and Pusa-basumati (53.44%), respectively. It was also observed that superfine varieties exhibited maximum percentage of broken rice recovery and husk content. Since milling involves the abrading of kernel against kernel, the longer and thinner kernels would tend to break more easily. Similarly, Goodman and Rao (1984)

Table 2 : Starch, amylose and amylopectin content of rice varieties

Variety	Starch (%)	Amylose (% dry basis)			Amylopectin (%)
		Total	Soluble	Insoluble	
Navali	76.52	30.52	16.45	14.07	69.48
Dodiga	84.04	28.90	15.67	13.23	71.10
Prasanna	74.20	25.43	13.03	12.33	74.57
Champakali	77.10	28.23	15.42	12.85	71.77
Rasi	75.49	28.60	15.24	13.40	71.40
Intan	77.07	27.61	14.36	13.25	72.39
Udarsali	82.10	30.66	17.80	12.86	69.34
K-44-1	75.40	31.26	16.14	15.06	68.74
Pusa-basumati	74.30	31.73	18.05	13.70	68.27
Abhilash	78.10	29.49	16.56	12.90	70.51
Mugad-basumati	76.47	31.53	16.14	15.29	68.47
Avinash	73.45	32.3	20.12	11.26	67.73
Jaya	79.56	28.85	12.41	16.37	71.15
Amruth	78.57	28.70	18.97	12.62	71.30
MTU-1001	75.81	29.48	17.30	12.18	70.52
Mean	77.21	29.70	16.24	13.43	70.43
F value	44.09**	62.10**	1858.63**	736.27**	35.31**
S.E.±	0.62	0.32	0.06	0.06	0.43
C.D. (P=0.01)	1.61	0.83	0.17	0.17	1.11

** - The values are significantly different at P=0.01, point of distribution of F

Table 3 : Milling quality (g/100 g) of rice varieties

Variety	Total milling yield	Husk	Head rice yield	Broken rice
Navali	78.30	21.70	73.05	26.91
Dodiga	73.80	26.20	55.09	44.91
Prasanna	67.05	32.95	53.20	46.80
Champakali	75.80	24.20	68.75	31.25
Rasi	74.40	25.60	64.24	35.76
Intan	79.30	20.70	76.95	23.05
Udarsali	76.00	24.00	65.50	34.50
K-44-1	70.25	29.75	65.98	34.02
Pusa-basumati	69.25	30.75	46.56	53.44
Abhilash	73.80	26.20	72.49	27.51
Mugad-basumati	70.35	29.65	49.60	50.40
Avinash	72.35	27.65	68.65	31.35
Jaya	76.55	23.45	58.10	41.80
Amruth	71.40	28.60	62.43	37.57
MTU-1001	73.90	26.10	67.16	32.84
Mean	73.56	26.41	61.25	38.34
F value	30.63**	110.10**	28.56**	58.13**
S.E.±	0.83	0.75	2.47	4.72
C.D. (P=0.01)	2.15	1.93	6.39	12.17

** - The values are significantly different at P=0.01, point of distribution of F

Table 4 : Gelatinization temperature of rice

Classification	Alkali value	Rice varieties
Low GT (<70°C)	6-7	K-44-1, Pusa-basumati, Mugad-basumati, Avinash, Amruth, MTU-1001
Intermediate GT (70-74°C)	4-5	Navali, Dodiga, Prasanna, Champakali, Rasi, Intan, Udarsali, Abhilash, Jaya
High GT (74.5-81°C)	2	-----

Table 5 : Popping quality of rice varieties

Variety	Popping yield (%)	Husk and unpopped rice (%)	Expansion ratio	Flake size (ml/popped rice)
Navali	69.59	30.41	13.34	0.43
Dodiga	67.90	32.10	10.04	0.36
Prasanna	65.45	34.55	14.70	0.45
Champakali	63.60	36.40	10.40	0.41
Rasi	66.10	33.90	14.18	0.45
Intan	73.38	26.62	20.85	0.57
Udarsali	61.65	38.35	14.50	0.51
K-44-1	64.26	35.74	10.30	0.32
Pusa-basumati	60.70	39.30	12.45	0.36
Abhilash	68.15	31.85	15.25	0.51
Mugad-basumati	56.40	43.60	14.55	0.35
Avinash	58.95	41.05	14.55	0.49
Jaya	64.80	35.20	10.65	0.31
Amruth	67.50	32.50	10.15	0.37
MTU-1001	62.17	37.83	10.14	0.31
Mean	64.70	35.25	13.08	0.41
F value	48.43**	42.75**	7.63**	137.62**
S.E.±	0.78	0.87	3.10	0.009
C.D. (P=0.01)	2.03	2.26	8.02	0.02

** - The values are significantly different at P=0.01, point of distribution of F

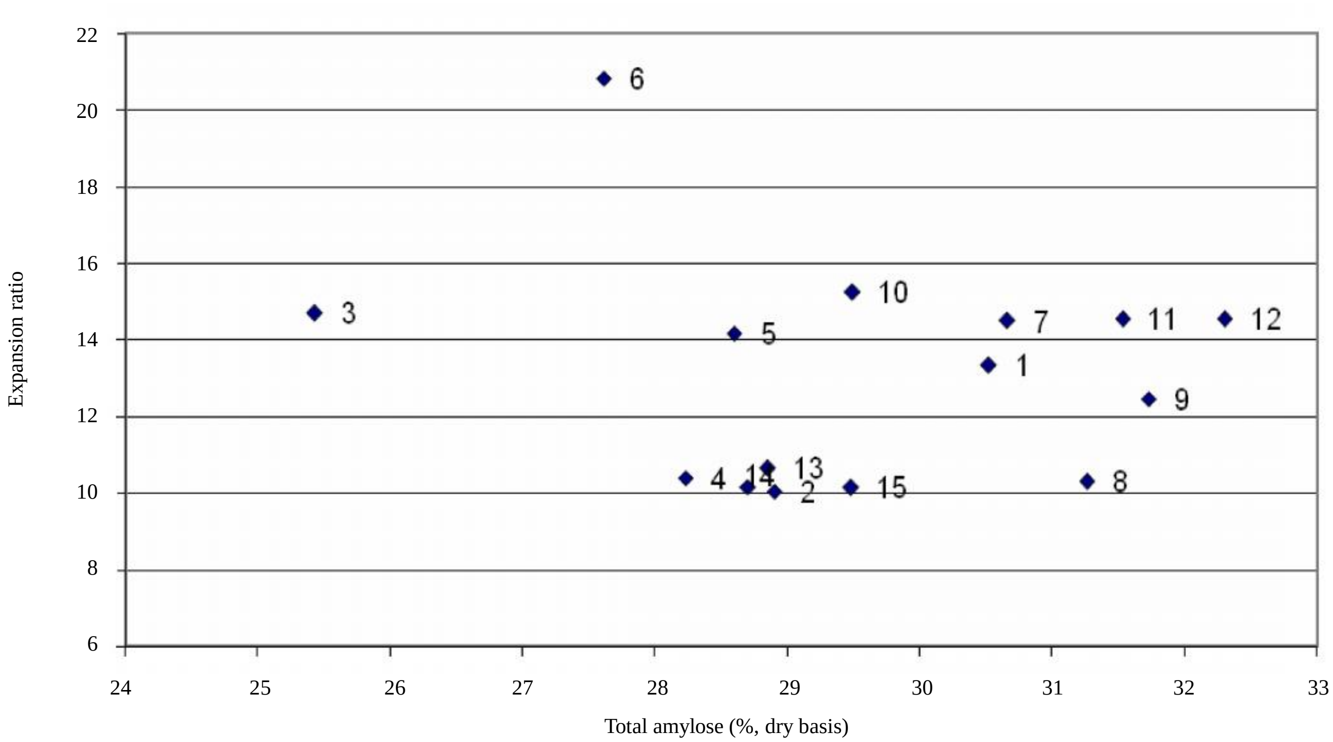

Fig. 1 : Relation between total amvlose content and expansion ratio of paped
(1) Navali, (2) Dodiga, (3) Prasanna, (4) Champakali, (5) Rasi, (6) Intan, (7) Udarsali, (8) K-44-1

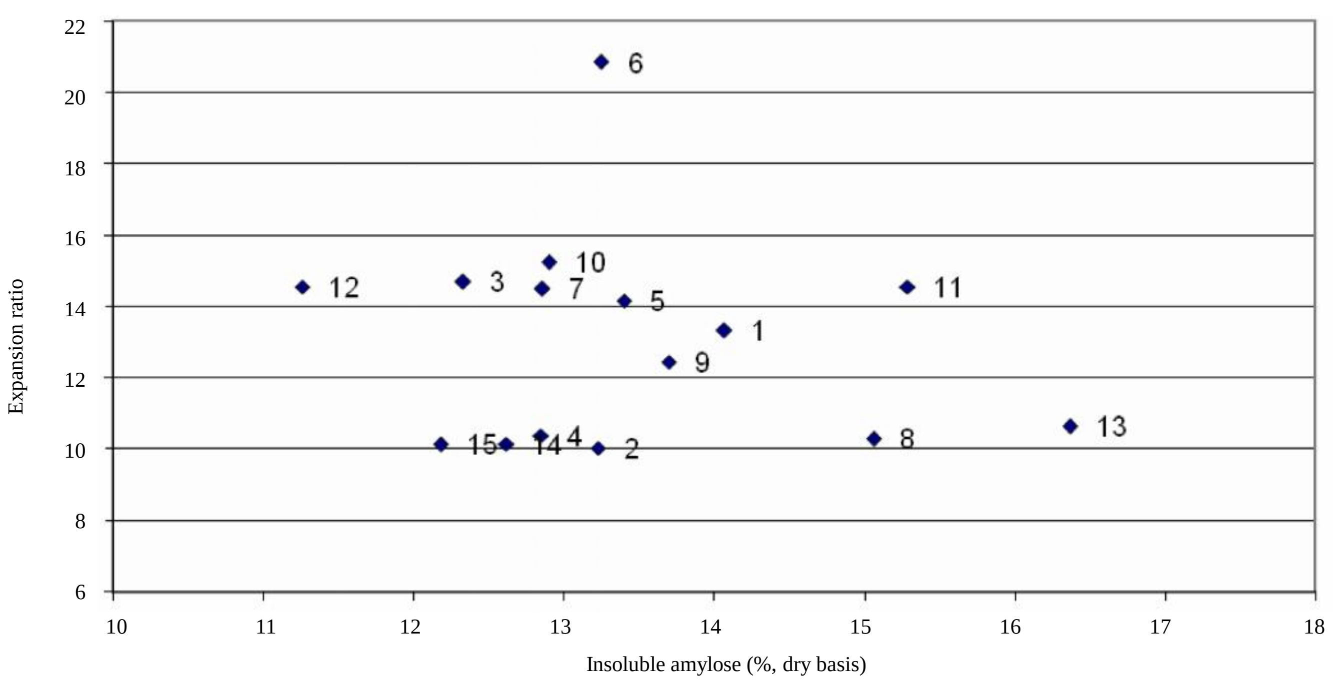

Fig. 2 : Relation between insoluble amvlose content and expansion ratio of paped
(1) Navali, (2) Dodiga, (3) Prasanna, (4) Champakali, (5) Rasi, (6) Intan, (7) Udarsali, (8) K-44-1

Table 6 : Relationship between physico-chemical and processing qualities of rice varieties

Rice quality	L: B	Thousand kernel weight	Bulk density	Total milled rice	Head rice yield	Husk content	Popping yield	Expansion ratio of popped rice	Starch	Amylose	Insoluble amylose	Amylopectin	Gelatinization temperature
L:B	-	-0.554*	-0.781**	-0.531*	-0.504*	0.543*	-0.436	0.527*	0.418	0.0937	0.045	-0.085	-0.235
Thousand kernel weight	-	-	0.679**	0.401	0.406	-0.511*	0.332	-0.167	0.462	-0.035	-0.029	0.025	0.521*
Bulk density	-	-		0.545*	0.626**	-0.554*	0.605**	-0.141	0.518*	-0.478	-0.175	0.468	0.380
Total milled rice	-	-			0.615**	-0.997**	0.582*	0.287	0.416	-0.194	0.038	0.186	0.422
Head rice yield	-	-			-	0.406	0.571*	0.273	-0.008	-0.235	0.413	0.234	0.235
Husk content	-	-					-0.586**	-0.280	-	-	-	-	-
Popping yield	-	-					-	0.274	0.199	-0.584**	0.036	0.573*	0.488
Expansion ratio of popped rice	-	-						-	-0.322	-0.135	-0.173	-0.126	0.159
Starch	-	-							-	-0.144	0.134	0.127	0.134
Amylose	-	-								-	0.161	-0.990**	-0.509*
Insoluble amylose	-	-									-	-0.169	0.310
Amylopectin	-	-										-	0.504*
Gelatinization temperature	-	-											-

observed that long grain type rice had significantly lower head rice yield than either short/medium type of rice. Sulochana and Pillaiyar (1994) also observed that lower husk content in coarse (20.80%) when compared to that in fine (21.90%) and superfine (22.10%) varieties. Sharma and Bains (1979) reported high variability in refractions, head rice recovery and broken rice yield within and between the varieties and also found that the breadth and weight were negatively correlated to husk content. In the present study, the husk content was negatively associated with breadth (r=-0.507) and thousand kernel weight (r=-0.511). Whereas the L:B ratio was positively correlated to husk content (r=0.543) and negatively correlated to head rice yield (r=-0.504), total milled rice yield (r=-0.531). Malik (1989) observed wide variation in brown rice (71.50 to 85.20%), milled rice (68.30 to 75.30%) and head rice (34.80 to 64.80%) recovery of 25 rice varieties and also noted that L:B ratio was inversely associated with head rice recovery. Chen (1983) found that, sudden exposure of rough rice to a relative humidity increase of 30 per cent or more caused a reduction in head rice yield, rice variety and grain type also influenced the loss of grain quality.

Similarly, the gelatinization temperature also achieved significant variation among the rice varieties (Table 4). From the results it was observed that, the gelatinization temperature of rice varieties ranged from 64.95°C to 73.23°C. Among the rice varieties Navali, Dodiga, Champakali, Prasanna, Rasi, Intan, Udarsali, Abhilash and Jaya had intermediate gelatinization temperature (70.09 to 73.23°C) and the rice varieties Pusa-basumati, MTU-1001, Mugad-basumati, K-44-1, Amruth, Avinash showed low gelatinization temperature (64.95° to 69.31°C). Juliano *et al*. (1964) reported that the final gelatinization temperature of 55 milled rice samples ranged from 56.50 to 71.60°C. Chakrabarthy *et al*. (1972) also observed that the varieties CR-1014, CR-200, Basmati, Pachodi, had higher gelatinization temperature (87.00° to 88.50°C) whereas Japonical varieties Taichung-65, Taiwan-3 had lower temperature of gelatinization (81.00°C). In the present study, it was observed that rice varieties Intan, Dodiga Udarsali, Navali, Abhilash, Jaya, Champakali posses good processing quality, exhibit optimum cooking time (19.00 to 23.50 min), high amylose content (27.6-30.6% db) and intermediate gelatinization temperature (70.09° to 72.45°C). The results of the present findings were in accordance with observation of Sivasubramanian *et al*. (1973) reported that, the rice varieties with high amylose content and intermediate gelatinization temperature are most suitable for good cooking, eating and processing qualities.

Popping and puffing quality of paddy varieties were generally assessed for the yield and expansion ratio. In the present study significant variation in popping yield, expansion ratio and flake size of paddy varieties was observed. The popping yield of paddy varieties ranged from 56.4 to 73.38 per cent (Table 5). Maximum popping yield was in Intan (73.88%) followed by Navali (69.59%), Abhilash (68.15%) and the minimum in Mugad-basumati (56.4%). The mean popping yield of paddy varieties was 64.70 per cent. The highest expansion ratio (20.85) and flake size (0.57) of popped rice was observed in rice variety Intan. Grain characteristics may be responsible for varietal variation in popping quality. Srinivas and Desikachar (1973) reported, good puffing varieties have high husk to kernel clearance and thinner aleurone layer at the specific point of bursting, whereas poor puffing varieties have a uniform, thick aleurone layer and a low kernel to husk clearance and the grain was easily shelled. In the study the popping yield was positively correlated with thousand kernel weight (r=0.332), bulk density (r=0.605), head rice yield (r=0.571), whereas the popping expansion was positively correlated to L:B ratio (r=0.527) and no significant correlation was found between popping expansion and amylose content and gelatinization temperature. Srinivas *et al*. (1973) also found that amylose content, gelatinization temperature and protein content appear to be unrelated to puffing expansion. Whereas Chinnaswamy and Bhattacharya (1983) reported that the expansion ratio of puffed rice correlated strongly with amylose content, being maximum at 27 per cent total amylose or 13.5 per cent hot water insoluble amylose, in the present study also the expansion ratio of popped rice of Intan found to be maximum at 27.6 per cent total amylose and 13.4 per cent hot water insoluble amylose (Fig. 1 and 2).

Conclusion:

Thus, from the present study it can be concluded that Grain dimensions, L:B ratio, thousand kernel weight, volume and bulk density, total amylose and hot water insoluble amylose content were strongly related to processing quality of rice varieties. The optimum total amylose content 27.60 per cent and 13.40 per cent (db) hot water insoluble amylose of rice variety were found to be the best combination for better expansion ratio of puffed and popped rice. The rice varieties possessing better milling quality have also exhibited better popping, puffing and flaking qualities. The rice varieties having high amylose content, optimum cooking time and intermediate gelatinization temperature were most suitable for conventional processing.

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