Available online @ www.actasatech.com

*acta*SATECH 4(2): 145 -156 (2013)

Research

Cooking Aspects of Nigerian Milled Rice Quality

Adeyeye, J. A[1].; Navesero, E. P[2].; Ariyo, O. J[3]

[1]*Department of Nutrition and Dietteics, Babcock University, Illisan, Remo*
[2]*Rice Quality Lab. IITA, Oyo Road, P. M. B. 5320. Ibadan*
[3]*University of Agriculture, Abeokuta. Nigeria*

*Corresponding author: <joshuaadeyeye@yahoo.com>

Abstract

This study aimed at identifying factors affecting the cooking quality of rice preferred by Nigerians and consequently to improve the locally produced rice to the taste of Nigerians. A total of 23 rice varieties were acquired from experimental fields of National Cereal Research Institute (NCRI), International Institute of Tropical Agriculture (IITA) in Ibadan and Badegi Rice Breeding Centre in Bida. Three (3kg) of each samples was parboiled, dried and milled. Cooking test were done on both parboiled and unparboiled samples to determine water up-take, volume of expansion, gell consistency and solid residue ratio. Parboiled samples took a longer time to cook, had lower water absorption and decreased percentage solid residue. Texture of parboiled cooked rice was fluffy and less moist, cooked separate when compared to unparboiled rice samples. The work was funded and supported by Rice Quality Program of IITA, for which the author is most grateful.

Introduction

Rice is used as food for human consumption. Boiled rice constitutes the largest consumption usage all over the world. Rice is also used in the form of dry breakfast cereal, canned rice, rice cakes, baby foods, adjunct in the brewing industries, rice flour as thickner in sauce gravies, pudding and some in preparation of fermented rice foods (Luh, 1980). As a result of these numerous uses, rice grain that is suitable for use in one purpose may not be suitable for another (Okwuriwe, 1974).

Cooking and processing as well as milling quality are fundamental qualities that determine the economic value of rice grain. Amylose content of rice is a major determinant factor for predicting rice cooking quality (William et. al., 1958; Halick and Keneater, 1956). Evaluations of rice quality based on a series of physicochemical tests serve as index of rice cooking and processing properties. However, these physical and chemical tests only predict and explain some of the observed differences in rice cooking and processing properties.

Generally, consumers vary greatly in their preference for cooked rice. While some prefer a cooked rice to be fluffy, dry and moderately hard, others desire moist and sticky rice. The cooking and eating characteristics of milled rice are influenced by the ratio of amylose and amylopectin (Sanjiva et. al., 1952). Amylose is almost absent from waxy (glutinous) rice. Such rice do not expand in volume and when cooked is glossy and sticky. However, rice varieties with high amylose content show high volume expansion and high degree of flakiness when cooked. Such rice cooks dry, hard and separate upon cooling (Luh, 1980). The intermediate amylose rice (20-25%) cooks moist and tender and does not become hard, while low amylose rice (10-20%) amylose has cooking properties between the intermediate and the waxy rice (IRRI, 1980).

Parameters used to evaluate the cooking qualities of rice include: swelling property, grain dimensions, milling recovery, chalkiness, water uptake at 60o-70oC, alkali degradation, starch gelatinization and pasting characteristics of rice starch. These properties may influence the selection of rice for use in various kinds of rice food products (Juliano et. al., 1965; Juliano, 1985). Quality evaluation of rice grain therefore is essential to determine the suitability of rice for a particular use. This work was therefore designed to achieve a rapid method of selecting rice grains with satisfactory cooking property required for usage by Nigerians.

Materials and Methods

Materials

Eight paddy rice samples from National Cereal Research Institute (NCRI) and eleven paddy rice varieties from International Institute of Tropical Agriculture (IITA) plus four additional paddy rice samples from Badegi Rice Breeding Centre were utilized for the study.

Parboiling Process

A total of 3 kg of each sample was processed by using modified parboiling method. Cleaned paddy rice sample of about 1500 g was steeped in 2L of distilled water at 80ºC for 6hr in water bath equipped with calibrated thermometer. The steeped paddy was then immersed and steamed for 18min in 2.5L of boiling distilled water using a laboratory electric steamer. The steamed paddy rice was then oven dried at 130ºC to about 16% moisture content and slowly dried to 11-13% moisture content in the shade drying (tempering) at room temperature to avoid grain kernel stress. Data were collected on physical, chemical and cooking properties of rice.

Whole Grain Rice Preparation

Triplicate of 200g of each rice sample of parboiled and unparboiled paddy was hulled in a laboratory Satake Husker (model: THU) operating on two robber roller system set at 0.8mm to determine the amount of hull to the brown rice. Also the triplicate of brown rice collected for unparboiled and parboiled rice sample was further milled to determine the amount of bran to that of polished rice.

The Grainman Milling Machine (model: 60-220T) a frictional type of milling machine with prescribed additional weight on the pressure cover milled the brown rice for 2min each in one pass. The difference in weight of brown rice to that of polished rice was used to calculate the percentage of bran and polished rice. A laboratory grader or disc separator (model: TGR) was used to determine the percentage of whole rain (head rice) to that of the brown rice. Most of the broken rice was discarded.

Grain dimensions

The average length and breadth of 20 kernels of brown rice were measured suing the caliper.

Alkali Digestibility Test

Alkali degradation on rice grain was done as an index of gelatinization temperature (gel. T) on milled rice of unparboiled and parboiled samples following the procedure of Little et. al.,1958). Six kernels of whole milled rice in triplicate were arranged so that the kernels did not touch each other, were then introduced into plastic boxes (4.6 x 4.6 x 1) cm3 containing 10ml of 1.7% KOH. The boxes were covered and incubated for 23hr at 30ºC. Evaluations were done visually to determine the extent of disintegration of the endosperm. Rice with low gelatinization temperature (gel.T) disintegrated completely while rice with intermediate gel.T showed partial disintegration and rice with high gel.T remained unaffected in the alkali.

Rice Amylose Content Test

Percentage amylose content in rice four was evaluated using Technico Auto-analyzer (model: TNII). The accuracy of this method was verified using the 300-N Micro-sample spectrophotometer determining in triplicates the percentage amylase content of rice flour following the methods of William et. al.,1958).

Percentage Rice Starch Content

The percentage starch content of rice flour for unparboiled and parboiled sample was determined using the phenol-sulphuric acid methods of Duboise et. al.,(1956).

Cooking test

Ranghino's (1966) method was adopted to determine the cooking time of polished rice samples. Triplicate 5g samples of whole milled rice were added into vigorously boiling 135ml of water in a 250ml beaker. After 12 minutes of boiling about 10 grains were removed each time with a perforated ladle and pressed between glass plates. The grains were considered cooked when at least 90% of the pressed grains no longer had opaque uncooked centers. The small scale cooking test procedure was also used following the methods of Batchet et. al., (1956) to determine the water uptake ratio and volume expansion ratio directly from the weight of cooked and raw rice.

Statistical Analysis

Analysis of variance was used to test the data and the differences among the means were compared using Duncan multiple range test (Duncan, 1955). Also simple correlation coefficients were calculated in all possible combinations between the cookie quality characteristics and instrumental parameters (Duncan, 1955).

Results and Discussions

The cooking properties of unparboiled, polished rice varieties are presented in Table1. Under cooking time (min), ART 12 rice variety had the longest cooking time of 31min, followed by ITA 118, ITA 132, IRAT 170 and IRAT 133 with corresponding cooking times of: (26, 26, 28, 29 min) respectively, while FARO 27, ITA 175, TOX 711 and TOX 894 varieties had the lowest cooking time of (20min) each. Under water uptake ratio ITA 132 had the highest water uptake ratio of 4, followed by FARO15 with ratio 3.9, while ITA 117 and IRAT 133 had the lowest ratio of (3.0) each. Under the value of expansion ratio ITA 132 and 1TA 175 had the highest volume of expansion ratio: (8.7 and 8.6), followed by ITA 131, ART 12 and FARO 29 with ratio: (6.7, 6.8 and 6.9) respectively, while IRAT 133 had the lowest volume of expansion of ratio 4.2. Under percentage solid residue IRAT 170 had the highest solid residue of 1.4% followed by ART 12 with 1.3% while FARO 12 with 0.2% had the least percent solid residue.

The cooking characteristics of parboiled, polished rice varieties are presented in Table 2. Under cooking time in minutes, ART 12 and ITA 144 had the longest cooking time of (32min) each, followed by IRAT 112 and IRAT 170 having (29min) of cooking time each, while TOX 711 and TOX 711 had the least cooking time of (21min) each. Under water uptake ratio, ITA 128, ITA 131 and ITA 132 rice varieties had the highest water uptake ratio of 3.3 each, followed by ITA 175 with (3.2) ratio, while IRAT 112 had the least water uptake (2.6) ratio. Under volume of expansion ratio, ITA 131 had the highest ratio of 5.9, followed by ITA 132 with a ration of 5.6, while ITA 118 had the least volume of expansion ratio of 2.6. Under the percentage solid residue, ITA 144 had the highest solid residue of 0.6%, followed by ART 12, ITA 131 and ITA 132 with 0.5% solid residue each, while FARO 12, FARO

15, and FARO 27 had the least percent solid residue of 0.2 for each sample.

The effect of parboiling and unparboiling processes on the cooking properties of rice varieties are presented in Table 3. The mean value between parboiled and unparboiled rice with respect to cooking time, water uptake ratio, volume of expansion and solid residue were significantly different. Parboiling processes elevated the cooking time and depressed the water- uptake ratio, volume of expansion as well as solid residue. The fact that the cooking time was higher in parboiled than unparboiled rice was probably due to the protein bodies that formed a complex with gelatinized starch in parboiled rice resulting in lowered water absorption, therefore requiring higher heat energy to cook the rice grain soft. Consequently, it took a longer time to cook parboiled rice samples. The fact that water uptake ratio, volume of expansion and solid residue were higher in unparboiled rice than those in parboiled rice can partly be explained by the fact that water absorption in raw rice occurred rapidly during the initial stage of heat treatment whereas starch granules swelled and increased before the starch gelatinized. The solid residue is an index of leaching out of amylose fraction of cooked starch. The solid residue increased also due to rupture and solubility of amylose formed the bulk of soluble material from starch granules heated in water, it is possible that the greater amylose content of rice starch in raw rice resulted in greater solubility of starches at higher temperatures.

The correlation coefficient of physicochemical properties of parboiled rice varieties are presented in Table 4. Grain hardness exhibited a negative correlation with amylose content suggesting that rice varieties of low amylose content are harder in texture after parboiling. Also in parboiled rice starch content had a positive correlation with water up-take, but had negative correlation with gel consistency, whereas starch content was only negatively correlated with volume of expansion. The positive correlation between rice starch content and water up-take ratio suggested that rice grains with low protein content absorbed water rapidly during cooking and as a result swelled considerably. The negative correlation between starch content and gel consistency of parboiled rice indicated the characteristic of rice starch of intermediate flakiness. Solid residue was negatively with volume of expansion this relationship suggested that rice starch with lower soluble fractions will swell to a significant degree with increasing volume of expansion. Also water up-take ratio exhibited a positive correlation with solid residue indicating that rice with high soluble fractions of starch can still absorb water during cooking to a considerable degree to enhance its swelling capacity. Finally, volume of expansion exhibited a negative correlation with solid residue in parboiled rice, this correlation confirmed the fact that rice starch with lower soluble fractions could swell to a noticeable level during cooking activities.

Conclusions

It is noted that parboiling treatments altered the physical, chemical, cooking and eating qualities of rice varieties. The result indicated that parboiling process and subsequent gelatinization harden the rice grain hence parboiled rice require longer time to cook to a soft consistency. The results also indicated that prolong cooking promoted the exudation of amylose fraction of rice starch into cooking water, since amylose formed the bulk of soluble material from rice starch granules heated in water. Also it is possible that amylose content of rice starch in raw rice resulted in greater solubility of starches at higher cooking temperatures. The fact that cooking time was higher in parboiled rice than unparboiled rice was probably because the protein bodies formed a complex with gelatinized starch of parboiled rice resulting in lowered water absorption and this requires higher heat to cook the parboiled rice samples.

References

Batcher, O. M., Helminotoller, K. F. and Dawson, E. A. 1956.Development and application of methods for evaluating cooking and eating quality of rice. Rice Journal. 59(3): 4-8.

Duboise, M.; Gilles, K. A.; Hamilton, J.; Robert, P. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. Analytical Chem. Vol. 28: 350-356.

Duncan, D. B. 1955. Multiple Range and Multiple F- test. Biometrics: 11-42.

Halick, J. V. and Keneastev, K. K. 1956. The use of starch-iodine blue test as a quality indicator of white milled rice. Cereal Chemistry 33: 315-319.

(IRRI): International Rice Research Institute. 1980. Quality characteristics of milled rice, grown in different countries. Juliano, B. O. and Pascual, C. G. (editors), Los Banos. Phil.: 1-25.

Juliano, B. O. Onate, L. U. and del –Mundo, 1965. Relation of starch composition, protein content and gelatinization temperature to cooking and eating qualities of milled rice. Food Tech. 19: 1006-1011.

Juliano, B. O. 1985. Co-operative test on cooking properties of milled rice. Cereal Food World, vol. 30: No. 9: 651-656.

Little, R. R.; Hinder, G. B. and Dawson, H. 1958. Differential effects of dilute Alkali on 25 varieties of milled white rice. Cereal Chem. 3; 111-126.

Luh, S. B. 1980. Rice: Production and utilization. Avi. Pub. Comp.Inc. Westport Conn.; 360-712.

Okwuraiwe, P. E. 1974. Biochemical and Nutritional changes involved in mechanical processing of selected rice varieties. Ph.D. dissertation. University of Ibadan

Ranghino, F. 1966. Valtutazion del resistanza del rise all conttura. In: Rice Quality testing methods (IITA): 12 .

Sanjiva, B. Vasudera, R. Subrahamanya, R. 1952. The amylose and amylopectin content of rice and their influence on cooking quality of cereal. In: IRRI. Annual Report of 1976. Los Banos Philippines.

Willam, V. R.; Tsai, Y. and Bates, H. 1958. Varietal differences in amylase content of rice starch. J. Agric. Food Chem. 6: 47-49.

APPENDIX

TABLE 1. COOKING PROPERTIES OF PARBOILED AND UNPARBOILED RICE VARIETIES

VARIETIES	COOKING TIM (min)	WATER-UPTAKE Ratio	VOLUME EXPANSION Ratio	% SOLID RESIDUE
ITA 117	23.0	3.0	4.4	0.6
ITA 118	26.0	3.2	5.3	0.5
ITA 123	21.0	3.4	6.2	0.3
ITA 128	25.0	3.2	5.8	0.4
ITA 144	30.0	3.5	5.2	0.8
ITA 212	23.0	3.7	6.0	0.8
RARO 11	27.0	3.2	4.6	0.8
FARO 12	21.0	3.7	6.3	0.2
FARO 15	21.0	3.9	5.4	0.5
FARO 27	20.0	3.6	5.3	0.5
FARO 29	23.0	3.7	6.9	0.4
IRAT 112	27.0	3.4	4.5	0.6
IRAT 133	29.0	3.0	4.2	0.5
IRAT 170	28.0	3.2	4.5	1.4
ART 12	31.0	3.5	6.8	1.3
ITA 131	25.0	3.5	6.8	1.3
ITA 132	26.0	4.0	8.7	0.7
ITA 175	20.0	3.4	8.6	0.4
TOX 1768	24.0	3.5	5.7	0.4
ITA 222	22.0	3.4	4.4	0.5
ITA 234	21.0	3.6	5.2	0.8
TOX 711	20.0	3.4	5.7	0.5
TOX 894	20.0	3.6	5.7	0.6
LSD	0.84	0.06	0.29	0.06

Each value is the mean of three samples

TABLE 2. COOKING CHARACTERISTICS OF PARBOILED, POLISH RICE VARIETIES

VARIETIES	COOKING TIM (mins)	WATER-UPTAKE Ratio	VOLUME EXPANSION Ratio	SOLID RESIDUE
ITA 117	24	2.9	3.5	0.4
ITA 118	27	2.8	2.6	0.4
ITA 123	24	3.0	3.2	0.3
ITA 128	27	3.3	4.1	0.4
ITA 144	32	2.8	3.7	0.6
ITA 212	24	3.1	2.9	0.4
RARO 11	28	2.8	2.3	0.3
FARO 12	22	3.0	2.8	0.2
FARO 15	22	3.0	4.3	0.2
FARO 27	22	2.9	4.5	0.2
FARO 29	24	2.9	3.0	0.3
IRAT 112	29	2.6	4.9	0.3
IRAT 133	30	2.7	4.9	0.4
IRAT 170	29	2.8	5.2	0.4
ART 12	32	3.0	4.8	0.5
ITA 131	26	3.3	5.9	0.5
ITA 132	27	3.3	5.6	0.5
ITA 175	21	3.2	2.9	0.3
TOX 1768	25	3.0	2.9	0.3
ITA 222	23	2.9	3.0	0.4
ITA 234	22	2.9	2.8	0.3
TOX 711	21	3.0	2.8	0.3
TOX 894	21	3.1	2.9	0.3
LSD	0.85	0.14	0.26	0.03

Each value is the mean of three samples

TABLE 3.. THE EFFECT OF PARBOILING ON COOKING PROPERTIES OF RICE.

Cooking properties	X Unparboiled	X parboiled
Cooking Time	24.04b	25.31a
Water uptake Ratio	3.46a	2.97b
Volume of Expansion	5.74a	3.72b
Solid Residue	0.61a	0.35b

Means not followed by the same letters are significantly different from each other by Duncan's Multiple Range Test at 0.05 level of probability.

Table 4. Correlation Coefficients of Physicochemical Properties of Milled Parboiled Rice Varieties

	Head rice	Broken	Grain Hardness	Length	Breadth	Protein	Amylose	Starch	Gel. Consistency	Uptake	Volume	Solid residue
Head Rice												
Broken	-0.97**											
Grain Hardnes	0.19	-0.21										
Length	0.27	-0.24	0.09									
Breadth	0.55**	-0.52	-0.07	-0.17								
Protein	0.09	0.01	-0.26	0.16	0.42*							
Amylose	-0.62**	0.67**	-0.43*	-0.00	-0.64**	0.14						
Starch	-0.07	0.10	-0.22	0.08	-0.28	-0.07	0.12					
Gel. Con.	0.54**	-0.64**	0.19	0.12	0.49*	0.03	-0.66*	-0.41*				
Uptake	-0.25	0.33	0.02	-0.03	-0.03	-0.03	0.05	0.44*	-0.55**			
Volume	-0.19	0.09	0.22	-0.08	-0.21	-0.28	-0.11	-0.27	0.43*	-0.33		
Solid	0.05	0.05	0.08	-0.04	0.21	0.11	-0.17	0.40	-0.53**	0.83**	-0.67**	1

*, **, Significant at 5% and 1% level respectively.

Gel. Conc. = Gel. Consistency
Uptake = Water uptake Ratio
Volume = Volume Expansion Ratio