Oryza Vol. 45. No.3, 2008 (230-234)

Effect of degree of polishing on the biochemical and cooking quality of aromatic rice

Kalpana Rayaguru*, J.P. Pandey

Department of Agricultural Processing and Food Engineering, CAET, OUAT, Bhubaneswar-751003, Orissa, India

ABSTRACT

The effect of extended polishing (0 to 105 seconds of polishing at an increment of 15s) and natural aging (0 to 180 days, at an interval of 30 days for paddy and polished rice) on quality aspects of three varieties of aromatic rice viz., Pusa Basmati, Tilak Chandan and Chini Kamini was investigated. The quality attributes included, kernel elongation ratio, volume expansion ratio, solid loss, amylose content, alkali digestion value, gel consistency and aroma. Regression analysis was performed to correlate the degree of polishing with quality parameters of experimented varieties of aromatic rice. The response pattern of all the experimented varieties could be divided into three zones based on degree of polishing. The cooking quality parameters increased at a higher rate in the under polished zone and reached the peak values in well polished zone (8 to 10%).The over polished zone (>10%) showed almost same level of quality attributes. Thus further polishing (higher than 10%) is undesirable and may be uneconomical due to reduced head yield. Therefore the degree of polishing must be specified while expressing the quality of polished rice.

Key words: *Degree of polishing, aromatic rice, cooking quality, biochemical properties*

India possesses the immense wealth of basmati and non-basmati aromatic rice exhibiting a wide variability in morphological characteristics. Among them basmati type is more restrictive to long slender grain with moderate to strong aroma. Accordingly, the small and medium grain aromatic varieties are being regarded as non-basmati aromatic rice. Many of these small and medium grain rice are superior to basmati types in many quality characteristics except for grain length. Though grown in small pockets, they are popular and command premium no less than the traditional basmati rice. Bringing such varieties to the knowledge of consumers abroad would help to find small but assured markets for them. There is a high prospect to expand national export potential of rice and different rice based products. In order to tap the full potential of export market, timely supply of quality standard grains is highly essential (Singh *et al.,* 2000)**.**

Conventional rice polishing practices involve the removal of husk, bran and polish from dried paddy to produce consumer acceptable polished rice. Many consumers dislike the undesirable eating qualities of brown rice due to outer tough and fibrous layer. Degree of polishing, the extent to which the germ and aleurone layers are removed from brown rice leaving the starchy endosperm, is generally estimated by millers through visual inspection. Rice with lower degree of polishing has a greater nutritional value, whereas it has lower market appeal as most of the consumers prefer well polished rice. Therefore, to achieve consumer acceptable quality and higher economic returns during rice polishing operations it is essential to have an optimum degree of polishing (Singh and Singh, 2001). Despite the large number of information published on the composition of rice and rice fractions (Pal *et al.*, 1999, Bajaj and Sidhu, 1985) so far, very little attention has been paid by the research workers to correlate degree of polishing with the resultant cooking characteristics. The trend for awareness of consumers for quality has been increasing for the last two decades. As India has emerged as one of the major exporters of aromatic rice in the international market, it imposes a great responsibility on engineers to provide acceptable variety of aromatic rice having high polishing recovery with better quality characteristics (Juliano and Duff, 1991).

MATERIALS AND METHODS

The experiments were conducted on aromatic paddy varieties Pusa Basmati, Tilak Chandan and Chini Kamini. Pusa Basmati, the number one export quality basmati variety (DRR, 2000) and Tilak Chandan (aromatic non basmati), a popular variety in the northern parts of India were procured from the Department of Plant Breeding and Genetics, Govind Ballav Pant University of Agriculture and Technology, Pantnagar so as to ensure genetic purity whereas Chini Kamini (aromatic non basmati) variety of paddy was collected from Orissa University of Agriculture and Technology, Bhubaneswar. After collection of the freshly harvested paddy, foreign materials such as dust, dirt, chaff etc. were removed using an air screen cleaner. The moisture content of the paddy sample was determined using air oven method. The lots were dried under shade till the moisture content of the paddy came down to 13±0.5% (db). The samples were kept for tempering for 6- 8 hours. The tempered samples were stored in air tight double layered polyethylene bags to avoid any moisture exchange.

The paddy varieties (Pusa Basmati, Tilak Chandan and Chini Kamini) were subjected to extended polishing. A sample size corresponding to 150g of paddy was taken. The polishing process consisted of two operations, dehusking and polishing. Dehusking was carried out in 'Satake' laboratory sheller (Model THW-35, Japan). The gap between the two rubber rolls were so adjusted that the shelling efficiency remained above 95%. The output of the sheller consisted of the brown rice, husk and unhusked paddy which were collected separately in polyethylene bags. The unshelled paddy and broken grains in the brown rice were separated manually and weighed using an electronic digital balance (Model-mettler PM 460). The samples of brown rice were then polished in a 'Satake' rice polisher (Model TM–25, Japan) for 0 to 105s at an interval of 15s. At the end of each operation the polished rice and the bran were collected separately and weighed. Degree of polishing was calculated using the following equation:

Degree of polishing = Wb x 100 / Wbr
Where, Wbr = Weight of brown rice, (g)
Wb = Weight of bran, (g)

The broken grains (less than $3/4^{th}$ the length of the whole rice) were separated manually. The samples from head rice were subjected to cooking quality analysis. The quality attributes included were kernel elongation ratio (KER), volume expansion ratio (VER), solid loss (SL), hot water insoluble amylose content (IAC), gel consistency (GC) and aroma. The optimum levels of degree of polishing were based on the desired polishing and cooking quality indices. Amylose content which is responsible for the texture of cooked rice and plays a major role in influencing the eating quality of polished rice was estimated as suggested by Sowbhagya and Bhattacharya (1971). Kernel elongation ratio is a quantitative trait of lengthwise expansion without increase in girth and is considered highly desirable in basmati rice. It is the ratio of the average length of cooked rice grains to the average length of raw rice grains (Azeez and Shafi, 1966). The volume of raw rice as well as cooked rice was found out by water displacement method as suggested by Sidhu *et al* (1975). Gel consistency is an index of cooked rice texture. The test is based on the consistency of the rice paste viscosity and differentiates among varieties with same amylose content (Cagampang *et al* 1973). It measures the tendency of the gelatinized starch to retrograde on cooling. Amount of total solid loss in cooking water (gruel) was determined using the method recommended by Sidhu *et al* (1975). Due to the lack of a quantitative assay for aroma, the rapid test for aroma determination suggested by Sood and Siddiq, (1978) has been used in the present study. Scoring for aroma was done using the four point scale (0 non scented, 1 slightly scented, 2 moderately scented and 3 strongly scented). Basmati 370, having score 3 was taken as standard for aroma test. Data were subjected to statistical analysis using MS EXCEL. Regression analysis was performed to correlate the degree of polishing with quality parameters of experimented varieties of aromatic rice. Various mathematical models (linear, exponential and quadratic) which could describe the relationship most satisfactorily were attempted. The models showing the correlation coefficient ('r') value more than 0.9 with least associated error were selected.

RESULTS AND DISCUSSION

The classification of different experimented rice was made on the basis of length of kernel and L/B ratio. Accordingly the varieties Pusa Basmati, Tilak Chandan and Chini Kamini were categorized as extra long slender, medium and short bold type (Singh *et al.*, 2000). Cooked rice quality attributes were affected by the polishing process, an essential post harvest practice the rice has to undergo. Table 1 mentions the mean values of cooking quality parameters for varieties Pusa Basmati, Tilak Chandan and Chini Kamini at different degree of polishing. The data indicated that the cooked rice was considerably sensitive to various degree of polishing. The other factor that may affect the cooking properties included paddy variety.

Extended polishing resulted in increase in alkali digestion value from 4.0 to 6.14, 5.0 to 6.71 and 4.0 to 6.43 for Pusa Basmati, Tilak Chandan and Chini Kamini, respectively (Table 1). The maximum percent (60.8%) of increase in alkali digestion value was found in Chini Kamini followed by Pusa Basmati (53.5%) and Tilak Chandan (34.2%). The values for alkali score for experimented varieties fall within the intermediate to low range of gelatinization temperature. Gel consistency value increased from 34 mm to 50 mm, 32.5 mm to 48 mm and 46.0 mm to 57.0 mm for Pusa Basmati, Tilak Chandan and Chini Kamini, respectively. The increase was observed till about 10% degree of polishing. Beyond this the gel consistency remained almost constant.

High kernel elongation ratio is a highly desirable trait in aromatic rice. In Pusa Basmati the kernel elongation ratio increased from 1.179 to 2.248 whereas in case of Tilak Chandan and Chini Kamini it was from 1.159 to 2.094 and 1.041 to 2.022. In all the experimented varieties the kernel elongation ratio increased with increase in extended polishing. But after

Table 1 Quality attributes of polished rice at different degree of polishing

TM second	DP%	KER	VER	SL%	AC%	ADS	GCmm	Aroma
				Pusa Basmati				
0	0	1.18	2.22	5.32	23.00	4.00	34.0	1.0
15	2.21	1.39	2.46	5.38	23.36	4.14	38.5	1.0
30	4.07	1.56	2.68	5.42	23.94	4.57	42.5	2.0
45	6.29	1.77	3.46	5.48	24.61	5.12	46.5	2.0
60	8.17	1.98	4.14	5.61	24.91	5.42	48.0	2.0
75	9.66	2.24	4.12	5.68	25.26	5.86	50.0	2.0
90	11.18	2.24	4.10	5.70	25.34	6.14	50.5	1.0
105	12.41	2.23	4.10	5..71	25.43	6.14	50.0	1.0
CD at 5% LS	0.16	0.21	NS	0.55	0.36	2.10	-	
				Tilak Chandan				
0	0	1.15	1.88	4.93	18.06	5.00	32.5	2.0
15	1.97	1.31	2.16	4.95	18.36	5.14	35.5	2.0
30	3.35	1.65	2.63	4.98	18.86	5.42	38.5	3.0
45	4.68	1.92	3.01	5.12	19.74	5.86	42.0	3.0
60	6.21	2.05	3.47	5.24	20.24	6.42	44.0	3.0
75	7.86	2.08	3.78	5.28	20.65	6.71	47.5	3.0
90	9.53	2.09	3.86	5.37	20.98	6.71	48.5	3.0
105	10.78	2.07	3.82	5.42	21.15	6.71	48.0	2.0
CD at 5% LS	0.12	0.24	NS	0.41	0.22	1.80	-	
				Chini Kamini				
0	0	1.04	1.36	3.46	12.95	4.00	46.0	2.0
15	2.26	1.13	2.02	3.52	13.46	4.29	48.5	3.0
30	4.21	1.48	2.72	3.58	14.42	5.00	51.0	3.0
45	6.32	1.70	3.28	3.84	15.21	5.43	54.0	3.0
60	8.35	1.92	3.62	4.02	15.76	6.28	56.5	3.0
75	10.25	1.98	3.80	4.12	16.12	6.43	57.0	3.0
90	11.32	2.04	3.86	4.15	16.48	6.43	57..5	2.0
105	12.01	2.02	3. 86	4.16	16.64	6.43	57.0	2.0
CD at 5% LS	0.08	0.31	NS	0.48	0.42	2.15	-	

TM=Time of polishing, DP=Degree of polishing about 8 to 10% of degree of polishing the change in the value of kernel elongation ratio was insignificant. The effect of extended polishing on volume expansion ratio was similar to that of kernel elongation ratio. The variety Pusa Basmati showed maximum expansion ratio (4.10) while Tilak Chandan and Chini Kamini showed almost same expansion ratio (3.82) and (3.70).

Solid loss of rice in gruel is a known phenomenon. Solid loss of brown rice at 0% degree of polishing was 5.32%, 4.93% and 3.46%, respectively for Pusa Basmati, Tilak Chandan and Chini Kamini. At 10-12% of polishing the values of solid loss increased by 0.39%, 0.49% and 0.70% for the varieties studied. It indicates that the solid loss was in an increasing trend, though the increase was not found significant.

Amylose content of Pusa Basmati, Tilak Chandan and Chini Kamini varied from 23.0% to 25.43%, 18.06 to 21.15% and 12.95 to 16.64% respectively during 0s polishing to 105s of polishing period. The variation of amylose content may be because of the removal of protein, fat and minerals which are located in the peripheral layers below the seed coat. The concentration of starch increases towards the centre of the rice kernel. As a result, the over polished samples have higher amylose content than the under polished samples.

Various research workers (Buttery *et al.,* 1983, Tsugita 1985-86) have identified that the aroma is generated during the process of cooking. It may be influenced by agroclimatic zone where it is grown. In addition to the field factors, moisture content of rice, polishing, processing and storage conditions might influence the aroma. The aroma test indicated that initially up to 2% degree of polishing, the aroma could not be sensed fully. It was felt only after 2% degree of polishing. This may be due to the fact that the aromatic compounds get expressed only after few layers of bran are removed. The aroma remained highest within the range of 2 to 10% degree of polishing and thereafter it was again reduced. On the basis of aroma, Tilak Chandan and Chini Kamini scored maximum while Pusa Basmati had minimum aroma. But the trend of aroma score with extended polishing remained uniform for all the varieties. This finding supports the past inference that at 12% moisture content the characteristic aroma is less in deep polished rice (Champagne, 1990).

From the experimental data it is observed that the removal of 2 to 6% of bran from the outer fibrous layers of rice resulted in improved cooking qualities. But an acceptable range of cooking properties has been achieved within the range of 8 to 10% degree of polishing (optimum) for all the experimented varieties irrespective of their physical and chemical composition. Above this range the rice samples maintained almost the same values of quality parameters with either less or no improvement. Thus further polishing is undesirable and may be uneconomical from polishing recovery (Rayaguru and Pandey, 2002) and nutritional point of view. The list of selected models from regression analysis is shown in Table 2 along with the correlation coefficient and associated error values. All the cooking attributes were found to be related to degree of polishing in a quadratic manner except the solid loss which showed an exponential relation. All the models are having correlation coefficient more than 0.98 which indicates the validity of the predictions.

Since all the varieties under study showed the similar trend, classifying the range of degree of polishing on the basis of quality responses would be a helpful tool in quick assessment of response pattern. The most commonly used groupings on the basis of degree of polishing are of under polished, polished and over polished type. In the under polished zone the cooking quality parameters increase at a higher rate and reach the desirable values in the well polished zone (8-10% degree of polishing). The over polished zone shows almost a constant level of quality attributes and the values do not differ significantly from those of well polished samples. More precisely the values of the aromatic rice may loose aroma at higher degree of polishing. Thus polishing beyond 8-10% will be uneconomical and inessential. Rice with lower degree of polishing has higher nutritional value but simultaneously fetches a poor market appeal as the desirable cooking qualities do not reach to an acceptable limit. Hence during rice polishing operation the degree of polishing must be optimized for maximum polishing and cooking characteristics with minimum loss, in aroma.

Table 2 Statistical parameters of selected models for quality attributes as influenced by degree of polishing

Model	Corr-Coeff	SEE	a	b	c
Pusa Basmati					
KER =1/(a + b x DM + c x DM^2)	0.994	0.054	0.862	-0.067	0.003
VER =1/(a + b x DM + c x DM^2)	0.983	0.183	0.497	-0.047	0.002
SL = a x exp (b x DM)	0.982	0.032	5.306	0.006	-
AC = a + b x DM + c x DM^2	0.994	0.126	22.87	0.319	-009
ADS =1/(a + b x DM + c x DM^2)	0.985	0.176	0.259	-0.013	0.0004
GC = a + b x DM + c x DM^2	0.997	0.573	33.47	2.575	-0.098
Tilak Chandan					
KER =1/(a + b x DM + c x DM^2)	0.992	0.053	0.873	-0.087	0.005
VER =1/(a + b x DM + c x DM^2)	0.998	0.060	0.554	-0.0631	0.003
SL = a x exp (b x DM)	0.981	0.041	4.884	0.009	-
AC = a + b x DM + c x DM^2	0.987	0.231	17.838	0.418	-0.009
ADS =1/(a + b x DM + c x DM^2)	0.970	0.217	0.210	-0.011	0.0005
GC = a + b x DM + c x DM^2	0.992	0.920	31.14	2.649	-0.095
Chini Kamini					
KER =1/(a + b x DM + c x DM^2)	0.992	0.061	0.989	-0.084	0.004
VER =1/(a + b x DM + c x DM^2)	0.995	0.109	0.663	-0.084	0.004
SL = a x exp (b x DM)	0.982	0.060	3.413	0.017	-
AC = a + b x DM + c x DM^2	0.996	0.142	12.829	0.403	-0.007
ADS =1/(a + b x DM + c x DM^2)	0.991	0.160	0.261	-0.018	0.0007
GC = a + b x DM + c x DM^2	0.992	0.639	45.47	1.721	-0.061

DP=Degree of polishing, %

REFERENCES

Azeez MA, Shafi M 1966. Quality in rice. Deptt. Agric. Govt. West Pakistan Tech. Bull. 13: 50

Bajaj M and Sidhu JS 1985. Extended polishing of Indian rice I: Effect on physicochemical and polishing characteristics. Rice J 87(5): 15-21

Buttery RG, Ling LC, Juliano BO and Turribaugh JG 1983. Cooked rice aroma and 2-acetyl-1-pyrroline. J Agric. Food Chem. 32(4): 823-826

Cagampang GB, Perez CM, Juliano BO 1973. A gel consistency test for eating quality of rice. J. Sci. Food Agric 24: 1589-1594

Champagne ET, Marshall WE and Goynes WR 1990. Effect of degree of polishing and lipid removal on starch gelatinization in the brown rice kernel. Cereal Chem. 67(6): 570-574

Directorate of Rice Research 2001. Basmati Rice: Heritage of India. Hyderabad, DRR report. pp: 28

Juliano BO, Duff B 1991. Rice grain quality as an emerging priority in national breeding programme. In: Rice grain marketing and quality issues, IRRI, Los Banos, Philippines. p 55-64

Pal V, Pandey JP and Sah PC 1999. Effect of degree of polish on proximate composition of polished rice. J. Food Technol. 36(2): 160-162

Rayaguru K and Pandey JP 2002. The influence of extended polishing on the head yield profile of aromatic rice. International Rice Research Notes. 27(2): 35-36

Sidhu JS, Gill MS, Bains GS 1975. Polishing of paddy in relation to yield and quality of rice of different varieties. J Agric Food Chem 23: 1183-1185

Singh H and Singh N 2001. Relationship between Parboiling, degree of polishing, ash distribution and conductivity in rice. J Food Sci. Technol. 38(6): 629-631

Singh RK, Singh US, Khush GS 2000. Aromatic Rices. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi

Sood BC, Siddiq EA 1978. A rapid technique for scent determination in rice. Indian J Genetics Pl. Breed 38: 268-271

Sowbhagya CM and Bhattacharya KR 1971. A simplified colorimetric method for determination of amylose content in rice Staerke 23: 53-56

Tsugita T 1985-86. Aroma of cooked rice. Food review international. 1: 497-520