

QUALITY INDICES IN RICE : A REVIEW

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ABSTRACT

Rice is the prince among cereals and is the staple food in areas of high population density and fast population growth. Nutritive security is as important as food security for the developing countries of tropical Asia in general and India in particular. As such the quality indices in rice play major role in nutritional budgeting of million of Indians as well as Indian economy. It was in this context that recent reviews focussed in detail on the rice quality indices/parameters, the production quality, rice agronomic research accomplishment in the country and present scenario quality rice in the national economy.

Rice (*Oryza sativa* L) is the prince among the cereals and is the major staple food in areas of high population density and fast population growth. Siddique (1996) reported that out of projected food production of 220.5 million tones by 2001-02, rice output is targeted at 94 million tones. Interestingly, rice production has increased four folds from about 20million tones during 1950-51 to about 82 million tones during 1997-98 (Siddique, 1999). Of course, rice will continue to be the mainstay of millions of human population in the centuries to come, in spite of innovative approaches of biotechnology to manufacture alternative food and unquestionably it is the most important food crop, contributing 8 per cent to the cereals and 42 per cent to the total food grain production (Paroda, 1992). It is grown in an area of 42 million hectares under highly diverse agroecological conditions ranging from below sea level in Kuttanad district of Kerala to a height of 2000metrs in high hills under low temperature, parched sloppy hillocks to Rajasthan to a deep water regime of 5-7 meters in West Bengal and problem soils to highly fertile soils under heavy pressure of biotic stress. Considering the increasing demand of rice and the scope of quality rice in the international market, interactive research work in almost all aspects of rice is in progress in the country. It is in this context that details of quality indices in rice and the related researches are presented as under.

Rice grain quality improvement program:
Systemic rice grain quality improvement in the

country started with the introduction of semidwarf high yielding Taichung Native 1 and IR-8 in the mid sixties. A special coordinated trial, "Slender Grain Variety Trial" was started by All India Coordinated Rice Improvement Program (AICRIP) in 1968 in order to select varieties of long slender and medium slender grain types that were also free from abdominal white to insure good milling quality. Later on other program called "Basmati Derivative Trials" was designed specially to develop high quality aromatic lines. Apart from IRRI, Philippines, ICAR through All India Coordinated Rice Improvement Program (AICRIP); Central Rice Research Institute, Cuttack and Central Food Technological Research Institute, Mysore are the, major research institutions engaged in rice grain quality improvement programme.

Rice quality attributing indices/characters/features/parameters : Quality refers to degree of excellence and suitability for specific utility of the plant product. A number of botanical, genetical, chemical, nutritional and processing features are involved in determining the quality features in rice. The main aspects of rice quality indices are the size, shape and appearance of grains; hulling, milling, cooking and nutritional quality and some other special qualities, which include scent, and linear expansion of kernel on cooking. These quality parameters have been reviewed by a number of research workers (Jennings *et al.*, 1979; Chatterjee and Maiti, 1985; Singh, 1993 and Mahendrapal *et al.*, 1996) and these rice quality

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indices are presented in the Tables (1-4). A perusal of Table 1 indicates the shape and size of the rice grains. They are of five types with their

Table 1: Shape and size of grain.

Grain type	Length	L/B ratio
Long slender	6 mm and above	3 and above
Short slender	less than 6 mm	3 and above
Medium slender	less than 6 mm	2.5 to 3.0
Long bold	6 mm and above	less than 3.0
Short bold	less than 6 mm	less than 3.0

respective length varying from less than 6mm to 6mm and above and L/B ratio ranging between less than 2.5 to 3 and above. Long slender grains about 6mm long and 1.6mm breadth with 3.5L/B ratios are reported to be the ideal. Although preferences for grain size and shape vary from region to region but in tropical Asia, most of rice medium to long with some extra long grains is

preferred ones as reported in literature. The rice grain appearance depends upon the following three factors viz., endosperm opacity, amount of the chalkiness (dorsal side i.e. white belly as well as at the center (i.e. White Center) and condition of the eye. Of the three factors enumerated, the appearance of the grain also plays major role in preference of quality rice. Conclusively translucent grains with less chalkiness are highly preferred. Hulling and milling quality has been enumerated in Table 2. Obviously rice grains after harvesting are duly processed. This is rough rice/hull. It is now subjected to hulling which is a process of removing husk from the kernel and the resultant is brown rice. Next process is milling which is also simultaneously the polishing in which bran, embryo and aleurone layer are removed and the resultant is polished white kernel. The remainder consists of unbroken kernels. Unbroken kernel; is also

Table 2 : Hulling and milling quality.

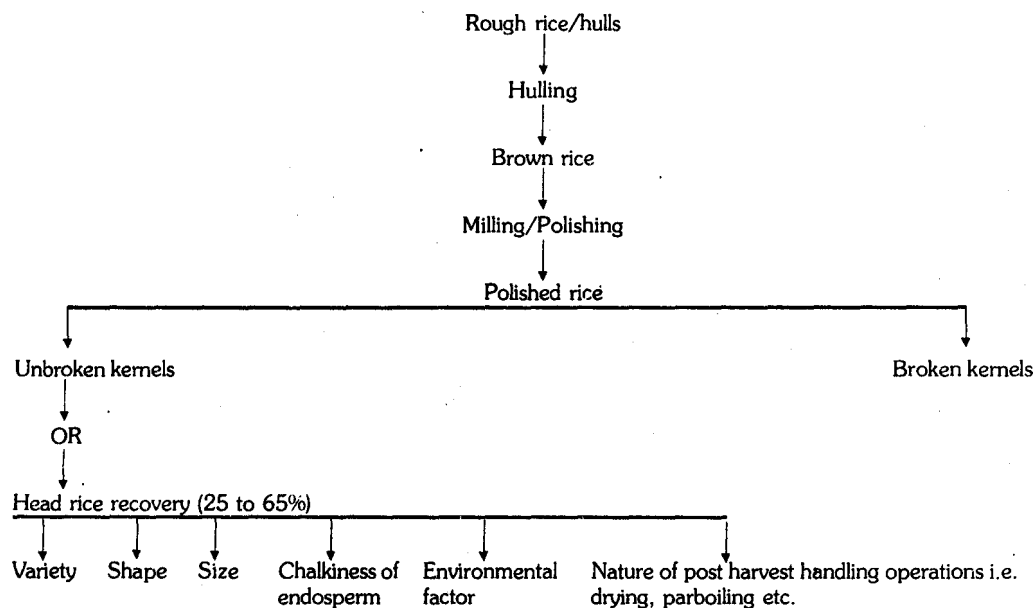


Table 3 : Cooking quality.

Gelatinization temperature of starch	Amylose content	Gel consistency	Volume expansion or kernel expansion	Kernel elongation
Low: 55-69 °C	Low : 10-20%	Hard : 40 mm or less	2.0 to 4.35 times	High degree
Medium: 70-74 °C	Medium : 20-25%	41 to 60 mm	3.7	(10 mm)
High: 75-79 °C	High : 25-30%	>60mm		

termed as head rice recovery, which in general varies from 25 to 65%. The head rice recovery depends upon a number of factors such as variety, shape, size, chalkiness of endosperm, nature of post harvest handling operations and environmental factors mainly being temperature and moisture. As evident from the literature in hulling and milling, polished rice grain with about 40% head rice recovery is the ideal one.

Cooking quality has been mentioned in Table 3. The gelatinization temperature of starch may be low (55-69°C), medium (70-74 °C) and high (75-79°C). The amylose content too may be low, medium and high with their respective ranges of 10-20%, 20-25% and 25-30%. The gel consistency may be hard (40mm or less), medium (41-60mm) and soft (>60mm). The volume expansion/kernel expansion may be between 2.0 to 4.35 times and the kernel elongation after cooking of high degree may reach 10mm. From quality point of view, a polished rice grain with medium gelatinization temperature (70-74 °C), medium amylose content (20-25 %), soft gel consistency of more than 60mm with 3.7 times volume expansion and high degree of kernel elongation upto 10mm is the most preferred one for human preferences.

Nutritional quality has been presented in Table 4. The protein of rice is essentially one of the best among cereals. Main protein in rice is oryzenin. Amino acids are glutamic acid, aspartic acid and arginine. Rice grains are rich in lysine approximately 4% of the protein fraction. The loss of thiamine causes the disease 'beriberi' in human being. In general there is a decreasing trend in all the constituents of milled rice when compared to husked ones and the nutritional quality of rice largely depends on quality of its proteins.

Major research accomplishments :

Nutritive security is as important as the food security for the developing countries, especially tropical Asia and rice is the principal source of dietary energy of tropical Asians. It is in this respect that the prominent research findings on quality rice researches are presented as under. Planting time, seedling age and planting geometry are essential low monetary inputs playing significant role in ensuing higher grain

Table 4 : Nutritional quality.

Constituents(%)	Husked rice	Milled rice
Carbohydrates	77.2	79.4
Fats	2.0	0.3
Proteins	8.9	7.6
Ash	1.9	0.4
Vitamins (ppm)		
Thiamin (B ₁)	3-5	0.6-1.0
Riboflavin(B ₂)	0.8-1.0	0.28
Nicotinic acid (Niacin)	55.0	15.20
Pantothenic acid	17.0	6.4
Minerals (%)		
Calcium	0.084	0.009
Phosphorous	0.290	0.096
Iron	0.002	0.001

yields and better grain quality. From the results (Table 5) it is apparent that maximum values of hulling (77.5%), milling (72%), kernel length before cooking (6.58mm, L/B ratio 3.94), alkali value (5.1-5.2), amylose content (20-23%), water uptake (27%) and volume expansion (5.33) were recorded under July, 15 planting. Only three characters i.e. maximum kernel breadth (1.8mm), kernel length after cooking (11.70mm) and elongation (1.92) appeared to be more under July 25 planting. Delayed transplanting i.e. August 4 recorded the highest head rice recovery (50%). Therefore, considering majority of the quality parameters Kasturi should be planted between July 15 to July 25.

The results of a study on the effect of planting schedule on optimal cooking time (mnts) of raw paddy have been presented in Table 6. The optimal cooking time tended to increase when transplanting was delayed. Apparently the varieties PR 106 and PR 103 took minimum cooking time of approximately 20 minutes, when they were transplanted till June 10. Therefore, for quality purpose rice genotypes should be transplanted from 3rd week of May upto 2nd week of June to have optimal cooking time.

Use of fertilizers of different NPK compositions for ten years (pooled data) influenced the grain protein content and protein fractions (expressed as g/100g sample and g/100g protein) of rice differently (Table 7). The standard dose of N-fertilizer (100kgN/ha) caused significantly the higher true protein (7.40) as compared to the control (7.00). This might be due to higher availability of nitrogen both in plant

Table 5 : Effect of date of planting on grain quality of scented rice variety (Kasturi).

Quality parameters	Date of planting		
	July 15	July 25	August 4
Hulling(%)	77.5	75.5	77.5
Milling(%)	72.0	69.0	71.6
Head rice recovery(%)	30.0	36.0	50.0
Kernel length before cooking (mm)	6.58	5.98	6.55
Kernel breadth (mm)	1.67	1.80	1.71
L/B ratio	3.94	3.32	3.83
Kernel length after cooking (mm)	11.4	11.7	11.1
Elongation ratio	1.78	1.92	1.71
Alkali value	5.1-5.2	2.0-3.9	4.6-4.8
Amylose (%)	20.2	15.9	17.7
Water uptake	2.75	24.5	25.0
Volume expansion	5.35	4.38	3.63
Aroma	-	-	-

Source: Singh and Pillai (1995).

Table 6 : Effect of planting schedule on optimal cooking time (mts) of raw paddy.

Variety	Date of planting							
	May21	May31	June10	June20	June30	July 10	July 20	July 30
PR 106	20.2	20.2	20.4	21.2	21.4	21.5	21.6	22.0
PR 103	19.0	19.0	19.2	19.2	19.5	19.8	20.0	20.2
HM 95	22.5	22.6	22.5	22.5	22.5	23.6	23.0	24.0
IR 8	23.0	23.0	23.2	23.2	23.5	23.5	24.0	24.0
Plaman 579	20.5	20.5	21.0	21.5	21.5	22.5	22.5	23.0

Source: Singh *et al.* (1984).

and in grain for protein synthesis. Addition of phosphorous as 100% NP resulted into significantly highest true protein (9.01) which might be due to stimulating effect of phosphorous for more assimilation of nitrogen. But the addition of potash as 100% NPK reduced the true protein (7.90), which might be probably due to dilution effect of potash. 50 per cent increase to the standard dose as 150% NPK increased insignificantly the true protein (8.10) whereas 5 per cent reduction in dose as 50% NPK reduced significantly the true protein (7.85). Also S-free NPK as 100% -S increased true protein (8.60) insignificantly as compared to the

Table 7. Effect of long term use of different NPK compositions on true protein content and three soluble protein fractions of rice (10 year pooled data).

Treatments	True protein contents	Protein fractions (g/100g sample)			Protein fractions (g/100g sample)		
		Albumin	Globulin	Glutinin	Albumin	Globulin	Glutinin
0% NPK	7.00	0.53	0.57	5.86	7.52	8.04	83.38
100% N	7.40	0.41	0.63	6.27	5.62	8.55	85.86
100% NPK	9.01	0.54	0.64	7.77	6.03	7.04	86.11
100% NPK	7.90	0.48	0.60	6.79	5.99	7.61	85.37
50% NPK	7.85	0.52	0.59	6.64	7.60	7.28	84.16
150% NPK	8.10	0.62	3.59	6.47	6.61	7.54	84.92
100% NPK-S	8.60	0.44	0.65	7.44	5.10	7.52	86.53
CD (Tr) at 5%	0.334	0.032	0.023	0.152	0.40	0.52	0.72

Source: Parida *et al.* (1994).

standard dose viz., 100% NPK. Similarly the variations in protein fractions were also recorded. Conclusively the long-term use of fertilizer of different NPK compositions caused nutrient imbalance resulting variations in true protein and the three protein fractions.

Milling quality in terms of head yield and broken percentage for PR 106, PR 103, and HM

95 with respect to stage of harvesting (time in days after 50% flowering) is shown in figure 1. It is apparent from the figure that the varieties PZR 106 and HM 95 registered head yields of 75 and 73 per cent respectively when harvested 35 days after flowering. PR 103 variety closely followed this trend. Also lowest broken percentage was recorded at the same harvesting date. It is in this

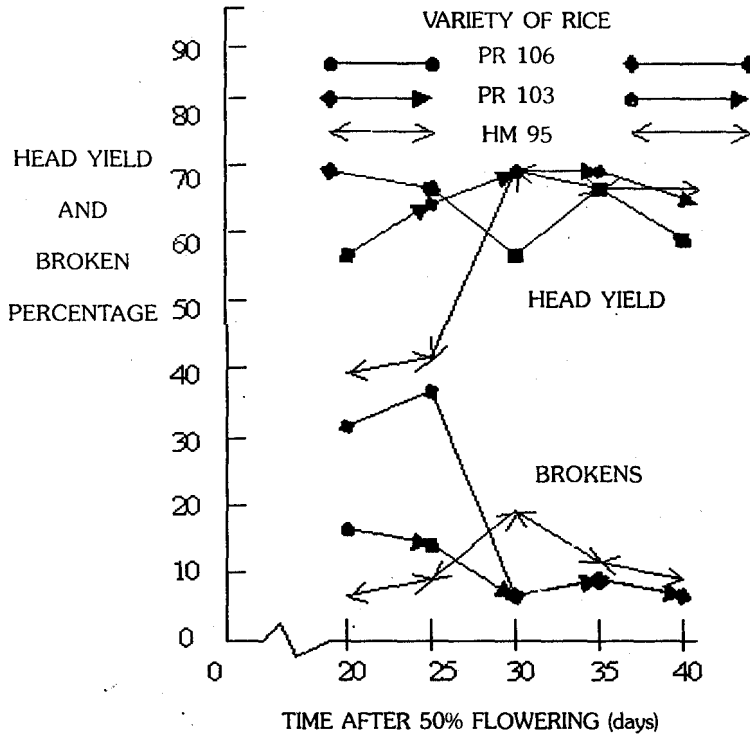


Fig 1 : Effect of time of harvest on milling quality of raw rice
Source : Singh *et al.* (1984).

respect that harvesting is important aspect for achieving higher milling recovery.

Data presented in Table 8 revealed that of the four forms of rice the more was the improvement in appearance the more was the gradual decline in nutritional quality thiamin, riboflavin and niacin. Suggestively refinement ought to be done to have dividend but never the less it must not be at the cost of complete elimination of the three components of vitamin B complex. Results (Table 8B) showed that parboiled milled form of rice exhibited lower loss of vitamin B₁ content both in washing and gruel (25%) as compared to

raw milled form with 55% and 3% in washing and gruel, respectively. As such it was further suggestive that the same should be cooked in a pressure cooker with over all objective of maintaining the rice cooking quality.

Quality indices of recommended rice varieties of Bihar have been tabulated (Table 9). Of the 17 varieties, only Sugandha, Kamod, Kamini and Basmati 370 are reported to be quality rice varieties having aroma present and of these four scented genotypes, only Basmati 370 exhibits the ideal picture. Export quality rice should have slender grain with highest L/B ratio of 3.89 and

Table 8. Rice quality features studies.

(A) Effect of milling on vitamin contents (B complex) of rice grain.					
Form of rice	Thiamin (mg/g)	Riboflavin (mg/g)	Niacin (mg/g)		
Brown (husked but unpolished)	3.55	0.60	53.03		
Parboiled and milled	1.74	0.30	45.00		
Under milled	1.70	0.35	24.40		
White (polished)	0.84	0.26	19.62		
(B) Effect of washing and cooking on thiamin contents of rice grain.					
Form of rice	Initial B ₁ content (mg/g)	Washing water B ₁ content (mg/g)	% loss in washing	B ₁ content in gruel(mg/g)	% loss in gruel
Raw milled	1.1	0.6	55.0	0.25	30
Parboiled milled	2.2	0.2	9.0	1.40	25

Source: Govindaswami (1976).

Table 9 : Quality indices of recommended rice varieties in Bihar.

Variety	Shape, size, & appearance	L/B ratio	Milling (%)	Head rice recovery (%)	Total protein (%)	Amylose content (%)	Kernel expansion	Aroma
Turanta	Medium bold	2.03	65.75	31.71	6.58	20.78	1.42	-
Prabhat	Medium slender	2.50	67.71	48.50	7.26	22.34	1.47	-
Pusa 2-21	Short bold	2.33	64.25	41.90	7.14	21.65	1.39	-
Saket-4	Long bold	3.05	68.12	45.95	7.48	22.31	1.41	-
B.R-34	Medium bold	2.56	69.25	58.36	8.28	23.08	1.52	-
Sita	Long bold	3.25	69.42	53.42	7.62	21.86	1.48	-
Rajshree	Medium bold	2.51	72.41	64.12	8.70	22.21	1.72	-
Kanak	Bold	2.31	67.40	52.67	7.14	21.01	1.38	-
Radha	Bold	2.46	66.75	51.20	7.41	22.43	1.42	-
Shakuntala	Long bold	3.14	68.32	53.14	7.82	19.98	1.39	-
Vaidehi	Bold	2.42	62.42	48.27	8.54	22.50	1.38	-
Sudha	Long bold	3.01	61.05	44.38	8.67	23.17	1.41	-
Gautam	Medium bld	2.33	65.73	41.71	7.62	22.04	1.47	-
Sugandha	Short	1.71	69.83	62.32	8.53	22.75	1.62	Present
Kamod	Short	1.83	68.28	61.07	8.48	21.97	1.71	Present
Kamini	Medium slender	3.02	67.47	58.84	8.62	22.09	1.82	Present
Basmati 370	Slender	3.89	67.95	41.12	8.37	22.14	1.63	Present

Source: Annual Report 1991-1997. All India Co-ordinated Rice Improvement Program, R.A.U.Pusa, Samastipur, Bihar.

maximum kernel expansion (1.63) after cooking along with aromatic smell at the time and after cooking.

Present scenario : Initially in the beginning, the mandate of rice researches was to maximize the yield. But in recent past it has been shifted to quality rice production also. This is only because the quality rice is not only the choice of the millions of people, but significantly it adds to a large extent our national economy and important source of foreign exchange earnings. Mishra (1997) reported that 0.49 million tones of Basmati rices were exported by India to the international market earning a foreign exchange of worth rupees 12 million. The country is earning as high as Rs. 37.84 crore from the

export of around 3.0 million tonnes of rices (both Basmati and Basmati types) according to an estimate upto obvember, 1998 (Anonymous, 1999). Table 10 show twelve year data on export of quality rice from India to foreign countries and foreign exchange earned in the respective years. Although from 1987-88 to 1992-93 and during 1995-96 quantity of export was almost similar but the foreign exchange earnings in general both the quantity of export as well as related foreign earnings had a quantum jump. Interestingly quantity exported increased two folds while exchange earning three folds.

Conclusion and suggestions for future lines of work : Nutritive security is as important as the

Table 10 : Basmati exports from India 1987-88 to 1994-95 (8 years)

Year	Quantity (lakh M.T.)	Value (Rs in crore).
1987-88	3.66	339.95
1988-89	3.50	333.53
1989-90	3.97	412.09
1990-91	2.42	287.31
1991-92	2.29	429.92
1992-93	2.86	699.89
1993-94	5.36	1030.95
1994-95	5.35	1000.00
1995-96*	3.75	560.00
1996-97*	5.10	1250.00
1997-98*	5.95	1650.00
1998-99*	6.05	1890.00

Source: 1. Singhal (1995).

*2. Anonymous (2000).

food security for the developing countries of tropical Asia in general and India in particular. As such the quality indices in rice play a major role in nutritional budgeting of million of Indians as well as countries economy. It was in this context that recent reviews focussed in detail, the rice quality indices/parameters, the production quantity, rice agronomic research

accomplishments in the country and present scenario of quality rice in the national economy. Conclusively components of Basmati quality of rice have been presented. Agronomic researches related to location specific trials with the genotypes showing wide diversity, nitrogen management, date of planting, effect of long term use of fertilizer of different NPK composition, age of the seedlings to be planted, effect of time of harvesting, agronomic trials on other non-monetary inputs and trials on processing of grains do have great bearing on quality rice production and productivity.

While Indian Basmati rices' particularly traditional like Karnal Basmati and Basmati 370 and improved high yielding varieties like Pusa Basmati-1 match well with the quality needs of Basmati importing countries, our research emphasis in future of quality features as presented in Table 11. There is need to provide strong research and policy support to these rices for their commercial exploitation. Simultaneously there is great need of seed production programs of these rices to be further grown by the farmers for export.

Table 11 : Component quality features and their minimum range to quality as Basmati quality of rice.

Component features	Minimum acceptable range
Aroma	Fine appealing smell at the time and after cooking
Cooked rice appearance and texture	Non stiky reparable
Kernel dimensions	
Length(L)	6.5 mm
Breadth(B)	2.0 mm
L/B ratio	3.5
Milling recovery	40 % and above
Alkali spreading and clearing value (27-30°C in 1.7% KOH)	5-6
Water uptake (approx.)	250 ml and above
Volume expansion(approx.)	3.7 and above
Kernel length after cooking	10 mm and above
Elongation ratio	1.5 and above

Source: Khalidi *et al.* (1994).

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