Cooking and Eating Quality of Rice Yellow Mottle Virus Resistant Rice Mutants: Its Implications for Future Breeding Work

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Abstract

The study was conducted to evaluate the cooking and eating quality of mutant lines obtained from irradiating a local cultivar, Supa. Five early maturing mutant lines plus two controls, IR! 53234-27-1 and Supa were evaluated for their physical grain characteristics including length and shape of grain kernel, translucence and chalkiness of the endosperm. Cooking qualities of the tested genotypes were evaluated in terms of percent amylose content and gelatinization temperature. To determine the eating quality, a taste panel comprising of extension officers and the staff of the Kilimanjaro Agricultural Training Centre, Moshi, Tanzania was used. The panel was required to taste the cooked rice of the seven genotypes and to record the aroma, stickiness, softness, taste and general acceptability of the cooked rice. Regression analysis was also performed on selected parameters in order to isolate those that have more influence on the inherent variety quality. The results showed that all the rice genotypes tested had grain appearance that was accepted by the taste panel. The taste panelists, however, generally rated supa parent variety as very good and SSD 7 as normal. The results revealed that significant differences were observed for all the characters tasted except the taste of the cooked rice. Regression analysis showed that of the six parameters of quality, aroma significantly contributed to the isolation of the rice quality, while softness of cooked rice and aroma determined the general acceptance by the panelists. These parameters could be useful as selection criteria in evaluation for rice grain quality.

Key words: Rice, Grain quality, Mutants, Supa Variety

Introduction

Improvement in rice has hitherto been carried along the lines of increasing the yield and improving other hereditary characters that enable the cultivation of a good crop. However, it has long been realized that the appearance of rice together with its cooking and eating quality are important to the consumer. These have to be taken into consideration by the producer, the miller and the breeder (Little *et al.*, 1958). Grain quality determines to a large

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Accepted June, 2008

degree, the market price of a rice variety, and preferences differ from one area to another (De la Cruz and Khush, 2000; Jennings *et al.*, 1979; Azeez and Shafi, 1966). Grain quality is, therefore, an important consideration in rice variety selection and development. Singh *et al.* (2000) concluded that grain quality is second only to yield as the major breeding objective.

Rice grain quality includes the physical characteristics and physico-chemical behaviour of the rice grain. Physical characteristics of grain consist of length and shape of the kernel, translucency and chalkiness of endosperm. Grain length is a measure of milled rice kernel in its greatest dimension. The grain length to its width ratio determines the shape of rice grain. Grain appearance is important because it attracts the attention of the consumers, and although it has no bearing on cooking and eating quality it is the basis on which farmers can accept or reject a variety.

Cooking and eating qualities are determined by amylose content of starch, gelatinization temperature and gel consistency. In the tropics and subtropics, varieties with intermediate amylose content and intermediate gelatinization temperature are preferred (Khush, 1995). Varieties may be grouped on the basis of their amylose content into waxy (1 – 12% amylose), low amylose (12 – 20%), intermediate amylose (20 – 25%), moderately high amylose (25 – 27%) and high amylose (>27%) (Dela Cruz and Khush, 2000).

Gelatinization temperature (GT) is a physical property of starch, and it is the range of temperature with which the starch granules begin to swell irreversibly in hot water.

The gelatinization temperature determines the time required for cooking. The GT is estimated by the extent of alkali spreading and clearing of milled rice soaked in 1.7% Potassium Hydroxide (KOH) for 23 hours at room temperature (Little *et al.*, 1958). Two varieties with the same amylose content may have different acceptability score. Varieties having the same amylose content may be differentiated for differences in tenderness of cooked rice by the gel consistency test. Within the same amylose group, varieties with softer gel consistency are preferred because the cooked rice is tenderer than those with hard gel consistency.

Eating quality is determined mainly by the texture of the cooked rice (cohesiveness, tenderness). Cooking tests and taste panel evaluation are normally conducted in many breeding programmes. Another criterion the consumer uses to selects rice a variety is the aroma. Many preferred high quality varieties are aromatic. Scented rice commands high prices and is used in special occasions.

Rice improvement work at the Sokoine University of Agriculture (SUA) in Morogoro, Tanzania has been geared at developing varieties that have good agronomic characteristics such as high yield and resistance to pests and disease attack. However, it has been noted that traditional varieties often out compete introduced varieties on local markets; even though the former have lower yield potential. Breeding work incorporating grain quality was started in 1972 with the aim of developing varieties which combine high grain yield and grain quality particularly protein content and quality (Monyo, 1974). Since then grain quality has become one of the selection criteria in the rice breeding programmes.

The present study was, therefore, undertaken to evaluate the cooking and eating quality of the mutant lines derived from the local cultivar *Supa*. These mutants have been selected on the basis of earliness and resistance to rice yellow mottle virus disease.

Materials and Methods

The rice genotypes used in the study included five early maturing mutants derived from popular rice cultivar *Supa* and two check varieties including the parent. In 1994, *Supa* variety was irradiated with 170gy, 210gy and 240gy doses of gamma rays (gy) from Cobalt 60 (^{60}60) at the International Atomic Energy Agency (IAEA) Seibersdorf Laboratory, Vienna, Austria (Kihupi, 1997). The test mutant lines originated from plants that were selected using modified Single Seed Descent (SSD) method from 170 gy treatment. The grain quality analysis was done on the seeds from M_8 generation which was harvested in 2000.

Physical characteristics of rice consist of length and shape of the kernel, translucency and chalkiness of endosperm. Chalkiness and translucency were measured using a visual rating of the chalking proportion of the grain. The scale was 1-9, where 1 = less than 10% chalkiness, 5 = 10 – 20%, and 9 = more than 20% (Khush *et al.*, 1979). Grain Length and width were measured by using dial calipers while the shape was calculated by dividing the length by the width. All the parameters were assessed according to the Standard Evaluation system for rice (IRRI, 1988).

Percent amylose content was evaluated by the modified iodine calorimetric procedure (Juliano, 1971). Gelatinization temperature was measured by the alkali spreading value (Jennings *et al.*, 1979; Juliano, 1971). This is the extent of disintegration of milled rice soaked in 10ml of 1.7% KOH solution for 23 hours at 30°C. A high rating (7) indicates more disintegration and a low gelatinization temperature while a low rating (1) indicates no disintegration and high amylose content. Gel consistency was measured by the length of cold milled rice paste in a test tube in a horizontal position. A high number indicates a softer consistency (Cagampang *et al.*, 1973). The physical and chemical characteristics were analysed at SUA's Laboratory in the Department Food Science and Technology Department of Sokoine University of Agriculture.

Taste panel for eating quality of rice was done at the Kilimanjaro Agricultural Training Centre (KATC), Moshi, Tanzania in

September, 2000. Forty four (44) panelists including extension officers (crop specialists) who were attending a rice production workshop and KATC staff were asked to evaluate the seven rice genotypes. The criteria used were aroma, appearance, taste, stickiness, softness/hardness and general acceptability of the rice. Equal samples of each genotype was boiled in automatic rice cookers whose timing was calibrated to show the exact time it took for each genotype to cook. The 44 respondents rated the quality of the cooked rice genotypes by ranking them using a scale as: 1 for very good, 2 for good, 3 for normal, 4 for poor and 5 for very poor.

The above ranks were later used in the analysis as predictors of the quality of the varieties based on the respondents' preferences. Descriptive statistics were carried out to obtain frequency counts of various coded responses of the selected parameters. Cross-tabulations were carried out to obtain chi-square values for testing the influence of individual parameters on the rice quality as ranked by the respondents' preferences. Regression analysis was carried out to find the combined influence of the different rating parameters of the seven rice genotypes. Correlation analysis was run to find the inter-relationship between the rice genotypes and the evaluation parameters.

Results

Table 1 shows the physical and biochemical characteristics of the tested genotypes. The hull colour of all the mutants except SSD 35 was gold similar to the parent *Supa*. SSD 35 and IR 53234–27-I exhibited brown hull colour. The kernel length of all the mutants and IR 53734-27-1, were long while SSD 35 and *Supa* were extra long. Similary, SSD 35 was different from the other genotypes in terms of grain shape. All the other genotypes were slender in shape while SSD 3 was medium in shape. In terms of degree of chalkiness or opacity SSD 1, SSD 3, SSD 35, *Supa* and IR 53234-27-1 were translucent while the others had less than 10% chalkiness (Table 1).

Table 1: Grain quality characteristics of the tested rice genotypes

Line / Parent	Grain length (mm)	Length/ Breadth (mm)	Opacity	Amylose content %	Gel Cons. (mm)	Gel temp	Aroma
IR 53234-27-1	7.0	2.40	No chalkiness	29.51 H	140 soft	Int.	No
SSD 1	7.8	2.91	No chalkiness	29.51 H	72 soft	Int.	No
SSD 3	6.8	2.45	No Chalkiness	18.38 Int.	135 soft	High	Slight
SSD 5	6.7	2.73	< 10%	22.08 Int.	130 soft	High	Slight
SSD 7	7.3	2.89	< 10 chalkiness	14.68 L	160 soft	High	Mod
SSD 35	8.0	3.02	10% chalkness	22.08 Int.	137 soft	Low	No
Supa	7.9	2.87	No chalkiness	25.79 Int.	130 soft	Low	Aromatic
Mean	7.4	2.75	-	22.03	-	-	-
Lsd (5%)	0.44	0.03	-	0./23	-	-	-
CV. (%)	3.2	0.66	-	0.58	-	-	-

Gel Cons. = Gel Consistency
Gel Temp. = Gelatinization Temp.
H = High
Int. = Intermediate
L. = Low
Mod. = Moderate

Most genotypes tested exhibited high gelatinization temperature with the exception of *Supa* and SSD 35 which had low GT. The amylose content was high for SSD 1and IR 53234-27-1 intermediate for SSD 5, SSD 35 and *Supa*, while low amylose content was exhibited by SSD 3, SSD 7. The Gel consistency of all the genotypes except SSD 1 was soft. None of mutants was as aromatic as the parent *Supa*, however SSD 3, SSD 5, SSD 7 were slightly aromatic (Table 1).

The results of the taste panel are shown in Table 2. Of the 44 respondents who participated in the taste panel, 72% rated Supa variety as very good on aroma, while 44.2% and 40.5% rated SSD3 and SSD35 as normal on aroma respectively (Table 2). The difference in aroma between the mutants and the controls was found to be statistically significant at $p < 0.01$ (Table 2). Based on visual appearance, out of the 44 panelists 52.3% rated SSD3 as normal while 51.2% rated *Supa* variety as good in appearance. The difference in the means of grain appearance between the six genotypes was found to be statistically significant at $P < 0.002$ (Table 2).

Softness .... 1 = Very soft, 2 = Soft,, 3 = Normal, 4 = Hard, 5 = Very hard

General ... 1 = Very good, 2 = Good, 3 = Normal, 4 = Poor, 5 = Very Poor

R^2 = Coefficient of determination

Discussion

Rice is one of the crops much affected by consumer preferences such as cooking and eating qualities. Grains quality determines to a large degree, the market price of a rice variety, and preference differ from one area to another. Grain quality is, therefore, an important consideration in rice variety selection and development. Singh *et al.* (2000) concluded that grain quality is second only to yield as the major breeding objectives. Measures of appearance or physical characteristics are related to observations consumers make in the market. Physical characteristics include whiteness, broken grains, length, translucency and chalkiness and consumers usually prefer white, translucent, long-grain rice with few broken grains.

All the genotypes tested had long and extra-long grain length. This characteristic may be acceptable to the consumers. The genotypes also exhibited translucency or little degree of chalkiness, which is a good attribute. Furthermore, based on visual appearance, 52.3% of taste panelists rated SSD 3 as normal and 57.2% rated *Supa* as good in appearance. Amylose content is the most important chemical characteristic as rice with intermediate amylose content cook moist and is tender and do not harden after cooling. Many traditional rice varieties grown in Tanzania are of this type. High amylose rice, including most of the introduced varieties harden after cooling and are less preferred. Since the test genotypes exhibited intermediate and high amylose content, it is possible to select the lines with preferred amylose content. These results correlated well with the taste panel which rated Supa as very good in stickiness while IR 53234-27-1, SSD 5 and SSD 7 were rated as normal in stickiness.

Gel consistency is a measure of texture. Among high amylose rice, those with soft gel consistency will be preferred because the cooked rice is tenderer. All the tested genotypes exhibited a soft gel consistency which is a good attribute as far as cooking and eating quality is concerned. The Gelatinization temperature (GT) of the genotypes ranged from low to high. Genotypes with low GT are expected to take less time to cook. Although SSD 1 and IR 53234-27-1 exhibited high amylose content, these genotypes had intermediate GT and soft gel consistency and thus may cook tender and stand a better chance to be accepted by the consumers.

Aroma is an important quality characteristic of high quality rice. In most countries aromatic rice commands higher prices in the domestic market (Singh *et al.*, 2000). The results from biochemical analysis showed that out of the genotypes tested only *Supa*- parent was aromatic (Table 2). Similarly, the taste panel mostly preferred *Supa* parent as far as aroma was concerned. This means that there is a need for further improvement of this trait in the breeding lines.

Regression results showed that of the six parameters of quality, aroma significantly contributed to the isolation of the rice quality. However, from the taste panel results, softness of the cooked rice was the highest predictor of the rice quality. This makes the gel – consistency test, amylose content and aroma to be important parameters in evaluating the grain quality. However, since amylose content correlates negatively with gel consistency (Jennings *et al.*, 1979), and GT test is easier to perform as compared to amylose test, genotypes with low and intermediate GT should be preferred in the future breeding programmes in order to isolate genotypes with high or intermediate amylose content.

Conclusion

The results showed that the genotypes tested, which included *Supa* variety and its five mutants plus a check variety differed in some parameters tested. Aroma and softness of cooked rice were found to be the predictors of the rice quality. The results obtained underscore the importance of evaluating grain quality in a breeding programme, in order to select the rice genotypes which will be acceptable to the consumers.

Acknowledgements

We acknowledge the financial assistance provided by the International Atomic Energy Agency and SUA/NORAD Project. The Authors thank the extension officers who were attending a short course at KATC, and the staff at KATC, Moshi, Tanzania for forming the taste panel.

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