RICE BREEDING FOR GRAIN QUALITY IN THE MEKONG DELTA

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ABSTRACT

Grain quality improvement in the Mekong based on the crosses between Jasmine and CLRRI varieties has been implemented. The study aims was focused on producing high yielding varieties with good grain properties adapted to rice export demand. For that, thirty-seven genotypes were evaluated. The chemical properties such as amylose content (AC), alkali-spreading value, gel consistency well exhibited among the selected lines. The best qualities in grain appearance, cohesiveness, tenderness on touching, tenderness on chewing, taste, aroma, elongation were observed in OM7OL, Can Tho 2, Can Tho 3. The grain protein content (GPC) is considered as an important factor in rice nutrition. One of various factors affected GPC was recognized such as store timing. The study revealed that some of the rice varieties exhibited their high grain quality properties, which could be used in rice breeding programs to meet the demand of rice markets.

Keywords*: alkali spreading value, amylose, gel consistency, grain protein content.*

INTRODUCTION

Breeders are currently working to develop new rice varieties with improved agronomic characters to aim at giving higher grain yields. While for many years Vietnam has achieved its high yield target per hectare, grain quality has now become a priority research in the rice-breeding program. Breeders should evaluate early breeding lines for grain quality and more advanced lines for nutritional factors. Cooking and eating quality of rice have never been serious problem in Vietnam, as more than 95% of the rice area is planted with Indica varieties for their moistness, tenderness, gloss and taste. Recently, however, the breeding program has turned its attention to the development of long grain Indica rice varieties, with respect to cooking and eating quality. Newly released as OM4900, OM6162, OM6161 mostly have low amylose content (16-20%) with acceptable cooking quality for the local consumers. Amylose content, gel consistency, gelatinization temperature and grain elongation are the main factors affecting the cooking and eating quality of rice grain.

MATERIALS AND METHODS

Breeding materials included 37 high yielding genotypes were used for evaluation with IR64 as check. The physical traits as brown rice (BR), rough rice were measured by dehulling with a standard dehusker. Thus, average whole-grain of BR was determined (Dela Cruz *et al*., 2000).

- Head rice recovery (HR) was tested by using hundred grams of dehulled rice grains that had no visible breakage. The percentage of HR and broken rice was calculated (Dela Cruz *et al*., 2000).

- Grain classification was based on dehusked brown rice. The result was used for computing the grain shape and grain size. Minimum of 10 full grains per replication were measured using dial micrometer and L/B ratio was calculated. Based on the L/B ratio, grains were classified into long slender (LS), short slender (SS), medium slender (MS), long bold (LB) and short bold (SB) (Dela Cruz *et al*., 2000).

- Chalk index determination: Ten dehusked rice grains were placed on light box and visually identified the grain with more than 50% of chalkiness, weighed and percentage of chalkiness were calculated (Dela Cruz *et al*., 2000).

Grain quality properties as amylose, aroma, gel consistency, gelatinization temperature were evaluated according to IRRI (2007).

- Amylose content (AC) test: The AC of different varieties was calculated in comparison with standard graph (Williams 1958 and Perez *et al*., 1978).

- Aroma test: 5 g of rice, 15 ml of water was added, soaked for 10 min and cooked for 15 min, transferred into a petri dish and placed in refrigerator for 20 min. Then the cooked rice was smelled by a random panel: strongly scented (SS); mild scented (MS); non-scented (NS) (Sood *et al*., 1978).

- Gel consistency (GC) test: Milled rice samples were ground into a fine powder (IRRI 2007). The degree of disintegration and the transparency of paste dissolved out of the kernels were evaluated using a seven-point scale (Bhattacharya 1979).

- Alkali spreading and clearing test for gelatinization temperature: eight milled rice grain were taken in Petri plates and 10 mL of potassium hydroxide (19.54 g of potassium hydroxide dissolve in one liter) was added to the sample. Samples were kept undisturbedly for 23 hours in an incubator

The data was statistically analyzed using SAS software.

RESULTS AND DISCUSSION

Grain dimension

Grain dimension is a primary quality factor in any breeding program. In early generations, close visual comparisons are made to ensure that grain dimension conform to the requirements of each grain type. The CLRRI breeding program starts selection for grain size and shape from lines generation and continues until the line develops into a variety based on visual characters in early generations, but measurement that is more exact are made in the advanced generations. Grain dimension, such as grain length, width and shape are controlled by genetic factors. Grain dimension affects price and determines the planted area under different varieties. The long grain varieties are generally preferred in the Mekong delta. Farmers prefer long and heavy grain varieties, whereas consumer prefers sticky and soft rice grain varieties. Table 1 shows the mean of the various components of grain dimension for different new rice groups. The best grain dimension is found among the aroma rice varieties. Grain length has long been used in most rice breeding programs as a property for classifying rice varieties. Milled rice is classified based on average length into four clusters: short, medium, long and extra long. Grain width is an important factor in determining grain shape and weight. Grain width helps to classify the rice grain for mill processing and separate the immature grains from whole grains.

Grain appearance and chalkiness

Grain appearance depends on endosperm opacity and the amount of chalkiness. According to endosperm opacity, rice grain is classified into waxy or opaque, in waxy grains with high amylopectin and low amylose content; and non-waxy or translucent grains, with high amylose content and a different type of chalkiness. The site of chalkiness is termed as white centre, white belly or white back; while the degree of chalkiness varies greatly both among and within cultivars. Chalkiness is caused by the loose arrangement of starch granules with air spaces, and it usually results in lower milling recovery. Chalkiness is influenced by environmental factors such as drought stress during ripening and blast disease. There is evidence, however, that this trait is also under genetic control. Chalkiness reduces the milling recovery of rice grain by increasing the breakage ratio and by decreasing the head rice output. It also directly affects the rice storage period, as it is more susceptible to attack from insects. Chalkiness does not affect cooking and eating quality, however, as it disappears during cooking. Generally, most of the rice varieties exhibited good translucency and low chalkiness under normal growing conditions, with heavier milling pressure; short grain types have a white colour. Among these varieties, OM4900 was considered as an ideal genotype in grain appearance because of its highly translucent property. On the order hand, OM6162, OM4900, OM 70L, CanTho 3 exhibited higher chalkiness than other rice varieties.

Cooking and eating properties

Vietnam consumers prefer cooked rice to be moist and sticky. Therefore, the cooking and eating quality of rice has never been a serious problem in Vietnam, since 95% of the rice area is planted with indica rice varieties because of their moistness, tenderness, gloss and taste. Rice is consumed as a completely cooked milled grain, and starch constitutes over 90% of grain weight. There are some cooking and eating quality characters that affect the structure and properties of the starch components during cooking. In addition, an important effect of moist heat on rice is the swelling and solubilization of starch, which leads to changes in increase in volume, splitting and fragmentation or sloughing, and development of various textural qualities. Amylose content, gel consistency, gelatinization temperature and grain elongation are the main characters for measuring cooking and eating quality and they directly affect the palatability characters. In addition, protein content has the same effect because of its negative correlation with amylose content. Environmental and cultural practice affecting cooking and eating quality characters are follows: soil, location, that of seeding and harvest, fertilizers, maturity and post harvest processes. Some characters greatly vary while others seem unaffected, depending of the degree of differentiation among varieties. Also, cooking and eating quality characters are affected by the crop season. However, these properties differ more in the new crop than in the old crop, even for the same varieties. Therefore, we can not differentiate between rice groups for cooking and eating quality characters.

Table 1. Grain quality in Winter-Spring (2012-2013) crop season

No	Designation	Grain length (mm)	L/B ratio	*Chal-kiness*	*AC* (%)	*GC* (cm)	*GT*	GPC (%)	Aroma	Phytic acid
1	OM8108	7.4a-e	3.2a-c	1	24.2ab	62.5jk	70	8.5d-f	0	2
2	OM6707	7.5a-e	3.1b-d	0	24.5a	65.5ij	70	8.7b-d	0	2
3	OM10037	7.7a-c	3.2bc	1	23.5a-c	65.8h-j	70	7.4kl	0	2
4	OM10040	7.2d-f	3.5a	0	21.3ef	69.5f-i	70	9.1a	0	2
5	OM10258	7.4b-f	3.2bc	1	22.3c-e	70.2e-h	70	7.8ij	0	2
6	OM46L	7.0f	3.2bc	9	1.2i	100.0a	60	8.6c-e	0	2
7	OM10041	7.3c-f	3.1b-d	0	20.5fg	74.2b-e	70	8.9ab	0	2
8	OM10375	7.4b-f	3.0c-e	0	21.2ef	71.2d-g	70	8.7b-d	0	2
9	TLR390	7.6a-d	3.0c-e	0	21.2ef	72.3c-g	70	8.5de	0	2
10	CẦN THƠ 3	7.8ab	3.3ab	0	18.2h	77.4b	65	8.8bc	1	2
11	OM70L	7.9a	3.2bc	0	18.6h	77.6b	65	8.7b-d	1	2

12	TLR391	7.4b-f	3.1b-d	0	23.2a-d	75.6b-d	70	7.8ij	0	2
13	TLR397	7.5a-e	3.2bc	0	22.2c-e	75.2b-d	70	7.9hi	0	2
14	OM27L	7.6a-d	3.1b-d	0	20.1fg	74.1b-e	70	7.5k	0	2
15	OM72L	7.6a-d	3.2bc	0	20.1fg	74.2b-e	70	7.6jk	0	2
16	OM7L	7.6a-d	2.9de	0	23.2a-d	77.2b	70	7.8ij	0	2
17	OM10418	7.7a-c	2.9de	0	19.5gh	76.3bc	70	7.8ij	0	2
18	OM10030	7.4b-f	3.2bc	0	24.1ab	56.3l	70	8.2fg	0	2
19	TLR392	7.2d-f	3.2bc	1	23.2a-d	68.3g-i	70	8.4ef	0	2
20	OM10037-3	7.4b-f	3.1b-d	1	22.1de	69.5f-i	70	8.2fg	0	2
21	OM10383	7.6a-d	3.2bc	0	20.1fg	70.4e-g	70	8.1gh	0	2
22	OM10029	7.6a-d	3.1b-d	0	23.1b-d	71.2d-g	70	8.8bc	0	2
23	CẦN THƠ 2	7.8ab	3.2bc	1	19.5gh	73.5b-f	65	8.2fg	2	2
24	TLR393	7.4b-f	3.1b-d	0	23.4a-d	71.4d-g	70	8.6c-e	0	2
25	OM6L	7.5a-e	3.2bc	0	24.1ab	60.6kl	70	8.5de	0	2
26	OM9922	7.6a-d	3.1b-d	0	22.1de	71.2d-g	70	8.7b-d	0	2
27	TLR348 (waxy)	7.0f	3.2bc	9	2.3i	100.0a	60	8.9ab	0	2
28	OM31L (waxy)	7.1ef	3.2bc	9	2.1i	100.0a	60	8.7b-d	0	2
29	OM6613	7.2d-f	3.1b-d	0	22.1de	71.4d-g	70	7.4kl	0	2
30	OM5894	7.5a-e	3.2bc	0	23.2a-d	72.2c-g	70	7.5k	0	2
31	OM10179	7.6a-d	3.0c-e	0	22.1de	71.2d-g	70	7.4kl	0	2
32	TLR394	7.7a-c	2.9de	0	21.4ef	77.3b	70	7.6jk	0	2
33	OM6832	7.4b-f	2.8ef	0	23.2a-d	70.2e-h	70	7.2l	0	2
34	TLR395	7.5a-e	2.9de	1	23.4a-d	71.7d-g	70	7.4kl	0	2
35	TLR396	7.6a-d	2.6f	0	23.4a-d	68.6g-i	70	8.5de	0	2
36	OM10174	7.4b-f	2.9de	0	23.4a-d	68.3g-i	70	8.9ab	0	2
37	OM10236	7.2d-f	3.1b-d	1	23.2a-d	68.4g-i	70	7.5k	0	2

Table 2. Grain protein content at different storage time

No	Designation	Grain protein content after harvest (%)			
		1 week	1 month	2 months	3 months
1	OM8108	6.33h	6.27i	6.25c	6.21d
2	OM6707	8.39g	8.05g	8.05g	8.04f
3	OM10037	5.75j	5.43p	5.30j	5.23k
4	OM10040	6.80c	6.21k	6.20d	6.20)
5	OM10258	6.89a	6.71a	6.60x	6.60x
6	OM46L	8.06m	7.72o	7.56o	7.50o
7	OM10041	8.18i	7.89j	8.76b	8.75b
8	OM10375	8.64e	8.17e	6.10f	6.10f
9	TLR390	7.74q	7.29v	7.25r	7.24r
10	CẦN THƠ 3	8.26h	7.88jk	7.88j	7.84j
11	OM70L	9.28a	8.85a	8.82a	8.82a
12	TLR391	6.81c	6.29h	6.25c	6.24c
13	TLR397	8.67d	8.39c	8.34d	8.30d
14	OM27L	7.07x	6.78z	6.75v	6.73v
15	OM72L	8.47f	7.77n	7.75l	7.74l
16	OM7L	6.56e	6.41f	6.41a	6.40a
17	OM10418	9.07b	8.52b	8.51c	8.51c
18	OM10030	6.99z	6.71a	6.71w	6.70w
19	TLR392	6.88a	6.64b	6.56y	6.55y
20	OM10037-3	7.64r	7.38t	7.35q	7.35q
21	OM10383	7.15w	6.61c	6.61x	6.60x
22	OM10029	6.10i	5.75o	5.75h	5.74i
23	CẦN THƠ 2	8.63e	7.70p	7.70m	7.68m
24	TLR393	7.81p	7.93i	7.90i	7.90h
25	OM6L	8.99c	8.31d	8.31e	8.30d
26	OM9922	8.11jk	7.81m	7.81k	7.80k
27	TLR348 (Nếp)	8.10k	7.95h	7.90i	7.90h
28	OM31L (Nếp)	8.39g	8.15f	8.10f	8.10e
29	OM6613	7.62s	7.36u	7.34q	7.34q
30	OM5894	6.34gh	6.25j	6.25c	6.25c
31	OM10179	8.12j	7.59q	7.59n	7.50o
32	TLR394	7.01y	6.33g	6.30b	6.30b
33	OM6832	6.54f	5.74o	5.74h	5.74i
34	TLR395	7.54t	7.44s	7.40p	7.40p
35	TLR396	5.46k	5.36q	5.36i	5.35j
36	OM10174	7.50u	7.03x	7.03t	7.01t
37	OM10236	8.39g	7.87k	7.87j	7.86i
38	IR64	8.05m	8.04g	8.01h	8.01g

Grain protein content

The quantity and type of protein are important factors in rice nutrition. Various factor affect protein content of rice: climate and environment, kind and quantity of fertilizer applied, duration of maturity, degree of milling, and varietal characteristics. The protein content of OM rice varieties ranged from 5.46 to 9.07 % and remains relatively unchanged during the first 3 months after storage (Table 2). Indica rice genotypes offered higher protein content than the others. On the other hand, rice varieties derived from crossing show intermediate values for protein content. Thus, large variations in protein content exist among rice cultivars due to genetic and environmental factors.

Table 3. Milling recovery of tested cultivars

No	Designation	Brown rice (%)	White rice (%)	Head rice (%)	No	Designation	Brown rice (%)	White rice (%)	Head rice (%)
1	OM8108	80.3g	72def	52.3cd	20	OM10037-3	82.6cd	72.4c-f	52.3cd
2	OM6707	81.5d-g	71ef	51.1de	21	OM10383	81.2d-g	71ef	51.2de
3	OM10037	80.5fg	70.2ef	51de	22	OM10029	80.6efg	70f	50.1e
4	OM10040	81.2d-g	71.3ef	51.3de	23	CẦN THƠ 2	84.2c	74bcd	54.2b
5	OM10258	84.3c	74.2bcd	54.2b	24	TLR393	84.2c	74bcd	51.3de
6	OM46L	80.4fg	70.2ef	50.2e	25	OM6L	88a	77a	57.2a
7	OM10041	80.1g	70.1ef	51.2de	26	OM9922	87.4ab	76ab	56a
8	OM10375	80.6efg	70.5ef	51.2de	27	TLR348 (wx)	81.3d-g	71ef	51de
9	TLR390	86.2b	75.5ab	55.6ab	28	OM31L(wx)	84.2c	74bcd	54bc
10	CẦN THƠ 3	82.3de	72.5cde	52.1d	29	OM6613	81.3d-g	71.2ef	51.3de
11	OM70L	82.6cd	72.3c-f	52.1d	30	OM5894	81.2d-g	71ef	54bc
12	TLR391	81.6d-g	71ef	51.2de	31	OM10179	84.3c	74.2bcd	54.2b
13	TLR397	80.5fg	70f	50.2e	32	TLR394	80.4fg	70.2ef	50.2e
14	OM27L	82.3de	72def	52.4cd	33	OM6832	80.1g	70.1ef	51.2de
15	OM72L	81.3d-g	71.2ef	51.2de	34	TLR395	80.6efg	70.5ef	51.2de
16	OM7L	84.2c	74bcd	54.2b	35	TLR396	86.2b	75.5ab	55.6ab
17	OM10418	86.3ab	72.3c-f	52.3cd	36	OM10174	82.3de	72.5cde	52.1d
18	OM10030	86.2b	75.6ab	55.6ab	37	OM10236	82.6cd	72.3c-f	52.1d
19	TLR392	86.2b	75ab	55.5ab					

Milling quality

Head rice is the main factor affecting milling quality, which in turn influences the economic value of the rice grain. Head rice production widely varied, it is depending on different factors, such as grain type and varieties. In addition, chalkiness, environment during ripening, post harvest handling, storage period, storage condition, and milling process are considered as side effect. Most of these factors cause crack formation with reduced head rice percentage. Table 3 shows a little variation in crack resistance among 44 rice varieties and new lines with both drying methods. However, all varieties showed high resistance to cracking (except the long grain varieties such as OM6L, OM6707. Milled rice consists of different sizes of unbroken and broken rice and some bran. Some consumers and markets refused total milled rice and prefer head rice only. The separation of these particles is known as grading. However, the broken grains are fragments of grains. The length of which is less than three-quarters of the whole grain and are later separated into two different sizes.

CONCLUSION

In the present study, physical, chemical and cooking characteristics were evaluated among 37 high yielding cultivars. The expressed their good physical characteristics as maximum hulling, HR recovery, L/B ratio. The chemical properties as AC, alkali spreading value, and gel consistency are noticed to be excellent among the varieties. The best qualities such as grain appearance, cohesiveness, tenderness on touching, tenderness on chewing, taste, aroma, elongation were observed in OM70L, Can Tho 2, Can Tho 3. Some of the rice varieties exhibit their high grain quality properties. They can be used in rice breeding programs for further improvement purposes.

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CHỌN TẠO GIỐNG LÚA CÓ PHẨM CHẤT GẠO TỐT Ở ĐBSCL

Cải tiến phẩm chất hạt ở ĐBSCL được thực hiện trên nền tảng các cặp lai giữa Jasmine và dòng giống cao sản, ngắn ngày. Mục tiêu nghiên cứu là tạo ra được các giống lúa cao sản có phẩm chất gạo ngon phục vụ yêu cầu xuất khẩu tại nhiều thị trường có thị hiếu khác nhau. Việc đánh giá được thực hiện trên 37 vật liệu là giống lúa cao sản. Phẩm chất hóa học như hàm lượng amylose, nhiệt độ hóa hồ, độ bền thể gel đều được thể hiện qua nguồn vật liệu có chọn lọc. Phẩm chất tốt nhất thí dụ như độ bóng sáng, dạng hạt, độ dính dẽo của cơm, độ mềm cơm, mùi thơm, độ dãn nở theo chiều dài hạt cơm được quan sát trên giống lúa OM7OL, Can Tho 2, Can Tho 3. Hàm lượng protein trong hạt được xem như một trong những chỉ tiêu quan trọng bị ảnh hưởng rõ rệt bởi thời gian tồn trữ. Nghiên cứu này cho thấy các dòng giống ưu việt về phẩm chất hạt có thể được sử dụng có hiệu quả cho chương trình cải tiến giống lúa cao sản, phục vụ yêu cầu xuất khẩu gạo của Việt Nam.