Indian J. Genet., **66**(2): 107-112 (2006)

Physio-chemical and cooking quality characteristics of promising varieties and hybrids in rice (*Oryza sativa* L.)

Asish K. Binodh, R. Kalaiyarasi, K.Thiyagarajan and S. Manonmani

Deptt. of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore 641 003

(Received: October 2005; Revised: May 2006; Accepted: May 2006)

Abstract

Grain quality characteristics of fifty five promising rice (*Oryza sativa* L.) cultures/varieties and hybrids were analyzed for fourteen physiochemical and cooking quality traits and compared with national check variety BPT 5204. Hulling per cent of rice varieties ranged from 49.20 % to 89.50%. Milling out turn for the varieties was satisfactory. All rice hybrids showed high milling out turn and head rice recovery compared to varieties. Head rice out turn of varieties ranged from 27.50% to 67.40%. Length and breadth of reported varieties ranges from 4.0 mm to 7.0 mm and 1.7 mm to 4.0 mm respectively. The highest length/breadth ratio with long slender grain was observed in hybrids TNRH55, TNRH31, ADTRH1 and variety TKM 11and culture PM 01011. The kernel of TP 20001 and CR 1009 were short and bold and remaining 49 varieties were medium slender in nature. Cooking characters *viz.*, elongation ratio of rice varieties ranged from 1.18 to 1.88. High elongation ratio was found in Improved White Ponni (IWP), CR 1009, PMK 2, and ADRH 15. Most of the varieties have high gelatinization temperature and alkali spreading value ranges from 1.0 to 6.60. Rainfed rice varieties and hybrids showed intermediate gelatinization temperature. Gel consistency (GC) of tested entries ranged from 30.0 mm to 170.0 mm. Most of the varieties exhibited soft to medium gel consistency. Amylose content of tested varieties ranged form 18.4% to 28.8%. Amylose content was found to be intermediate in 25 rice varieties and 5 hybrids including the premier quality check variety BPT 5204. The present results revealed that out of 55 rice varieties/cultures and hybrids tested for physio-chemical and cooking properties, 30 varieties showed desirable grain quality parameters. The hybrids TNRH 55, TNRH 31, TNRH 50, ADRH 15, ADTRH 1, varieties ADT 43, ADT(R) 45, ADT(R) 46, MDU 5, PMK 1, ASD 16, and cultures TP 1050, TP 20001 and CB 98004 were identified as most promising for most of the quality characters. These rice varieties could be effectively utilized in quality improvement programme in rice.

Key words: Rice, grain and cooking quality, head rice, amylose content

Introduction

Rice occupies a pivotal place in India's food and livelihood security system. It provides about 75% of the calorie and 55% of the protein in the average daily diet of the people [1]. Traditionally, plant breeders concentrated more on breeding for high yields and pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice. Rice quality is a complex trait comprising many physio-chemical characteristics. All consumers want the best quality that they can afford. With many countries achieving self sufficiency in rice production, the demand by consumer for better quality rice has increased.

Milling out turn is one of the important properties to the millers. The rice millers prefer varieties with high milling and head rice out turn, whereas consumer preference depends on physiochemical, cooking and eating qualities [2]. Head rice recovery varies depending on many factors [3]. Size and shape are also important factors to consumers. Preference for grain size and shape vary from one group of consumer to another [4]. The amylose content of rice is the main parameter of cooking and eating qualities [5]. Amylose content, volume expansion, water absorption influences many of the starch properties of rice [6]. Cooking time is important as it determines tenderness of cooked rice as well as stickiness to a great extent. The higher the imbibitions ratio of rice, the lower will be the energy content per unit volume or weight of cooked rice as they will have more water and less solid materials [7].

Rice production technologies regarding high yielding varieties are now well developed in most of the countries in Asia for maximum production. Hence it is need of the hour to develop rice varieties with high yield with improved quality. It is urgently needed to characterize the promising rice cultures and already released varieties in rice regard to their physio-chemical properties. Thus, the knowledge may be utilized for devising breeding strategy to their improvement for yield keeping intact their physio-chemical characteristics.

In this article efforts have been made to present the results of 55 rice lines for 14 physio-chemical and cooking quality parameters.

Materials and methods

Materials: The materials for the present study were rice grains of different duration groups of promising rice cultures, varieties and hybrids of Tamil Nadu. A total of 55 rice cultures/varieties *viz.*, 9 early varieties (6 cultures + 3 varieties), 6 mid early varieties (3 cultures + 3 varieties), 11 medium varieties (7 cultures + 4 varieties), 7 long duration varieties (4 cultures + 3 varieties), 10 rain fed varieties (4 cultures + 6 varieties), 3 quality rice cultures, 6 hybrids and 3 varieties (Table 1) were evaluated for 14 physio chemical and cooking properties in rice during the year 2003-2004. Analysis was carried out at rice quality lab at Dept. of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. The premier quality rice variety BPT5204 was taken as standard check for all traits.

Methods: Standard evaluation system/methods were followed for evaluation.

Physical characters

Kernel length measurement: On the basis of average length, kernels were classified as follows

Size	Length (mm)
Extra long	> 7.50
Long	6.61-7.50
Medium	5.51-6.60
Short	< 5.50

Kernel length/breadth ratio: The ratio of kernel length and kernel breadth was worked out. Based on the ratio, the following categories were made for grain shape.

Shape	L/B ratio
Slender	> 3.0
Medium	2.1-3.0
Bold	1.1-2.0
Round	< 1.0

Cooking qualities

Linear elongation ratio: The ratio of mean length of cooked rice to mean length of milled rice was computed as linear elongation ratio [8].

Chemical characters

Gelatinization temperature: Gelatinization Temperature (GT) was estimated based on alkali spreading score (ASS) of milled rice [9]. The appearance and disintegration of kernels was rated visually based on the following 7 point numerical spreading scale.

Kernel with a score of 5.5-7.0 was classified as low GT (55-69^{o}C), 3.5-5.4 as intermediate GT (69-74^{o}C), 2.6-3.4 as intermediate to high GT and 1.0-2.5 as high GT (74.5^{o}C-80^{o}C) types.

Score	Spreading	Alkali digestion
1	Kernel not affected	Low
2	Kernel swollen	Low
3	Kernel swollen, collar incomplete or narrow	Low/Intermediate
4	Kernel swollen, collar complete or wide	Intermediate
5	Kernel split or segmented, collar complete and wide	Intermediate
6	Kernel dispersed, merged with collar	High
7	Kernel completely dispersed	High

Amylose content: Simplified procedure of Juliano [10] was used for the estimation of amylose content. Based on amylose content milled rice was classified [5] as follows

Waxy	1-2%	amylose
Very low	> 2-9%	amylose
Low	> 9-20%	amylose
Intermediate	> 20-25%	amylose
High	> 25-33%	amylose

Gel consistency test: Gel consistency was analyzed based on the method described [11].

The test classified the rice into three categories

1. Very flaky rice with hard gel consistency (length of gel – < 40 mm)
2. Flaky rice with medium gel consistency (length of gel 40-60 mm)
3. Soft rice with soft gel consistency (length of gel – > 60 mm)

Results and discussion

Milling characteristics of rice varieties: The hulling per cent ranged from 49.2 % (ADT 42) to 89.50% (TKM 12). Based on the recommendation of [12], the results showed that rice varieties TKM 12, TKM 11, ADT (R) 45, PMK 1, ADT 43, ASD 16 and hybrids TNRH 55, TNRH 31, CORH 2 and culture CB98004 exhibited high hulling per cent (Table 1). Milling per cent ranged from 38.6% to 78.8%. Out of 55 varieties analyzed, 23 rice cultures/varieties exhibited high milling out-turn. Milling out turn is the measure of rough rice recovery during milling. Among seven groups of rice cultures analyzed, all the hybrids showed high milling out turn. Milling per cent was high in hybrids TNRH 55, TNRH 31, ADTRH 1, TNRH 50, CORH 2, varieties ASD 16, ADT(R) 45 and culture AS 00004. The milling out turn of modern rice varieties ranges from 69-73% [13]. Head rice out turn is the proportion of the whole grain in milled rice. It varies depending on the variety, grain type, cultural practices and drying condition [14]. Highest head rice recovery was observed in ADT(R) 45 (67.40%)

higher than the check variety BPT 5204 (53.90%) followed by ADT 43 (61.10%), mid early group variety ASD 16 (56.40%), PMK(R) 3 (55.80%) and rainfed culture CB (MAS 1) 20001 (54.00%) and hybrid TNRH 55 (54.00%). A good rice variety should have head rice out turn of atleast 45 per cent. A total of 24 genotypes exhibited more than 45% head rice recovery and all hybrids showed satisfactory head rice recovery (Table 1). Rainfed varieties *viz.*, CB (MAS1) 20001, PMK 1, PMK 2, PMK(R) 3, MDU 5, TKM 12 and early group varieties *viz.*, AS 00004, TP 20001, TP 1050 and ADT 43 exhibited high head rice recovery.

Physical characteristics of rice varieties: Grain length, shape, size and uniformity determine the consumer preference. Highest kernel length of 7.0mm was observed in hybrid TNRH 55 followed by TNRH 31(6.7mm) while lowest length of kernel was observed in ADT 42 (4.0 mm) (Table 1). Kernel of TNRH 55, TNRH 31, ADTRH 1 and PM 01011 were long slender while those of TP 20001 and CR1009 were short and bold. Among the 55 rice cultures/varieties analyzed, 19 genotypes belong to medium size. Highest length breadth ratios were observed in MDU 5 (3.7), followed by ADT 38 (3.61), ADT (R) 46 (3.55), PM 01011 (3.52), TNRH 55 (3.5), ADTRH 1 (3.35), PM 0200022 (3.25), CB (MAS1) 20001 (3.1). Consumer's preference for grain size and shape vary from region to region. Most of the rice cultures/varieties are short to medium slender. Length and breadth of the genotypes analyzed in the study ranged from 4.0 mm to 7.0 mm and 1.7 mm to 4.0 mm respectively. The highest length breadth ratio was observed in hybrids TNRH 55, TNRH 31 and ADTRH 1.

Cooking characteristics of rice cultures/varieties: Elongation ratio of the test entries ranged from 1.18 in CORH 2 to 1.88 in ADRH 15 (Table 1). It is an important parameter for cooked rice. If rice elongates more lengthwise it gives a finer appearance and it expands girth wise, it gives coarse look. The elongation ratio was high in ADRH 15, CR1009 (1.88) followed by PMK 2 (1.81) and Improved White Ponni (1.81). The volume expansion ratio of most of the tested varieties was more than 4 and it is considered as a positive quality feature especially for the lower income group for whom quantity is important criteria. However, higher the volume expansion ratio of rice, lower will be the energy content per unit per volume or weight of cooked rice as they will have more water and less solid materials. Similar results for volume expansion were reported [14]. Volume expansion of the tested entries ranged from 2.4 (MDU 5) to 6.20 (IR 64). Among the seven groups of rice varieties analyzed all rice varieties/cultures belongs to early duration, mid-early duration and hybrids showed volume expansion more than 4 which indicated that there is scope for exploitation of imbition ratio in the above group for quality improvement programme. Kernel breadth after cooking was low in ADT 42 and BPT 5204 (2.0 mm) and < 2 mm of breadth of cooked rice is desirable feature. None of the varieties exhibited < 2 mm of breadth of cooked rice.

Chemical characteristics of varieties/cultures: Alkali spreading value of varieties ranged from 1.0 to 6.6 (Table 1). Highest alkali spreading value was observed in three varieties *viz.*, ADT(R) 46, PMK(R) 3, and MDU 5 while lowest alkali spreading value was observed in as many as forty rice varieties. Low gelatinization temperature among the waxy rice has been reported [15]. High alkali spreading value corresponded to low gelatinization temperature. The results showed that most of varieties required high temperature (74.5°C-80°C) for cooking. Varieties with intermediate gelatinization temperature are desirable. Intermediate gelatinization temperature was observed in TP 20001 (5.3), ADT 44 (5.4), PM 01011 (5.1), PMK 1(5.3), TKM 11 (5.2), TKM 12 (5.3), TNRH 50 (5.3), TNRH 31 (5.1), TNRH 55 (5.3). The check variety BPT 5204 exhibited intermediate GT with alkali spreading value of 5.1. Varieties with high amylose content cook dry, less tender, and become hard upon cooling. In contrast, low amylose rice varieties cook moist and sticky. Intermediate amylose is most preferred in India. Amylose content of tested varieties ranged from 18.4% to 28.8%. Amylose content is the major factor for eating quality in rice [16]. It is an indicator of volume expansion and water absorption during cooking, and correlates with hardness, whiteness, and dullness of cooked rice. Intermediate amylose content was observed in 25 rice varieties comprising of 5 in early duration group, 4 in mid early group, 6 in medium group, 4 in long duration group, 1 quality rice group and 5 in hybrid group. The check variety BPT 5204 exhibited intermediate amylose content (24.3%).

Amylose content of rice determines the hardness or stickiness of cooked rice. Higher amylose content (>25%) gives non sticky soft or hard cooked rice. Rice varieties having 20-25% amylose give soft and flaky cooked rice. Rice hybrids *viz.*, TNRH 31, TNRH 55, CORH 2 and ADTRH 1 and early duration cultures AD 99110, AD 00119, AS 00004, TP1050 and ADT(R) 45 exhibited intermediate amylose content (Table 1).

Gel consistency of tested varieties ranged from 30.0 mm (TP 1038) to 170.0 mm ADT(R) 46 (Table 1). Interestingly the result showed that more than 35 varieties exhibited soft gel consistency while 15 varieties had medium gel consistency. The tested varieties showed satisfactory soft gel consistency. Soft gel

Table 1. Physio-chemical and cooking quality properties of rice cultures/varieties/hybrids

Entries/Characters	Hulling %	Milling %	HRR (%)	KL (mm)	KB (mm)	L/B ratio	KLAC (mm)	KBAC (mm)	LE ratio	BE ratio	VE	GT	GC (mm)	AC (%)
Early duration														
AD 99110	67.40	50.50	46.40	5.0	2.2	2.27	7.3	2.5	1.46	1.14	5.6	1.0	90.0	20.4
AD 00119	58.70	53.80	34.30	5.8	2.0	2.90	8.1	2.7	1.39	1.35	4.7	1.6	90.0	22.4
AD 00141	69.60	62.40	44.20	5.4	2.2	2.45	8.3	3.3	1.53	1.50	4.7	5.6	80.0	19.2
AS 00004	74.90	70.00	51.40	5.5	2.7	2.07	8.0	3.6	1.42	1.33	4.9	1.0	123.0	21.6
TP 20001	72.70	66.80	51.10	4.5	2.6	1.73	7.5	2.7	1.66	1.03	4.7	5.3	85.0	19.6
TP 1050	74.30	65.60	53.10	5.8	2.4	2.41	8.5	3.1	1.46	1.29	5.7	1.3	150.0	22.4
ADT 43	76.40	63.60	61.10	5.5	1.9	2.84	7.5	2.8	1.38	1.47	5.5	1.0	70.0	28.0
ADT(R) 45	78.40	70.50	67.40	5.5	2.0	2.75	8.0	2.8	1.45	1.40	5.9	1.0	87.0	24.0
Co 47	56.10	47.30	37.00	4.8	1.8	2.66	8.2	2.8	1.70	1.55	5.5	1.6	137.0	26.4
Mid-Early duration														
TP 1121	63.30	58.90	31.30	5.4	2.0	2.70	7.4	2.0	1.37	1.00	5.8	1.3	92.0	24.8
CB 98004	75.40	49.50	40.30	5.5	2.0	2.75	7.9	2.4	1.60	1.26	5.0	1.3	131.0	21.4
CB 20021	70.40	57.20	48.60	5.1	2.0	2.55	8.3	2.4	1.63	1.20	5.8	1.0	123.0	25.6
ASD 16	75.30	72.70	56.40	5.6	2.7	2.07	8.1	3.1	1.45	1.15	4.2	1.6	42.0	26.4
ADT 42	49.70	38.60	30.10	4.0	1.8	2.32	5.2	2.0	1.35	1.16	3.8	1.3	60.0	20.8
IR 64	70.60	66.10	44.10	6.5	2.2	2.45	9.0	2.6	1.38	1.18	6.2	4.8	42.0	24.8
Medium duration														
AS 00044	63.80	58.40	28.70	6.1	4.0	1.52	8.7	2.5	1.42	0.63	3.2	1.3	150.0	27.2
AD 99217	71.60	65.00	40.90	5.4	2.0	2.70	8.8	2.5	1.62	1.25	4.0	1.6	121.0	24.8
AD 99218	69.40	58.80	32.70	5.0	2.0	2.50	7.9	2.6	1.58	1.30	5.2	1.6	85.0	23.6
CB 99019	57.80	51.40	48.60	5.2	2.0	2.60	8.5	2.3	1.63	1.15	4.2	1.3	35.0	21.2
CB 20090	70.40	65.10	53.30	5.6	2.2	2.54	7.8	2.7	1.39	1.22	3.8	1.3	55.0	25.2
CB 20035	70.80	63.50	53.60	5.0	2.1	2.38	7.3	2.3	1.46	1.09	3.4	1.0	76.0	26.4
AD 00194	72.58	64.93	37.51	5.6	2.0	2.82	8.6	2.4	1.53	1.18	4.2	1.3	56.3	23.6
IWP	64.10	58.00	44.80	5.3	2.0	2.65	9.6	2.3	1.81	1.15	5.8	1.0	32.0	29.6
ADT(R) 46	73.60	68.30	48.90	6.4	1.8	3.55	10.2	2.6	1.59	1.44	4.2	6.6	170.0	23.6
ADT 38	65.80	60.00	46.60	6.5	1.8	3.61	8.5	2.5	1.31	1.38	3.8	1.0	36.0	23.6
BPT 5204	59.10	56.20	53.90	4.9	1.9	2.57	7.9	2.0	1.61	1.05	4.1	5.1	57.0	22.4
Long duration														
TP 1038	61.50	52.30	42.40	5.3	2.0	2.65	8.6	2.7	1.62	1.35	3.5	1.3	30.0	21.2
KR 99001	69.50	62.00	37.50	5.5	2.2	2.50	7.5	2.3	1.36	1.04	3.8	1.0	90.0	24.4
CR 1009	71.30	63.00	27.60	4.4	2.3	1.91	8.3	2.2	1.88	0.95	4.6	1.0	42.0	25.6
AD 99001	71.60	65.00	40.90	5.4	2.0	2.70	8.8	2.5	1.62	1.25	4.0	1.6	121.0	24.8
Swarna	69.70	62.30	32.50	5.1	2.1	2.42	7.5	2.4	1.47	1.14	3.8	1.3	85.0	25.2
ADT 44	70.60	62.60	50.10	5.7	2.3	2.47	10.2	2.8	1.79	1.21	4.5	5.4	48.4	23.6
BPT 5204	59.10	56.20	53.90	4.9	1.9	2.57	7.9	2.0	1.42	1.05	4.1	5.1	57.0	22.4
PM 01011	63.70	58.20	52.90	6.7	1.9	3.52	9.0	2.5	1.62	1.31	3.9	5.1	37.0	28.4
PM 01010	60.90	50.00	42.90	5.6	2.1	2.66	7.4	2.6	1.58	1.24	3.5	1.3	35.0	28.8
PM 0200022	52.50	48.10	37.80	6.5	2.0	3.25	8.6	2.4	1.63	0.37	2.5	1.6	35.0	28.4
CB (MAS 1) 20001	72.50	64.00	54.00	6.2	2.0	3.10	8.6	2.8	1.39	1.40	3.9	1.3	110.0	27.2
PMK 1	77.00	69.70	50.30	5.6	2.1	2.66	7.5	3.0	1.46	1.43	3.2	5.3	107.0	19.6
PMK 2	62.40	57.50	50.00	5.5	2.5	2.20	7.5	2.7	1.81	1.08	3.8	5.6	152.0	18.4
PMK (R) 3	70.00	63.60	55.80	6.2	2.3	2.61	9.5	3.0	1.59	1.30	4.2	5.5	131.0	27.6
MDU 5	71.10	65.90	48.40	6.3	1.7	3.70	8.0	2.7	1.31	1.58	2.4	6.1	51.0	28.0
TKM 11	82.70	54.80	43.10	7.5	2.3	3.20	7.2	2.7	1.61	1.35	3.2	5.2	64.0	19.2
TKM 12	89.50	63.30	47.80	6.5	2.5	2.60	6.0	2.6	1.62	1.18	3.2	5.3	40.0	19.6
Quality rice														
TP 1021	63.79	59.83	31.28	5.5	2.1	2.69	7.3	2.0	1.46	1.01	5.8	1.3	92.2	25.0
TP 1028	69.80	63.03	32.95	5.1	2.1	2.45	7.3	2.4	1.43	1.15	3.8	1.3	85.3	25.5
ACK 99017	71.54	63.01	37.76	5.4	2.0	2.70	8.3	2.3	1.54	1.17	4.6	1.5	111.5	24.8
Hybrids														
TNRH 50	74.80	70.60	51.50	6.2	2.1	2.95	9.5	2.9	1.36	1.40	4.5	5.3	58.0	28.4
ADRH 15	67.85	62.50	48.70	5.3	2.0	2.65	8.7	2.5	1.88	1.20	4.6	1.3	56.0	28.8
ADTRH 1	74.80	71.10	48.60	6.7	2.0	3.35	11.0	2.2	1.47	1.10	4.3	1.3	60.0	24.6
ADT 43	76.40	63.60	61.10	5.5	1.9	2.84	7.5	2.8	1.79	1.47	5.5	1.0	70.0	28.0
ADT(R) 45	78.40	70.50	67.40	5.5	2.0	2.75	8.0	2.8	1.45	1.40	5.9	1.0	87.0	24.0
TNRH 31	80.80	75.80	42.60	6.7	2.1	3.19	9.8	2.9	1.46	1.38	4.3	5.1	64.0	24.8
TNRH 55	83.20	78.80	54.00	7.0	2.0	3.50	10.5	2.7	1.50	1.35	4.8	5.3	58.0	23.6
CORH 2	75.60	70.20	51.60	6.1	2.4	2.54	7.2	2.9	1.18	1.21	5.3	1.6	46.0	23.2
BPT 5204	59.10	56.20	53.90	4.9	1.9	2.57	7.9	2.0	1.61	1.05	4.1	5.1	57.0	22.4
Mean	69.52	61.58	46.10	5.6	2.1	2.68	8.2	2.6	1.53	1.22	4.4	2.6	79.2	24.3
Range	49.70-89.50	38.6-78.8	27.6-67.4	4.0-7.5	1.7-4.0	1.52-3.70	5.2-11.0	2.0-3.6	1.18-1.88	0.37-1.58	2.4-6.2	1.0-6.6	30-170	18.4-28.8
SE	1.96	1.06	0.74	0.09	0.04	0.04	0.14	0.04	0.03	0.02	0.07	0.05	1.42	0.40

HRR - Head rice recovery, KBAC - Kernal Breadth after cooking, VE - Volume expansion, KL - Kernal length, LE ratio - Linear elongation ratio, GT - Gelatinazion temperature, KB - Kernal breadth - BE ratio - Breadth wise elongation ratio, GC (mm) - Gel consistancy, KLAC - Kernal length after cooking, AC - Amylose content

consistency of high values (> 150 mm length) was observed in AS00044, ADT (R) 46, PMK 2, TP1050 (Table 1). Low gel consistency of < 40 mm was observed in medium duration culture CB 99019 (35.0 mm), Improved White Ponni (32.0 mm), ADT 38 (36.0 mm), rain fed cultures PM 01011 (37.0 mm), PM 01010 (35.0 mm), PM 0200022 (35.0 mm) indicated that these varieties have very flaky rice with hard gel consistency.

Promising rice varieties/cultures identified based on physio-chemical and cooking qualities are listed (Table 2). The rice culture *viz.*, AS 00004, TP1050, TP 20001 and varieties ADT(R) 45 and ADT 43 in early group showed good milling and chemical properties. Among the four cultures, TP1050 had medium slender grain and exhibited good milling out turn, high head rice recovery, volume expansion, soft gel consistency with intermediate amylose content. The cultures/ varieties CB 98004, CB 20021, TP1121, IR 64 and ASD16 are promising for quality traits in mid early group. Among the medium duration rice varieties, ADT (R) 46 identified as most promising for milling, head rice recovery, volume expansion, soft gel with intermediate amylose content. Other promising rice varieties/cultures in medium duration are ADT 38, AD 99217, AD 99218, and CB 99019. Among 10 rice varieties from rain fed group, 7 rice varieties/cultures PMK 1, PMK 2, PM 01010, MDU 5, TKM 11, TKM 12 and CB (MAS1) 20001 found desirable for quality traits. This indicates that the above mentioned drought tolerant varieties could be useful for quality improvement coupled with drought tolerant. The long duration varieties AD 99001, KR 99001 and ADT44 showed desirable quality characters like milling, head rice recovery, volume expansion, soft gel consistency and amylose content. Only one culture ACK 99017 belongs to quality rice group exhibited soft gel, good volume expansion, and intermediate amylose content.

All the hybrids had satisfactory quality features compared to varieties. The hybrid TNRH 55 showed high hulling, milling out turn, head rice recovery, volume expansion, intermediate gelatinization temperature and amylose content with long slender grain type followed by TNRH 31, TNRH 50, ADTRH 1, ADRH 15 and CORH 2 also exhibited desirable quality attributes for most of the quality characters studied.

The present study revealed that out of 55 rice varieties/cultures/hybrids analyzed, 30 rice varieties showed desirable quality parameters. The hybrids TNRH 55, TNRH 31, TNRH 50, ADRH 15, ADTRH 1 and short duration varieties ADT(R) 45, ADT 43, medium duration variety ADT(R) 46, rainfed variety MDU 5, PMK 1, mid early variety ASD 16, CB 98004, early group culture TP1050, TP 20001were identified as most promising quality cultures/varieties/hybrids. These varieties could be effectively utilized in quality improvement programme which would be helpful to develop high yielding varieties with better grain quality.

Table 2. Best varieties of rice identified for physio-chemical and cooking qualities

Hulling %		Milling %		HRR (%)		KL (mm)		KB (mm)		L/B ratio		LE ratio		VE		GT		GC (mm)		AC (%)	
Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value	Entries	Value
TKM 12	89.50	TNRH 55	78.80	ADT(R) 45	67.40	TKM 11	7.5	MDU 5	1.7	MDU 5	3.70	ADRH 15	1.88	IR 64	6.2	ADT 44	5.4	ADT(R) 46	170.0	TP102 1	25.0
TNRH 55	83.20	TNRH 31	75.80	ADT 43	61.10	TNRH 55	7.0	ADT 38	1.8	ADT 38	3.61	CR100 9	1.88	ADT (R) 45	5.9	TNRH 55	5.3	PMK 2	152.0	AD992 17	24.8
TKM 11	82.70	ASD 16	72.70	ASD 16	56.40	PM 01011	6.7	ADT(R) 46	1.8	ADT(R) 46	3.55	IWP	1.81	TP1021	5.8	TP2000 1	5.3	TP1050	150.0	AD990 01	24.8
TNRH 31	80.80	ADTRH 1	71.10	PMK (R)3	55.80	ADTRH 1	6.7	Co 47	1.8	PM 01011	3.52	PMK 2	1.81	CB200 21	5.8	TNRH 50	5.3	AS0004 4	150.0	ACK99 017	24.8
ADT(R) 45	78.40	TNRH 50	70.60	TNRH 55	54.00	TNRH 31	6.7	ADT 42	1.8	TNRH 55	3.50	ADT 43	1.79	IWP	5.8	PMK 1	5.3	Co 47	137.0	TP112 1	24.8
PMK 1	77.00	ADT(R) 45	70.50	CB (MAS1) 20001	54.00	TKM 12	6.5	PM 01011	1.9	ADTRH 1	3.35	ADT 44	1.79	TP1121	5.8	TKM 12	5.3	PMK (R)3	131.0	TNRH 31	24.8
ADT 43	76.40	CORH 2	70.20	BPT 5204	53.90	ADT 38	6.5	ADT 43	1.9	PM 0200022	3.25	Co 47	1.70	TP1050	5.7	TKM 11	5.2	CB9800 4	131.0	IR 64	24.8
CORH 2	75.60	AS0000 4	70.00	CB2003 5	53.60	IR 64	6.5	BPT 5204	1.9	TKM 11	3.20	TP200 01	1.66	AD991 10	5.6	TNRH 31	5.1	CB2002 1	123.0	ADTRH 1	24.6
CB9800 4	75.40	PMK 1	69.70	CB 20090	53.30	PM020 0022	6.5	TNRH 55	2.0	TNRH 31	3.19	PM020 0022	1.63	Co 47	5.5	BPT 5204	5.1	AS0000 4	123.0	KR990 01	24.4
ASD 16	75.30	ADT(R) 46	68.30	TP1050	53.10	ADT(R) 46	6.4	ADTRH 1	2.0	CB (MAS1) 20001	3.10	CB 99019	1.63	ADT 43	5.5	PM 01011	5.1	AD 99217	121.0	ADT (R) 45	24.0

HRR - Head rice recovery, KL - Kernel length, KB - Kernel breadth, L/B - Length breadth ratio, LE ratio - Linear elongation ratio, VE - Volume expansion, GT - Gelatinization temperature, GC - Gel consistency, AC - Amylose content

References

1. **Anonymous.** 2002. National workshops on Rice Research and Extension 2002. Feeding the extra millions by 2025. Bangladesh Rice Research Institutes, Gazipur, p. 1.
2. **Merca F. E. and Juliano B. O.** 1981. Physico-chemical properties of starch of intermediate amylose and starch. Starke, **33**: 253-260.
3. **Adair C. R., Bolich C. N., Bowman D. H., Jodon N. E., Johnston T. H., Webb B. D. and Askins J. G.** 1973. Rice breeding and testing methods in the United States. *In*: Rice in the United States: Varieties and production. U.S. Dept. Agrl. Hand Book-289 (revised), pp.22-75.
4. **Khush G. S., Paule M. and De La Cruz N. M.** 1979. Grain quality evaluation and improvement at IRRI. *In*: Proc. the Workshop on Chemical aspect of rice grain quality. Int. Rice Res. Inst., Philippines, pp. 21-31.
5. **Juliano B. O.** 1972. Physico-chemical properties of starch and protein in relation to grain quality and nutritional value of rice. *In*: IRRI Rice Breeding. IRRI, Los Banos, Philippines, pp. 389-405.
6. **Juliano B. O.** 1979. The chemical basis of the rice grain quality. IRRI, Philippines, pp. 69-90.
7. **Juliano B. O.** 1985. Polysaccharides, protein and lipids of rice. *In*: Rice Chemistry and Technology (B.O. Juliano ed.) 2nd Edition. Am. Assoc. Cereal Chem. St. Paul, pp. 59-179.
8. **Juliano B. O. and Perez C. M.** 1984. Results of a collaborative test on the measurement of elongation of milled rice during cooking. J. Cereal Sciences, **2**: 281-292.
9. **Little R. R., Hilder G. B. and Dawson E. H.** 1958. Different effect of dilute alkali on 25 varieties of milled white rice. Cereal Chem., **35**: 111-126.
10. **Juliano B. O.** 1971. A simplified assay for milled rice amylose, Cereal ScienceToday, **16**: 334-338, 340-360.
11. **Cagampang B. G., Perez C. M. and Juliano B. O.** 1973. A gel consistency test for eating quality of rice. J. Sci. Food Agric., **24**: 1589-1594.
12. **Rice Technical Working Group (RTWG) National Seed Industry Council.** 1997. National Co-operative Testing Manual for Rice: Guidelines and policies. Philippines Rice Research Institute Mahigaya, Science City of Munoz, Nueva Euja.
13. **Biswas S. K., Banu B., Kabir K. A., Begum F. and Choudhary N. H.** 1992. Physico-chemical properties of modern and local rice varieties Bangladesh. Bang. Rice. J., **3**: 128-131.
14. **Dipti S. S., Hossain S. T., Bari M. N. and Kabir K. A.** 2002. Physico-chemical and cooking properties of some fine rice varieties. Pak J. Nut., **1**: 188-190.
15. **Perez C. M. and Juliano B. O.** 1979. Indicators of rating quality for non-waxy rice. Food Chemi., **4**: 185-195.
16. **Juliano B. O.** 1993. Rice in human nutrition. Food and Agriculture Organization of the United Nations, Rome.