Tropical Agricultural Research Vol. 20: 168 - 176 (2008)

Cooking and Eating Quality Traits of Some Sri Lankan Traditional Rice Varieties across *Yala* and *Maha* Seasons

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ABSTRACT. *Rice (Oryza sativa L.) is the most important cereal crop in the developing world and is the staple food for over half the world's population including Sri Lanka. Rice is grown widely on all continents and under all agro-climatic conditions. This wide adaptation has led to evolution of thousands of varieties of rice having diverse cooking, eating, and product making characteristics. In this study, Sri Lankan traditional rice varieties were analysed for amylose content (AC), gelatinization temperature (GT) and gel consistency (GC) which are major physico-chemical parameters responsible for cooking and eating qualities of rice. Twenty five different Sri Lankan traditional rice varieties cultivated in Yala (2006) and Maha (2006-2007) seasons were analyzed for AC, GT and GC, for possible variation due to seasonal differences in these parameters and for correlation of GT and GC with AC. Amylose content of selected Sri Lankan traditional rice varieties varies from 27-31% and are all high amylose varieties. Difference in AC, among rice varieties was statistically significant (P<0.05). However, variation in AC due to seasonal difference was not significant (P>0.05). GT of the selected rice varieties varied from high, high- intermediate, intermediate and low and GC was hard, medium or soft. There was no correlation found between AC and GT (r = -0.09, P>0.05), AC and GC (r = -0.15, P>0.05) and GT and GC (r = 0.26, P>0.05) of selected Sri Lankan traditional rice varieties. The current trend of research is to develop rice varieties with consumer acceptable grain quality traits, and therefore these findings will be useful in rice breeding when choosing selective germplasms for release or in further developments.*

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INTRODUCTION

Rice is described as the ancient staple food of the Asian world with its origin somewhere in Southeast Asia (Samarajeewa, 1999). Rice feeds more than half the population of the world and is the staple in the Sri Lankan diet (Samarajeewa, 1999; Juliano, 2003). As the staple food, it reaches every household and is popularly consumed by the people. It remains as the major source of calories and protein for Sri Lankans (Mendis, 2006).

As the staple food, the country produces about 3 million tons of paddy annually in about 870,000 ha spread all over the country cultivated in two seasons, *Yala* and *Maha* (Mendis, 2006).

Rice is classified under the genus *Oryza* and *Oryza sativa* is the main cultivated rice species. Rice is grown widely on all continents and under all agro climatic conditions. This wide adaptation has led to the evolution of thousands of varieties of rice having diverse cooking, eating, and product making characteristics. There are about 100,000 rice varieties, but only small proportions are actually widely cultivated (Juliano, 2003).

Rice is consumed mainly as cooked grain kernels, and the physico–chemical properties of cooked rice are important from the viewpoint of its edible quality. Rice grain quality is a very complicated character, mainly defined by four constituents, namely milling quality, appearance quality, cooking and eating qualities and nutritional quality, among which the cooking and eating qualities of rice are the most important quality attributes in many rice production areas of the world. The traits that exert major effects on the cooking and eating qualities are related to the physico–chemical properties of rice grains such as amylose content (AC), gelatinization temperature (GT) and gel consistency (GC) (Zefu *et al*., 2003).

The amylose content of rice is considered to be one of the most important factors influencing the cooking and processing characteristics of rice. It is commonly used as an objective index for cooked rice texture (Delwiche *et al*., 1995). Low amylose levels are associated with cohesive, tender, and glossy cooked rice (Juliano, 1971). Conversely, high levels of amylose cause rice to absorb more water and consequently expand more during cooking, and the grains tend to cook dry, fluffy, and separate (Juliano, 1971). Beside the effect of amylose, many other factors are also important in determining rice quality. It has been found that among the rice with similar AC, the cooking and eating qualities of rice were quite distinct due to the differences in GT and GC (Wan *et al*., 2007). The time required for cooking is mainly determined by the gelatinization temperature of starch and GC is a good measure of gel viscosity of milled rice.

The cooking and eating quality traits are mainly governed by the genotype as well as the environment. The environmental conditions such as changes in the temperature, day length and genotype-environment interactions also affect the cooking and eating qualities of rice (Jianrong *et al.*, 2005).

The country has now achieved a production level of early self sufficiency in terms of its requirement as the staple food. In the rice improvement programme of Sri Lanka, rice breeders mainly concentrate on yield, with little attention paid to grain quality. Therefore only a handful of rice varieties are widely grown, which are developed by hybridization and selection (Jayawardana, 2003). Before the introduction of inbreds, there were over four hundred different traditional varieties of rice grown in the country, each with different nutrient values and cooking and eating characteristics. The local germplasm has not yet been evaluated for these cooking and eating quality traits. Breeding is a tool, which could upgrade the rice grain quality through bio-fortification. The initial selection of parental lines for breeding is done by a screening process. Therefore, the objectives of this study were to asses the cooking and eating quality traits of some Sri Lankan traditional rice varieties and to evaluate the seasonal effect with the intention of identifying varieties which are less sensitive to the seasonal effects and to provide the findings to rice breeding programmes in choosing selective germplasms for release or in further developments.

MATERIALS AND METHODS

Materials

Twenty five different Sri Lankan traditional rice varieties (Table 1) in two replicates were grown in Randomized Complete Block Design (RCBD) in the plot size of 1.9 × 1.2 m and spacing of 20 × 15 cm, in the Low Country Wet Zone (LCWZ), at the Regional Rice Research and Development Center (RRRDC), Bombuwala, during the 2006 *Yala* and 2006-2007 *Maha* seasons.

Sample Preparation

Samples obtained from RRRDC were dehusked using husker machine (model; Satake THU 35B, Japan) and stored in airtight containers and stored at 8 °C in a cold room. The whole grains milled (particle size 0.5 mm, 150 µm) were used for the determination of amylose and gel consistency.

Amylose Content (AC)

1 ml of 95% ethanol and 9 ml of 1 N sodium hydroxide were added to 100 mg of flour sample (particle size 0.5 mm). The sample was heated for 10 min in a boiling water bath to gelatinize the starch. Sample was cooled and the volume was made up to 100 ml. 5 ml of solution, 1 ml of 1 N acetic acid and 2 ml of 0.2% iodine solution were transferred to 100 ml volumetric flask and volume was made up to 100 ml. Flask was shaken and allowed to stand for 20 min at 30 °C. Absorbance was measured at 620 nm using a UV/visible spectrophotometer (model; GBC-911A, scientific equipment, Australia). Total amylose content was determined from a standard amylose (Potato, Sigma) curve (Juliano, 1985).

Gelatinization Temperature (GT)

Gelatinization temperature of rice was determined by alkali digestibility test of Little *et al.* (1958). Duplicate sets of six undamaged grains of rice were added to 10 ml of 1.7% potassium hydroxide at room temperature and allowed to stand for 23 h and degree of spreading was scored visually using a seven point scale. Standard varieties were used as checks for high, medium and low gelatinization temperature.

Gel Consistency (GC)

Gel consistency of rice was determined by the procedure of Cagampang *et al*. (1973). A sample of 100 mg of rice flour was wetted with 0.2 ml of 95% ethanol containing 0.025% bromothymol blue in 2.00 ml of 0.2 N potassium hydroxide. The tubes were placed for 8 min in a boiling water bath and allowed to cool in an ice water bath for 20min. The cooled tubes were laid horizontally over ruled graph paper and the gel length was measured after 1 h.

Statistical Analysis

Data were analyzed using SAS statistical software. $P<0.05$ was considered as significant. AC was analyzed using ANOVA, followed by Duncan's Multiple Range Test. For correlation analysis, Pearson correlation was used.

RESULTS AND DISCUSSION

Amylose content (AC)

Amylose content of the 25 rice varieties analyzed is given in Table 1.

Table 1. Amylose content of some traditional Sri Lankan rice varieties

Variety	Pericarp color	*Maha* AC (%)	*Yala* AC (%)	Pooled amylose (%)
Rathal	White	29.27 ± 0.94	30.05 ± 0.48	29.66 ± 0.81^{a}
Murungakayan	White	30.10 ± 0.50	28.55 ± 0.28	29.32 ± 0.91^{ab}
Kahata Wee	Red	30.94 ± 0.39	27.60 ± 0.21	29.27 ± 1.81^{ab}
Kalu Heeneti	Red	29.15 ± 0.08	29.20 ± 0.26	29.18 ± 0.18^{abc}
Dik Wee	Red	28.28 ± 0.29	30.07 ± 0.29	29.18 ± 0.99^{abc}
Rath Suwadal	Red	29.10 ± 0.23	29.20 ± 0.67	29.15 ± 0.47^{abc}
Hondarawala	Red	29.20 ± 0.26	28.69 ± 0.51	28.95 ± 0.46^{abcd}
Sulai	Red	28.79 ± 0.24	28.64 ± 0.20	28.72 ± 0.22^{bcd}
Gonabaru	Red	30.19 ± 0.25	27.24 ± 0.52	28.72 ± 1.62^{bcd}
Kalubala Wee	Red	29.03 ± 0.41	28.23 ± 0.70	28.63 ± 0.68^{bcde}
Madathawalu	Red	28.60 ± 0.20	28.18 ± 0.33	28.39 ± 0.33^{bcdef}
Batapolal	Red	28.64 ± 0.20	28.11 ± 0.29	28.38 ± 0.37^{bcdef}
Kottayar	Red	27.63 ± 0.21	28.96 ± 0.35	28.29 ± 0.76^{cdefg}
Masuran	Red	27.82 ± 0.21	28.60 ± 0.48	28.21 ± 0.54^{defgh}
Goda Heeneti	Red	27.31 ± 0.21	29.01 ± 0.29	28.16 ± 0.94^{defgh}
Molligoda	Red	28.79 ± 0.44	27.24 ± 0.17	28.01 ± 0.88^{defgh}
Herath Banda	Red	27.51 ± 0.11	28.50 ± 0.32	28.00 ± 0.58^{defgh}
Devaraddhari	Red	27.38 ± 0.50	28.01 ± 0.33	27.70 ± 0.40^{efgh}
Wanni Dahanala	Red	28.52 ± 0.33	26.83 ± 0.26	27.68 ± 0.95^{fgh}
Pachchaperumal	Red	27.65 ± 0.38	27.65 ± 0.13	27.65 ± 0.26^{fgh}
Dahanala	Red	27.14 ± 0.20	27.99 ± 0.40	27.57 ± 0.54^{fgh}
Beath Heeneti	Red	28.11 ± 0.25	26.78 ± 0.64	27.45 ± 0.84^{fgh}
Sudu Heeneti	Red	27.53 ± 0.17	27.17 ± 0.13	27.35 ± 0.24^{gh}
Kattamanjal	White	26.22 ± 0.52	28.43 ± 0.26	27.32 ± 1.24^{h}
Rathu Heeneti	Red	26.59 ± 0.13	26.42 ± 0.25	26.50 ± 0.21^{i}

Data represented as mean ± SD. Values with the same letter are not significantly different. Data were pooled since there was no significant difference between the two seasons.

There was a significant difference ($P<0.05$) in AC among rice varieties and no significant difference ($P>0.05$) was evident due to seasonal difference. Therefore, the selected Sri Lankan traditional rice varieties may genetically have a higher amylose contents and may be less sensitive to the changes in the environmental conditions and to genotype-environment interactions.

Consumer preference for rice around the world, when compared as intact grain, is largely dependent on a desire for its cooked texture to be either firm or non sticky or soft and sticky. Amylose content is the key determinant of the different cooking, sensory and processing properties of rice (Chen *et al.*, 2007).

Based on the amylose content, rice can be classified into waxy (1-2%), very low amylose content (2-12%), low amylose content (12-20%), intermediate amylose content (20-25%) and high amylose content (25-33%) (Frei *et al.*, 2003). Results indicated that AC of selected Sri Lankan traditional rice varieties varies from 27-31% both in *Yala* and *Maha* seasons (Table 1) and are all high amylose varieties.

Yala season is reported to have a higher ambient temperature than in *Maha* season. Maximum and minimum temperatures of *Yala* and *Maha* seasons were 29.1-31.8 °C and 23.1-26.9 °C and 29.5-31.7 °C and 22.1-25.1°C respectively. Endosperm starch AC is influenced by ambient temperature. High ambient temperature decreases the AC. Cool temperature during grain development increases the AC (Juliano, 2003). Other than the environment temperature, genetics play a major role in the amylose content of rice. The level of waxy gene protein increases in lower temperatures resulting in higher amylose content in mature seeds (Suzuki *et al*., 2003). Amylose content thus can vary within the same year and site of cultivation, even within the same cultivar (Suzuki *et al*., 2003). The waxy gene, located in rice chromosome 6, encodes the enzyme granule bound starch synthase (GBSS) which plays a key role in amylose synthesis. In addition to the major effect of the waxy gene, minor genes and the environment are also thought to influence rice amylose content (Chen *et al*., 2007). A single dominant gene with a major effect and several modifying genes with minor effects determine the amylose content in non-waxy strains (Jianrong *et al.*, 2005). The amylose content of *indica* or *indica-japonica* hybrid rice is simultaneously controlled by genetic main effects of seed, cytoplasm and maternal plant and genetic environment interaction effects (Jianrong *et al.*, 2005). In this study, higher AC in *Maha* was not observed compared to that of *Yala* season.

Gelatinization temperature (GT)

Gelatinization temperature of the 25 rice varieties analyzed is given in Table 2. The time required for cooking is determined by the gelatinization temperature of starch. Based on the GT, rice can be classified into high GT (74.5-80 °C), high-intermediate GT (70-74 °C), intermediate GT (70-74 °C), and low GT (<70 °C) (Juliano, 1985). The results indicated that high amylose level was associated with low intermediate and high GT types (Table 2). However, no correlation was observed between AC and GT of rice ($r = -0.09$) tested in this study.

Environmental conditions such as temperature during grain development influence the gelatinization temperature. A high ambient temperature during grain ripening results in starch with higher gelatinization temperature (Faruq *et al.*, 2004). Results indicated that there was no difference in GT of selected Sri Lankan traditional rice varieties between the two seasons.

Gel consistency (GC)

Gel consistency of the 25 rice varieties analyzed is given in Table 3.

GC is a good measure of gel viscosity of milled rice. Based on the GC, rice can be classified into hard GC (26-40 mm), medium GC (41-60 mm) and soft GC (61-100 mm) (Cagampang *et al.*, 1973). GC of the selected Sri Lankan traditional rice varieties was hard, medium or soft according to this classification (Table 3).

There are significant differences in the rice quality among the rice varieties with similar amylose contents although amylose content has been verified as a major determinant for rice grain quality by many researchers (Li *et al.*, 1987; Han and Hamaker, 2001; Yan *et al.*, 2007). In this study, no correlation between AC and GC of tested rice varieties (r = -0.15) were observed.

Table 2. Gelatinization temperature of some Sri Lankan traditional rice varieties grown in *Yala* and *Maha* seasons

Variety	Alkali Spreading Value	Alkali Digestion	GT (°C)	GT Classification
Murungakayan	6	High	<70	Low
Kahata Wee	6	High	<70	Low
Kattamanjal	6	High	<70	Low
Sudu Heeneti	5	Intermediate	70-74	Intermediate
Devaraddhari	5	Intermediate	70-74	Intermediate
Goda Heeneti	5	Intermediate	70-74	Intermediate
Herath Banda	5	Intermediate	70-74	Intermediate
Kottayar	5	Intermediate	70-74	Intermediate
Sulai	5	Intermediate	70-74	Intermediate
Rath Suwadal	5	Intermediate	70-74	Intermediate
Pachchaperumal	5	Intermediate	70-74	Intermediate
Batapolal	4	Intermediate	70-74	Intermediate
Kalubala Wee	4	Intermediate	70-74	Intermediate
Molligoda	4	Intermediate	70-74	Intermediate
Wanni Dahanala	4	Intermediate	70-74	Intermediate
Dahanala	4	Intermediate	70-74	Intermediate
Madathawalu	4	Intermediate	70-74	Intermediate
Hondarawala	4	Intermediate	70-74	Intermediate
Masuran	4	Intermediate	70-74	Intermediate
Gonabaru	4	Intermediate	70-74	Intermediate
Beath Heeneti	3	Low- Intermediate	70-74	High - Intermediate
Rathu Heeneti	3	Low- Intermediate	70-74	High - Intermediate
Kalu Heeneti	3	Low- Intermediate	70-74	High - Intermediate
Dik Wee	2	Low	74.5-80	High
Rathal	2	Low	74.5-80	High

Values obtained were same for both *Yala* and *Maha* seasons

Amylopectin contributes more to gel viscosity than amylose. Rice with higher amylose and more long chain amylopectin tend to have hard cooking properties, whereas rice with lower amylose content and shorter chain amylopectin tend to have a softer texture. The longer amylopectin chain behaves like an amylose chain or branched form of amylose, which suggest that the longer chains of starch whether from amylose, amylopectin or intermediate material is responsible for the texture of rice (Rolando *et al.*, 2004). Other than the structure of amylopectin, GC of rice is affected by genetic effects as well as by environmental conditions such as temperature and day length. Both genotype and environment interactions affect the GC of rice. GC is also affected by degree of milling (lipid content), protein content (proteins contribute to gel viscosity), aging of milled rice (fat oxidation) and rice flour particle size (efficiency of dispersion) (Perez, 1979).

Table 3. Gel consistency of some Sri Lankan traditional rice varieties

Variety	*Maha* season		*Yala* season	
	Gel Length range (mm)	GC	Gel Length range (mm)	GC
Herath Banda	91 - 92	Soft	70 - 78	Soft
Batapolal	65 - 76	Soft	95 - 100	Soft
Kahata Wee	58 - 68	Soft	64 - 68	Soft
Molligoda	92 - 95	Soft	90 - 100	Soft
Kottayar	94 - 98	Soft	92 - 100	Soft
Pachchaperumal	90 - 95	Soft	98 - 100	Soft
Hondarawala	88 - 92	Soft	78 - 85	Soft
Gonabaru	92 - 96	Soft	90 - 98	Soft
Murungakayan	60 - 65	Soft	62 - 68	Soft
Kalu Heeneti	62 - 70	Soft	45 - 48	Medium
Rathu Heeneti	62 - 68	Soft	40 - 44	Medium
Sudu Heeneti	54 - 60	Medium	62 - 65	Soft
Goda Heeneti	58 - 63	Medium	62 - 65	Soft
Devaraddhari	50 - 60	Medium	65 - 75	Soft
Wanni Dahanala	51 - 59	Medium	60 - 68	Soft
Dahanala	42 - 52	Medium	70 - 78	Soft
Sulai	52 - 62	Medium	60 - 65	Soft
Rathal	48 - 56	Medium	50 - 55	Medium
Kalubala Wee	55 - 60	Medium	44 - 52	Medium
Kattamanjal	44 - 52	Medium	53 - 58	Medium
Masuran	43 - 45	Medium	45 - 50	Medium
Beath Heeneti	52 - 58	Medium	50 - 58	Medium
Rath Suwadal	30 - 35	Hard	40 - 44	Medium
Madathawalu	36 - 40	Hard	43 - 46	Medium
Dik Wee	26 - 30	Hard	35 - 39	Hard

GC classification: soft - 61 – 100 mm, Medium - 41 – 60 mm, Hard - 26 – 40 mm

It is anticipated that the findings on AC, GT and GC of traditional rice varieties tested be useful in breeding programmes in improving functional properties of Sri Lankan rice.

CONCLUSIONS

There was a significant difference in AC among the rice varieties tested and no significant difference was evident due to seasonal difference. The AC of selected Sri Lankan traditional rice varieties varies from 27-31% and are all high amylose varieties. GT of the selected rice varieties varied from high, high-intermediate, intermediate and low and GC either hard, medium or soft. There was no correlation between AC and GT, AC and GC and GT and GC of rice varieties tested both in *Yala* and *Maha* seasons. These findings will be useful in rice breeding when choosing selective germoplasms for release or in further developments.

ACKNOWLEDGEMENTS

The authors acknowledge the financial support granted by the Sri Lankan Treasury to Industrial Technology Institute (ITI) (No.10715TG6) and Bombuwala Rice Research Institute for supplying samples for the study.

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