PHYSICO-CHEMICAL AND GRAIN COOKING CHARACTERISTICS OF SELECTED RICE CULTIVARS GROWN IN MOROGORO.

NB Shayo, P Mamiro, CNM Nyaruhucha and T Mamboleo
Sokoine University of Agriculture, Department of Food Science and Technology,
P.O. Box 3006, Morogoro, Tanzania. E-mail; nbshayo@yahoo.com OR nbshayo@suanet.ac.tz

ABSTRACT

A study was carried out at Sokoine University of Agriculture to characterize the local rice varieties grown in Morogoro Region basing on their physical-chemical characteristics and cooking quality parameters. Five cultivars of rice were analyzed and these included Kaling'anaula, Kihogo Red, Salama M17, Supa and Salama. The samples were collected from Crop museum, SUA. The chemical analysis was done to determine the proximate composition, gelatinization temperature and gel consistency as main determinants of cooking quality, sensory evaluation tests was done as determinants for consumer acceptance. The proximate composition results indicated protein content values between 7.94 and 9.46%, ash content between 0.55 and 0.97%, fat content between 0.57 and 0.85%, fiber content between 0.29 to 0.73%. The amylose content values were between 18.25 and 19.25%. The gel consistency results showed that all cultivars analysed were hard with the gel length values between 27.50 and 31.80 mm There was a significant differences in composition as well as acceptability between the varieties. In all aspects, Supa cultivar appeared to be the most superior with mean score of 4.30 while Kihogo Red was the least superior with mean score of 2.93. The differences in the cultivars could be from environmental as well as genetic factors. This pauses a need for more studies to be directed to these factors in order to come up with useful alternatives on how to manipulate them so as to improve the cooking quality parameters, improve production of the local rice cultivars and increase the market demand for local rice.

INTRODUCTION

Rice (*Oryza sativa L.*) is the most important cereal crop in the developing world and is the staple food of over half the world's population. It is a semi-aquatic annual grass plant. About twenty species of the genus *Oryza* are recognized, but nearly all cultivated rice is *O. sativa* L. because of its long history of cultivation and selection under diverse environments. *O. sativa* has acquired a broad range of adaptability and tolerance so that it can grow in a wide range of water and soil regimes, from deeply flooded land to dry hilly slopes. (Lu and Chang 1980). Rice is grown in over 100 countries on every continent except Antarctica, extending from 50º North to South Latitude.

Rice is an important crop in Tanzania, with 60% of the population eating rice. Annual per capital consumption has risen from less than 15 kg in the 1970s (IRRI 2006) to more than 35-40 kg in 2005. Annual rice production in Tanzania decreased from 782,300 MT 2000 to 640,189 MT 2003 representing 18% decrease (GEOHIVE, 2006). In Tanzania rice is a major cash crop and the second most important food crop after maize (Esbern 1999). Most of the paddy in Tanzania is produced mainly by small scale farmers although there are a few large scale paddy farms which are owned by the National Food Corporation (NAFCO). Large scale paddy farming is largely done with irrigated water using modern irrigation facilities while small scale paddy farming is entirely dependent on rainfall. The major paddy producing regions in Tanzania includes Shinyanga, Mwanza, Morogoro, Mbeya and Tabora (MAFC 2005). The rice farmers in Tanzania prefer varieties with good grain quality such as the non-sticky rice with strong aroma (Msomba et al. 2004)

Supa, Kihogo Red and *Kaling'anaula*, local rice cultivars grown in Morogoro region enjoy prime positions in terms of high consumer preference and prices although no adequate information regarding the proximate composition, cooking quality parameters and their physical properties is available. With a view of ascertaining the differences in the quality of the local rice cultivars available in the market, a study to evaluate some of the important physical characteristics and cooking quality parameters was undertaken.

MATERIALS AND METHODS

Sample collection and preparation.

The samples of local rice cultivars grown in Morogoro region were collected from The Crop Museum of Sokoine University of Agriculture. The cultivars were *Salama, Salama M 17, Supa, Kalinang'anaula* and *Kihogo Red.* The five samples were selected based on previous observed farmers rice cultivar selection criteria i.e. productivity, household requirements and market demand. Local cultivars were purposely selected for characterization of physical properties and cooking parameters with the intention of promoting and preserving local rice germplasm. The paddy samples were dried for one day and then milled and stored at room temperature. A small portion of milled kernels from each cultivar was ground into fine rice flour for chemical analyses. The rest of the samples were used for cooking quality, physical characteristics and acceptability studies.

Chemical analysis

Proximate composition of rice was determined using standard methods (AOAC 1995, Pearson 1976, Pomeranz and Meloan 1971). For protein estimation, the factor of 5.17 was used to convert N_2 into protein (Mosses 1990). Amylose content was determined by colorimetric method described by Juliano (1971). Gelatinization temperature was determined by procedure described by Jones (1988). Gel consistency was determined using Cagampang et al. (1973) procedure.

Sensory evaluation

The sensory evaluation was conducted using five-point hedonic scale from very poor to highly acceptable. Four hundred grams of milled grains of each cultivar was cooked under similar conditions (using water, table salt and oil) for 25 minutes. The authors were for rice cooked in the normal way in most households. The cooked rice was left to cool for 10 minutes and then served in 30 equal portions. Thirty panelists who were typical rice eaters were invited to evaluate the appearance, smell, taste and general acceptability of each sample.

Statistical analysis

The results were statistically analysed by a one-way model of variance followed by the Duncan's Multiple Range Test (DMRT) for separation of treatment means at 5% level of probability (Steel and Torrie 1980), using the software package SPSS.

RESULTS AND DISCUSSION

Table 1 presents the proximate composition of five local cultivars grown in Morogoro region**.**

The dry matter values of the rice cultivars analyzed did not differ significantly ($p < 0.05$), however, the values were slightly higher than those reported by Araullo et al. (1976). The results may imply that the grains were very dry, a factor that affects the rice cooking quality in terms of cooking time and water uptake during cooking. It takes a long time for the grain kernels to swell and hence requiring longer cooking time.

Table 1: The proximate composition 1,2 of selected local cultivars of rice grown in Morogoro Region .

Cultivar	Dry Matter %	Ash %	Fiber %	Protein %	Fat %
Kaling'anaula	87.56 ± 0.330^{ab}	0.66 ± 0.035^{a}	0.29 ± 0.028^{a}	9.07 ± 0.021^{c}	0.85 ± 0.21^{a}
Kihogo red	87.84 ± 0.056^{ab}	0.97 ± 0.028^{b}	0.73 ± 0.040^{c}	8.84 ± 0.028^{b}	0.70 ± 0.14^{a}
Salama M17	87.66 ± 0.091^{ab}	0.55 ± 0.014^{a}	0.36 ± 0.028^{a}	9.46 ± 0.021^{c}	0.70 ± 0.19^{a}
Supa	87.37 ± 0.028^{a}	0.83 ± 0.622^{a}	0.40 ± 0.014^{b}	7.94 ± 0.021^{a}	0.83 ± 0.11^{a}
Salama	87.24 ± 0.700^{a}	0.18 ± 0.028^{a}	0.39 ± 0.028^{b}	9.30 ± 0.028^{c}	0.57 ± 0.98^{a}

[1] Means and SD of two independent determinations
[2] Means within a column with the same superscripts are not significantly different using Duncan Multiple Range Test (DMRT) at $p < 0.05$

Ash content of all the rice cultivars was higher than the available literature values. The difference may have been influenced by the differences in mineral content of the soils from which cultivars were grown and also the water used for irrigation. The high ash content may affect the sensory quality of the rice especially colour and taste (Julliano 1985). There was no significant difference ($p<0.05$) in fiber content between *Kaling'anaula* and *Salama M 17* also for *Supa* and *Salama*, however, a significant difference ($p < 0.05$) was reported for the *Kihogo Red* cultivar. Overall the fiber content values were lower than those reported by (Araullo et al. 1976, Shibuya 1989, and Okuda et al. 2005). The differences in fiber content between the cultivars may be due to differences in genotypes and milling conditions. The fiber content affects the rice digestibility (WHO 1985); whereby high fiber content in rice lowers its digestibility. In this case, the cultivar *Kaling'anaula* with the least fiber content has higher digestibility while *Kihogo Red* with highest fiber content is less digestible.

The protein content of all the rice varieties was higher than the value reported for milled rice by Araullo et al. (1976). There was no significant difference ($p < 0.05$) in protein content of *Kaling'anaula, Salama M 17* and *Salama* cultivars. *Kihogo Red* and *Supa* cultivars were significantly different ($p<0.05$) from each other and the rest of the cultivars. Several factors might have contributed to these variation including environmental stresses such as salinity and alkalinity, temperatures and diseases. Others include total nitrogen in the soil and other minerals such as molybdenum and total chlorine which tend to increase the grain protein content (Huang 1990). The rice that has high protein content presupposes high gelatinization temperature and tend to be undercooked (Juliano 1985).

There was no significant difference in fat content in all the rice cultivars despite that the values obtained were higher than those reported in literature (Araullo et al. 1976, Juliano et al. 1989, Wang et al. 2006). The difference could be accounted for by the differences in the degree of milling since most of the fat in rice is concentrated in the aulerone layer of the kernel (Wang et al. 2006). The unpolished milled rice might have remained with some small particles of bran hence causing higher fat values. Fat content influences on the taste of cooked rice i.e. rice with high fat content tend to be tastier and they have less starch (Taira and Fujii 1979).

Table 2: The percentage amylose content of selected local rice cultivars grown in Morogoro region.

Rice cultivars	Percentage amylose content
Kaling'anaula	15.40 $\pm$ 1.27^{c}
Kihogo red	8.25 $\pm$ 1.20^{a}
Salama M17	17.9 $\pm$ 0.28^{d}
Supa	12.95 $\pm$ 0.49^{b}
Salama	19.25 $\pm$ 0.49^{d}

[1] Means and SD of two different determinations
[2] Means within a column with the same superscripts are not significantly different using Duncan Multiple Range Test (DMRT) at $p < 0.05$.

All the five cultivars analysed showed low amylose content since all had percentage amylose content below 20. This indicates that the local rice cultivars analysed are waxy. However, there was a significant difference in amylose content between cultivars. *Kihogo Red* had the least amylose content of 8.25 $\pm$ 1.2 % while *Salama* had the highest value 19.25 + 0.49 (Table 2). The low amylose content observed may have been attributed by high protein content. Low temperature during ripening may increase amylose content (Nikuni et al. 1969). The low amylose content observed signifies that the cultivars analysed might have been ripened at relatively high temperature.

Table 3: Gel consistency and gelatinization temperature of selected local rice cultivars grown in Morogoro

Culivar	Gelatinization length (mm)	Temperature	Remarks
Kaling'naula	30.95 $\pm$ 0.07^{d}	High	Hard
Kihogo red	2865 $\pm$ 0.21^{b}	High	Hard
Salama M17	29.0 $\pm$ 0.14^{c}	High	Hard
Supa	31.80 $\pm$ 0.28^{d}	High	Hard
Salama	27.50 $\pm$ 0.71^{a}	High	Hard

[1] Means and SD of two different determinations
[2] Means within a column with the same superscripts are not significantly different using Duncan Multiple Range Test (DMRT) at $p < 0.05$.

Rice is classified based on gel length as soft (61 to 100mm), medium (41 to 60mm) and hard (27 to 40 mm) (Fan and Marks 199). All the cultivars analysed indicated to be hard since all have length between 27 to 40 mm (Table 3). There was a significant difference in consistency between cultivars analysed. Only *Kaling'anaula* and *Supa* had almost similar gel length values (Table 3) but the rest of the cultivars had significantly different values of gel consistency. The high values of gel consistency are associated with high protein content since high protein content is associated with harder gel consistency (Juliano 1985). The hard gel consistency implies longer time to cook and more water. Most consumers prefer soft than hard gel consistency (Juliano 1985).

Gelatinization temperatures of the different rice cultivars are reported in Table 3. The temperature directly affects the physical properties of the starch granules, which in turn influence the quality ratings of cooked rice. Similarly affects the degree of cooking of rice. Rice is classified as having high, intermediate and low gelatinization temperature based on the degree of dispersion of milled rice grains in the solution of potassium hydroxide after 23 hours at 30°C (Fan and Marks 1999). All the cultivars indicated high gelatinization temperatures since all the kernels were not affected by the alkali (Table 3). The high gelatinization temperature observed in the varieties implies that all the cultivars will require long cooking time and more water. Long cooking time will have an effect on the taste and aroma of the rice because some volatile components are likely to be lost during cooking which would contribute to the flavour and aroma of the cooked rice. There was a significant variation in appearance of the five cultivars (Table 5). The cultivar *Supa* scored the highest with a mean of 4.53, which was "highly acceptable" by 63.3% of all the panelists. *Salama M 17* scored the lowest with a mean value of 2.93 which was "satisfactory" by 30% of all the panelists.

Table 4: The sensory quality attributes of selected local rice cultivars grown in Morogoro

Cultivar	Appearance	Smell	Taste	General Acceptability
Kaling'naula	3.73 ± 0.58^{b}	4.66 ± 0.48^{b}	4.03 ± 0.72^{b}	3.76 ± 0.72^{b}
Kihogo red	3.70 ± 0.59^{b}	$4.23 \pm 0.77a^{b}$	3.47 ± 0.89^{a}	2.93 ± 0.83^{a}
Salama M17	2.93 ± 0.78^{a}	3.63 ± 0.81^{a}	3.60 ± 0.85^{a}	2.93 ± 0.83^{a}
Supa	4.53 ± 0.68^{c}	3.70 ± 0.79^{a}	4.40 ± 0.72^{b}	4.30 ± 0.70^{c}
Salama	3.66 ± 0.88^{b}	3.76 ± 0.73^{a}	3.50 ± 0.79^{a}	3.76 ± 0.79^{b}

[1] Means and SD of two different determinations
[2] Means within a column with the same superscripts are not significantly different using Duncan Multiple Range Test (DMRT) at $p < 0.05$.

The highly aromatic *Kaling'anaula* cultivar was the most preferred with mean score of 4. by 66.7% of the panelists who responded to "acceptable" in the preference scale, while *Salama M17* cultivar with the mean score of 3.63 by 6.7% of the panelists who responded "not acceptable" was the least preferred. There was no significant difference ($p<0.05$) among all the varieties except for cultivar *Kaling'anaula*. The taste of *Supa* and *Kaling'anaula* were significantly different ($p < 0.05$) from the rest of the cultivars tasted. *Supa* scored the highest with a mean score of 4.40 by 26.7% of the panelists who responded "highly acceptable". *Kihogo Red* was the least preferred. There was significant difference between the cultivars in terms of general acceptability.

The cultivar *Supa* was the most acceptable on the basis of appearance, aroma and taste, with mean acceptance of 4.30 by 43% of the panelists. *Kaling'anaula* was the second most acceptable with mean preference of 3.76 followed by *Salama* and lastly *Kihogo Red* and *Salama M17* which appeared to be equally least accepted with mean preference of 2.93.

CONCLUSIONS

The study revealed that the cultivar *Supa* was the best with respect to the studied characteristics followed by *Kaling'anaula*, and then *KihogoRed* and *Salama* and *Salama M17* scored the least in most of the characterisitics investigated. It should be realized that the physico-chemical characteristics and cooking quality characteristics greatly influence the farmers and consumers of a rice cultivar, marketability and prices, factors that pause a challenge to researchers on how to manipulate the culinary characters so as to increase the market-added value of improved rice cultivars.

ACKNOWLEDGEMENTS
The authors wish to thank the Sokoine University of Agriculture for the financial support and the Crop Museum of Sokoine University of Agriculture for providing the rice cultivars.

REFERENCES
AOAC 1995 Official Methods of Analysis of AOAC International., 16th edn, Vol.II. Association for Official Analytical Chemists International, Arlington, VA, USA.
Araullo EV, Padua DB and Graham M 1976 Rice Postharvest Technology. Int. Dev.Res. Cent., Ottawa, Canada.
Cagampang GB, Perez CM and Juliano BO 1973 A gel consistence test for eating quality of rice. *J. Sci. Food Agric*., **24:** 1589-1594.
Esbern FH 1999 Tanzania forgotten farmers. SEEDING: The quaterly Newsletter of Genetic Resource Action International (December, 1999).
Fan J and Marks BP 1999 Effects of rough rice storage conditions on gelatinization and retrogradation properties of rice flours. *Cereal Chem.,* **76(6)**: 894-897.
GEOHIVE 2006 World rice production. http://www.geohive.com/global/geo.php?xml=ag_rice&xsl=ag. Accessed 24/05/2006.
Huang PC 1990 Changing pattern of rice grain production, consumption and dietary life in Taiwan. In: *Proceedings, International Symposium, Dietary life of Rice Eating Populations*, 24 October 1987,. Kyoto Research Institute for Production Development Kyoto, Japan.
IRRI 2006 International Rice Research Institute Report. **http://www.irri.org/science/cnyinfo/tanzania.asp**. Accessed 24/05/2006
Jones JW 1988 The alkali test as a quality indicator of milled rice. *Am. Soc. Agron*. **30**: 960-967.
Juliano BO 1971 A simplified assay for milled rice amylose. *Cereal Sci. Today* **16**:334-340.
Juliano BO 1985 Factors affecting nutritional properties of rice protein. Trans. *Natl. Acad. Sci. Technol. (Philipp.)* **7:** 205-216.
Juliano BO, Perez CM, Maranam CL, Abansi CL and Duff B 1989 Grain quality characteristics of rice in Philippine retail markets. *Philipp. Agric.* **72:** 113 – 122.
Lu JJ and Chang TT 1980 Rice in its temporal and spatial perspective. In: Luh BS (ed) *Rice. Production and utilization*. , AVI Publishing Co. Westport, CT, USA.
Nikuni Z, Hizukuri S, Kumaga, K, Hasegawa H, Moriwak, T, Fukui T, Doi K, Nara S and Maeda I 1969 The effect of temperature during the maturation period on the physico-chemical properties of potato and rice starches. *Mem. Inst. Sci. Ind. Res. Osaka Univ*, **26**: 1-27.
MAFC 2005 Ministry of Agriculture, Food and Cooperatives - crops. **http://www.agriculture.go.tz/index.htm** Accessed 24/05/06
Mosses J 1990 Nitrogen to protein conversion factor for ten cereals and six legumes or oilseeds. A reappraisal of its definition and determination. Variation according to species and to seed protein content. *J. Agric. Food Chem*. **38:**18-24.
Msomba SW, Kibanda JM, Tusekelege H, Mkuna M, Kafiriti E, Mbapila JC and Kanyeka ZL 2004 TXD 306-a high yielding and medium maturing

aromatic rice for the rainfed lowland and irrigated ecosystems in Tanzania. *Intern. Rice Res. Notes* **29.1**.

Okuda M, Aramaki I, Koseki T, Satoh H and Hazshizume K 2005 Structural characteristics properties and in vitro digestibility of rice. *Cereal Chem.* **82(4):** 361– 368.

Pearson D 1976 Chemical Analysis of Foods*,* 7th edn, Edinburgh/ London/Churchill Livingstone, New York.

Pomeranz and Meloan CC 1971 Food Analysis: Theory and Practice*,* AVI Publishing Co.Westport, CT, USA.

Shibuya N 1989 Comparative studies on the cell wall polymers obtained from different parts of rice grains. In: Lewis NG and Paice MG (eds) *Plant cell wall polymers* Biogenesis and Biodegradation, Symp. No.399.

Steel RGD and Torrie JH 1980 The Principles and Procedures of Statistics. McGraw Hill, New York

Taira H and Fujii K 1979 Influence of cropping season on lipid content and fatty acid composition of lowland nonglutinous brown rice. *Nippon Sakamotsu Gakkai Kij*i,

Wang, HL, Wan, XY, Bi, JC, Wang, JK, Jiang, L, Chen, LM, Zhai HQ, and Wan, JM 2006 Quantitative analysis of fat content in rice by Near Infrared Spectroscopy Technique. *Crereal Chem.* **83(4):**402-406

WHO 1985 Energy and Protein requirements. Report of Joint FAO/WHO/UNU Expert Consultation. WHO Tech. Rep. Ser. 724. WHO, Geneva.