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Research

Biological and Chemical Qualities of Some Nigerian Rice Varieties: Effects on Processing and Utilization

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ABSTRACT

This study aimed at evaluating the biological and chemical qualities of some Nigerian rice varieties and identifying the rice quality that will satisfy the various usage of rice by Nigerians for their rice food diets. Twenty three rice varieties were acquired from experimental fields of National Cereal Research Institute (NCRI), International Institute of Tropical Agriculture (IITA) in Ibadan and Badegi. Triplicate (250g) of each sample of parboiled and unparboiled paddy at 12-13% moisture content was dehulled in a laboratory Satake Husker (model: THU) set at 0.8mm milled and polished in 2mins in a Grainman Milling Machine. A laboratory grader disc separator (model: TRG) was used to determine the percentage of whole grain to that of broken rice. Data were collected on percentage milling fractions, thousand kernel weight, grain hardness, length, breadth, and alkali digestibility. Crude protein content was determined in triplicate using the Kjeldahl process outlined in AACC methods based on 16.8% N in rice protein. Amylose content of rice flour was evaluated using Technicon Auto analyzer (model:IN11) and verified using 300-N-Microsample Spectrophotometer. Data were subjected to analysis of variance and the differences among the means were compared by Duncan Multiple Range Test. Significant differences in thousand kernel weight ranged from 24.0g (ITA 212) to 40.8g (IRAT 170). ITA 144 and IRAT 170 had the heaviest kernel and paddy while FARO 27 and ITA 212 had the lightest kernels. It appeared that the heavier the paddy the heavier the kernel. ITA 117 and ITA 131 had the highest rigidity, a characteristic that would offer greater resistance to insect perforation and inhibition of microbial and fungi invasions at storage temperature. Parboiling increased the yields of brown rice, polished and head rice significantly. It ranged from 76.0% (FARO 12 and FARO 29) to 90.4% (ITA 117). Thus parboiling can prevent abrasion and rice breakage.

Crude protein content of parboiled rice flour ranged from 6.0% (ITA 128, ITA 131, TOX 1768, ITA 234) to 9.8% (IRAT 170) making such rice a possible source of protein in the diets of Nigerians. These results indicated that some Nigerian rice possess some qualities found in imported rice. It suggests that for any rice improvement in Nigeria, these biological and chemical attributes and parboiling methods should be considered.

KEY WORDS: Parboiled rice, alkali digestibility, gel consistence, rice kernel hardness, brown rice, head rice.

Introduction

Rice (*Oryza Sativa*) is the staple food for over half the population of the world. It is grown as upland crop where there is no standing water and rainfall is the sole source of moisture and grown during dry season using irrigation system where such water is diverted to the farmland. In Nigeria, rice ranks the sixth crop in land area after cowpea, cassava, sorghum, millet and yam (FAO, 1994). Rice is grown in all ecological zones of Nigeria with different varieties possessing adaptation for each zone (Ayotade, 1981). The leading rice producing states in Nigeria includes: Niger, Sokoto, Kongi, Taraba, Kwara, Ogun, Anambra and Edo (Olusanya, 1987). Rice generally assumed a staple status in the Nigerian diet about a decade past. However, the increase in demand for rice was not accompanied with corresponding increase in production which resulted in an increase in rice importation. Nigeria preferred imported rice to the locally produced rice because of good processing and consequent improvement in cooking qualities of the imported rice (Umore, 1985). To improve the quality of rice to the taste of Nigerians, work needs to be done to determine the choice of rice quality that will satisfy the taste of Nigerians. This work was therefore designed to achieve the following objectives:

1. To screen and characterize Nigerian rice varieties on the basis of their biological qualities.
2. To determine the effects of processing on biological and chemical qualities of rice.
3. To identify rice qualities that will satisfy rice processing requirements and usage by Nigerians.

Materials and Methods

Fifteen paddy rice varieties from National Cereal Research Institute (NCRI) and eight additional paddy rice varieties from International Institute of Tropical Agriculture (IITA) were used for the study. These twenty three paddy rice were domesticated in the experimental fields of IITA and NCRI.

Parboiling Methods

Cleaned paddy sample of 1900g was steeped in a 2.5L of distilled water for 6 hours in a laboratory water bath at 60^{o}C. The steeped water paddy rice was then cooled for 18mins in a laboratory electric steamer. The steeped paddy was then oven dried at 130^{o}C to about 16% moisture content and further dried to 12-13% moisture content in the shade drying (tempering) at ambient temperature. Data were collected on the biological and chemical qualities of parboiled paddy rice. The data will include parameters on: rice kernel length, rice breath and shape, rice kernel hardness, rice flow characteristics in of milled rice.

Milling Characteristics

Triplicate (250g) of each sample of parboiled and unparboiled paddy at 12-13% moisture content was de-hulled in a laboratory Satake Husker (model: THU) operating on two rubber roller system set at 0.8mm and polished for 2mins in a Grainman Milling Machine (model: 60-220T).

Percentage Milling Fractions

A laboratory grader or disc separator (model: TRG) was used to determine the percentage of whole grain (head rice) to that of the broken rice. Data were collected on seven biological characteristics of parboiled and unparboiled rice samples which included: percentage milling fraction, thousand kernel weight, kernel hardness, length, breadth measurement and alkali digestibility.

Thousand Kernel weight

Thousand kernel weight or brown rice and paddy were determined for 100 kernels of both parboiled and unparboiled samples and then multiplied by a factor of 10. There were three replications. The average length and breadth of brown rice (20) were calculated using a calibrated caliper.

Rice Kernel Hardness

The Kiya Grain Hardness Tester modified by tapering the pressure rod to a circular point with an area of 0.49mm^2 as a constant was employed to test the hardness of polished rice. Twenty whole grain of polished unparboiled rice were tested by positioning one kernel at a time on a circular disk and rotating the pressure knob clockwise until the grain breaks. The registered pressure required to break the grain were recorded in kg/mm^2. The mean pressure of 20 grains and the grain hardness were calculated using the procedure outlined by Kongserree & Juliano (1972).

$$\text{Hardness kg/mm2} = \frac{\text{mean Pressure}}{0.49\text{mm}^2}$$

Alkali digestibility, an index of gelatinization temperature (gel. T), was carried out on milled unparboiled rice samples following procedure of Little *et al*. (1958).

Chemical Characteristics

Moisture content and crude protein (%N x 5.95) content of samples were determined by American Association of Cereal Chemists (AACC, 1962) methods. Amylose content of rice was evaluated using Technicon Auto-analyzer (model: INII). The accuracy of this method was verified using the 300-N Micro-sample Spectrophotometer (William *et al*., 1958). The flour crude protein was determined in triplicate using Kjeldahl procedure of 1976. Total nitrogen for each sample was multiplied with a factor of 5.95 which is based on the 16.8% Nitrogen in rice protein (IRRI, 1980). The percentage starch content of rice flour for parboiled and unparboiled sample was determine using phenol-sulphuric acid method of Duboise *et al*. (1956).

Gel consistency

The gel consistency test, an index of flow characteristics of milled rice gel was carried out on the flour sample according to Cagampang's (1973) method.

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).

Results and Discussion

The biological characteristics of unparboiled rice varieties are presented in Table 1. There were significant differences in the 1,000 kernel weight of rice samples ranging from 24.6g (ITA 212) to 40.8g (IRAT 170). After dehulling, the thousand kernel weight of brown rice did not follow the same trend as observed for the paddy rice probably because the weight of the hull differed among the varieties. ITA 144 and IRAT 170 had significantly heaviest kernel as well as paddy, while FARO 27 and ITA 212 had significantly lightest kernel and paddy. It appeared that the heavier the paddy the heavier the kernel. The heavy kernel and paddy characteristics exhibited by ITA 144 and IRAT 170 rice varieties may be partly due to the ability of these rice cultivars to adapt favourably to the environment during prolonged ripening stage where rice grains are fully filled with carbohydrates and other dry matters (del-Rosario *et al*., 1978). The light kernel and paddy in FARO 27 and ITA 212 can be attributed to increased respiratory consumption of carbohydrates during prolonged ripening stages as well as spikelet sterility and the degeneration of panicle tips (Luh, 1980).

Grain length ranges from 6.4mm (IRAT 133) to 8.9mm (FARO12). Long thin grain rice tend to break more easily during dehulling and debraning (FARO 12, FARO 15, FARO 27 and ITA 123), than shorter fatter grains (ITA 133, IRAT 133, ART 12 and ITA 123). FARO 12 with the longest and relatively broad rice kernel had the most slender grains. These qualities will make FARO 12 an acceptable choice of grain in Nigeria rice milling industry and in those zones of Nigeria where rice farina are used for local rice foods. The grain hardness is an index of grain rigidity and it varied from 21.6 (ITA 212) and 35.0 (ITA 131) kg/mm^2 of brown rice. ITA 117 and ITA 131 had the highest rigidity and this characteristics would offer greater resistance to insect perforation, inhibition of microbial and fungi invasions when stored at minimum moisture content. Grain hardness tends to decrease with length (r = -0.17), though not significant, but increase with increase in thickness (r = 0.44, P < 0.5). This measurement of grain hardness devised by Kongserree & Juliano (1972), may not really measure hardness of the kernel, which would be better measured from the narrow axis (thickness). However, it shows that tendency of the grain to breakage during milling may indicate the presence and the extent of checking in the kernel. Shape of the kernel depicted by the ratio of length to thickness may be a better indication of breakage during milling. A stout grain with low ratio should have greater milling yield than a thin or slender grain (higher ratio), barring defects such as checking and mechanical kernel damage. The length/width ratio for the 23 samples ranged from 2.0 (IRAT 133) to 4.0 (FARO 12).

The milling characteristics of unparboiled rice varieties are presented in Table 2. The percentage hull content varied between 17.1 and 25.3%. FARO 12, FARO 27 and FARO 29 had the highest proportion of hull with lower amount of brown rice. However, ITA 118 had the lowest proportion of hull with the highest amount of brown rice in FARO lines is a common characteristics in rice grown in tropical and sub-tropical environment. Bhattacharya (1970) and Nagato *et al*. (1960) observed that most tropical rice plants produce more straws with increasing thickness of the bran than rice grains partly because high temperature could cause high spikelet sterility and degeneration of panicle tips during flowering. Yields of polished and head rice appear to be influenced by hardness and stoutness (shape) of the kernel with each of these factors sometimes acting independently of each other. Hard, stout but short grains (IRAT 112, ITA 144, and IRAT 133) had relatively greater polished and head rice yield than softer or larger kernels of FARO 15, TOX 711 and FARO 29. Variety of FARO 27 with the lowest yield of head rice (1.8) as well as highest proportion of hull, bran and broken rice may partly due to inherent genetic properties which may be responsible for such varietal characteristics.

The physical properties of parboiled rice varieties are presented in Table 3. Thousand kernel weights of paddy and brown rice are similar for both parboiled and unparboiled samples in Table 2. However, the grain hardness was about doubled in parboiled process as a result of the effects of parboiling process that altered the physical, chemical and possibly the cooking and eating quality of rice grains (Adeyemi, 1985; Juliano, 1972; Olusanya, 1978). Parboiling is generally done to salvage checked or broken kernel before milling. The gelatinized starch upon drying forms a tough residuous mass that is much harder than the original endosperm, capable of resisting breakage as well as insect attack. However, the dimensional properties of length, width and their ratios remain similar in those of unparboiled samples.

The effects of parboiling process on milling properties of rice are presented in Table 4. Parboiling process increased the yields of brown rice, polished rice and head rice significantly. Yields of parboiled brown rice ranged from 76.0% (FARO 12 and FARO 29) to 90.4% (ITA 117) as compared to 74.7% to 82.8% yields in those of unparboiled rice. Yields of polished rice varied from 63.6% (FARO 27) to 85.5% (ITA 117) and head rice 29.5% (FARO 15) to 78.7% (ITA 128) also increased compared to yields of 47.8% (FARO 27) to 75.8% (ITA 118) also 1.8% (FARO 27) to 73.0% (ITA 117) of unparboiled head rice. However, varieties that had low yields of head and polished rice in the unparboiled state also had low yields after parboiling. Increase in polished and head rice yields resulted in decrease in the bran and broken rice fractions of the parboiled rice samples. Parboiling process toughened the endosperm and made it resistant to abrasion and breakages (Gariboldi *et al*., 1972). Also parboiled grain is more slippery due to oil from bran and thus become more difficult to abrade (Gariboldi *et al*., 1972; Juliano, 1972; Luh, 1980).

The chemical properties of parboiled and unparboiled rice flour varieties are presented in Tables 5 and 6 respectively. In the parboiled rice flour, the crude protein content ranged from 6.0% (ITA 128, ITA 131, TOX 1768, ITA 234) to 9.8% (IRAT 170). This is in agreement with the range usually reported for protein rice of South-East Asia (Juliano *et al.* (1964). Rice therefore could be a major source of protein in the diets of Nigerians due to its increasing consumption (Adeyemi, 1985). Starch content of flour of unparboiled rice varieties ranged from 62.0% (IRAT 112) to 85.0% (ITA 212). Amylose content of rice flour ranged between 110 (TOX 1768) to 28.8% (FARO 27), similar to the parboiled rice flour in Table 5. Parboiling increased the mean crude protein content of flour significantly. Generally the amount of protein increased with parboiling. The application of parboiling is known to concentrate the nutrients among the various parts of rice kernel (Ali & Ojha, 1976; Kenndy *et al*., 1975) therefore such increase is expected result. However, parboiling does not change significantly the mean starch and amylose content of rice flour in (Table 5).

Conclusion

The significant differences in kernel weight of unparboiled rice varieties indicated that the heavier the paddy the heavier the rice kernel. Such varietal characteristics showed the ability to adapt favourably to the environment during prolonged ripening stage when grains are filled with carbohydrates and other dry matter. Also FARO 12 with the longest and relatively broad rice kernel had slender grain. This quality can make FARO 12 an acceptable choice of grain for Nigerian rice milling industry and in those zones of Nigeria where farina is used for local rice foods. Parboiling process increased the yields of brown rice, polished rice and head rice significantly suggesting that parboiling of Nigerian rice must be given a priority before such rice is made available to consumers. Parboiling process also had potential of concentrating nutrients especially proteins among various parts of rice kernel, suggesting that rice could be a major source of protein in the diet of Nigerians.

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Table 1: Physical Properties of Unparboiled Rice Varieties.

Varieties	1,000 kernel wt. (g) paddy	1,000 kernel wt.(g) brown rice	Length (mm) brown rice	Thickness (mm) brown rice	Grain Hardness kg/mm of brown rice	Shape L/W	Alkali digestibility
ITA 117	31.7	27.8	8.2	2.7	30.9	3.0	IN
ITA 118	38.0	30.5	7.3	2.9	27.8	3.4	H
ITA 123	27.1	21.8	7.3	2.3	29.5	3.1	IN
ITA 128	33.8	28.9	7.5	2.7	25.9	2.9	IN
ITA 144	40.4	34.6	7.7	3.0	25.9	2.6	IN
ITA 212	24.6	21.4	7.1	2.3	21.6	3.0	H
FARO 11	32.7	28.2	7.4	2.7	22.0	2.7	H
FARO 12	29.8	24.2	8.9	2.3	26.2	4.0	IN
FARO 15	30.8	24.5	7.1	2.7	22.5	2.7	H
FARO 27	24.9	20.3	6.8	2.4	26.3	4.8	H
FARO 29	27.6	24.1	7.0	2.6	21.8	2.7	H
IRAT 112	37.5	32.3	8.1	2.7	25.7	3.0	IN
IRAT 133	36.3	31.3	6.4	3.2	25.0	2.0	IN
IRAT 170	40.8	34.2	7.6	3.0	23.5	2.5	IN
ART 12	39.7	33.6	7.7	3.0	52.0	2.5	IN
ITA 131	30.1	24.2	7.1	2.7	35.0	2.6	L
ITA 132	32.6	26.8	7.5	2.7	30.0	2.7	IN
ITA 175	27.9	23.2	6.5	2.8	30.0	2.3	IN
TOX 1768	31.0	52.9	7.9	2.6	28.0	3.0	H
ITA 222	27.6	24.8	7.3	2.5	22.9	2.9	H
ITA 234	28.8	24.3	7.3	2.4	25.0	3.0	IN
TOX 711	26.6	22.4	7.7	2.2	30.5	3.5	H
TOX 894	27.1	21.4	7.0	2.3	26.7	3.00	IN
LSD	**1.98**	**1.07**	**0.14**	**0.07**	**0.83**	**0.14**	

Each value is the mean of three samples
IN = intermediate gelatinization flow
L = Low gelatinization flow
H = High gelatinization flow

Table 2: Milling characteristics of unparboiled rice varieties.

Varieties	% Moisture content of paddy rice	% Hull	% Brown rice	% Polished rice.	% Bran	% Head rice	% Broken
ITA 117	12.7	17.8	82.2	75.4	6.3	73.0	2.4
ITA 118	12.5	17.1	82.8	75.8	6.6	56.4	19.2
ITA 123	12.1	23.4	76.6	66.7	9.1	35.5	31.3
ITA 128	13.8	20.1	79.9	71.4	7.4	66.2	4.6
ITA 144	13.0	18.3	81.7	74.4	6.6	71.0	3.1
ITA 212	11.9	24.0	76.0	65.6	9.9	44.5	21.4
FARO 11	13.8	20.5	79.5	70.2	8.4	63.2	6.5
FARO 12	12.2	25.3	74.7	65.8	8.4	36.4	29.5
FARO 15	14.2	24.7	75.3	65.8	9.0	23.7	42.5
FARO 27	11.9	25.0	75.0	47.8	25.5	1.8	45.2
FARO 29	11.7	25.0	75.0	59.8	14.4	27.2	32.7
IRAT 112	13.7	18.7	81.3	73.4	7.5	67.9	5.0
IRAT 133	11.9	17.9	82.1	74.5	7.4	72.2	2.4
IRAT 170	14.2	18.2	81.8	72.2	8.8	66.9	4.8
ART 12	12.5	21.0	79.0	70.7	7.9	65.9	4.0
ITA 131	13.2	21.9	78.1	69.0	8.8	63.8	4.2
ITA 132	13.0	22.5	77.5	68.2	8.2	62.2	6.0
ITA 175	12.9	23.9	76.0	56.4	8.9	44.0	22.3
TOX 1768	13.0	23.5	76.5	66.9	9.4	55.2	7.2
ITA 222	12.8	22.0	77.8	65.9	11.0	50.0	15.5
ITA 234	12.6	20.6	79.4	70.0	7.7	56.8	13.2
TOX 711	12.7	20.6	79.0	70.6	7.5	54.0	16.3
TOX 894	12.7	23.3	76.7	65.9	9.4	45.0	20.7
LSD	**0.18**	**0.65**	**0.63**	**1.46**	**0.95**	**4.39**	**3.22**

Each value is the mean of three samples

Table 3: Physical properties of parboiled rice varieties

Varieties	1,000 kernel wt. (g) paddy	1,000 kernel wt.(g) brown rice	Length (mm) brown rice	Thickness (mm) brown rice	Grain hardness kg/mm of brown rice	Shape L/W	Alkali digestibility
ITA 117	26.6	22.3	7.4	2.6	58.3	2.8	H
ITA 118	36.4	29.7	7.4	2.8	56.3	2.6	IN/H
ITA 123	27.5	22.2	7.4	2.4	49.0	3.1	In
ITA 128	31.6	26.9	6.6	2.7	49.0	2.5	In/H
ITA 144	39.7	33.3	7.6	3.1	59.3	2.5	In/H
ITA 212	26.7	22.2	7.2	2.3	52.8	3.1	H
FARO11	32.9	29.7	7.2	2.8	65.0	2.5	IN
FARO12	29.5	23.4	8.2	2.2	59.2	3.7	I/H
FARO15	30.6	23.9	7.0	2.7	51.2	2.6	H
FARO27	23.8	19.5	6.6	2.6	62.3	2.5	H
FARO29	25.8	22.5	7.0	2.6	54.8	2.7	In
IRAT112	35.0	31.5	7.4	2.8	58.0	2.7	H
IRAT133	36.4	30.9	6.6	3.3	58.7	2.0	In
IRAT170	40.7	33.8	7.4	3.2	61.1	2.3	In/H
ART 12	39.5	33.3	7.4	3.0	56.4	2.4	In
ITA 131	30.3	23.5	6.9	2.8	45.6	2.5	In
ITA 132	30.8	27.2	6.7	2.6	56.0	2.6	In
ITA 175	27.9	23.1	6.4	2.8	54.0	2.3	H
TOX1768	31.8	25.5	7.3	2.6	48.2	2.8	In
ITA 222	29.1	24.4	6.9	2.6	45.5	2.7	In
ITA 234	30.0	24.1	7.1	2.4	50.9	2.9	In
TOX 711	26.6	21.5	7.0	2.4	54.9	2.9	In/H
TOX 894	27.7	21.4	7.0	2.4	56.3	3.1	In
LSD	**1.16**	**1.07**	**0.10**	**0.07**	**1.29**	**0.9**	

Each value is the mean of three samples

Table 4: Milling characteristics of unparboiled rice varieties.

Varieties	% Moisture content of paddy	% Hull	% Brown rice	% Polished rice	% Bran	% Head rice	% Broken rice
ITA 117	12.0	9.7	90.4	85.5	14.5	78.4	9.3
ITA 118	11.9	13.3	86.7	80.2	4.5	59.9	29.4
ITA 123	13.4	20.3	79.7	75.0	3.5	45.5	29.4
ITA128	14.0	19.5	80.5	74.4	5.3	78.7	5.7
ITA 144	13.4	16.7	83.3	75.0	5.6	71.4	3.6
ITA 212	12.1	22.3	76.8	69.1	10.6	48.0	21.0
FARO11	12.0	20.0	80.0	72.0	8.3	57.0	9.8
FARO12	12.0	24.0	76.0	69.0	9.6	40.0	31.0
FARO15	13.6	25.9	80.0	69.7	9.7	29.5	43.5
FARO27	12.2	23.0	77.0	63.6	13.1	38.8	43.0
FARO29	12.0	24.0	76.0	66.0	19.0	39.3	41.6
IRAT112	13.5	17.0	83.0	79.1	6.1	73.0	3.9
IRAT133	12.6	16.0	83.8	80.0	6.9	78.6	2.0
IRAT170	12.6	16.2	83.5	76.6	10.0	70.4	4.0
ART 12	12.9	20.0	80.0	76.3	7.0	68.3	4.0
ITA 131	14.0	21.0	78.4	68.5	8.9	63.6	4.8
ITA 132	11.0	20.2	79.3	75.0	7.0	69.6	5.5
ITA 175	14.9	22.0	78.0	68.6	7.0	50.3	19.8
TOX1768	12.6	21.0	77.4	69.0	8.9	52.0	6.0
ITA 222	13.5	20.0	80.0	68.5	9.3	55.7	14.0
ITA 234	14.1	20.0	80.0	76.0	6.8	60.6	12.8
TOX 711	10.8	20.0	80.0	76.0	7.1	63.3	15.0
TOX 894	10.0	22.0	77.8	70.0	9.5	60.0	23.0
LSD	**0.29**	**0.87**	**0.85**	**1.29**	**0.84**	**3.31**	**3.34**

Each value is the mean of three samples

Table 5: Chemical properties of unparboiled rice flour.

Varieties	% Moisture content	% Crude protein	% Amylose content of flour	Dry wt. basis. % Starch of flour	Gel. (mm) consistency
ITA 117	12.0	8.6	22.0	72.0	57.0
ITA 118	12.0	7.9	16.7	83.0	73.0
ITA 123	11.5	8.9	28.5	66.0	40.0
ITA 128	11.8	6.0	17.8	69.0	67.0
ITA 144	12.0	8.6	17.8	63.0	72.0
ITA 212	11.0	7.3	25.4	85.0	43.0
FARO11	12.0	7.6	22.0	83.0	58.0
FARO12	10.9	7.7	24.6	76.0	46.0
FARO15	11.0	8.5	28.0	73.0	38.0
FARO27	12.2	6.8	28.8	70.0	36.0
FARO29	8.0	7.0	28.0	69.0	35.0
IRAT112	12.5	6.6	22.0	69.0	57.0
IRAT133	12.9	7.9	15.0	69.0	74.0
IRAT170	9.5	9.8	19.8	64.0	70.0
ART 12	15.4	8.9	18.0	77.0	66.0
ITA 131	12.0	6.0	12.4	69.0	77.0
ITA 132	11.4	6.3	11.7	73.0	78.0
ITA 175	11.4	6.4	15.0	65.0	55.0
TOX1768	11.3	6.0	11.0	73.0	75.0
ITA 222	11.0	6.4	26.0	73.0	26.0
ITA 234	11.6	6.0	25.0	74.0	51.0
TOX 711	11.3	6.3	27.0	77.0	28.0
TOX 894	11.0	6.4	27.0	73.0	28.0
LSD	**0.32**	**0.28**	**1.42**	**1.50**	**4.26**

Each value is the mean of three samples

Table 6: Chemical characteristics of parboiled rice flour

Varieties	% Moisture content	% Crude protein	% Amylose content of flour	Dry wt. basis. % Starch of flour	Gel. (mm) Consistency
ITA 117	11.5	10.2	22.0	71.2	55.0
ITA 118	11.3	9.3	16.5	82.3	75.0
ITA 123	11.4	9.6	28.5	66.0	22.0
ITA 128	11.4	8.0	17.9	70.0	72.0
ITA 144	11.2	9.6	17.8	63.0	71.0
ITA 212	11.0	7.8	26.0	85.0	42.0
FARO11	11.2	10.2	22.0	82.0	60.0
FARO12	11.2	8.2	25.0	77.0	47.0
FARO15	11.2	9.0	28.0	73.0	40.0
FARO27	11.2	7.3	28.8	69.0	37.0
FARO29	11.3	8.2	28.0	71.0	37.0
IRAT112	11.2	10.3	21.9	62.0	56.0
IRAT133	11.2	9.5	15.5	63.0	75.0
IRAT170	11.2	9.9	20.0	66.0	71.0
ART 12	11.4	9.7	18.0	74.0	69.0
ITA 131	11.8	7.0	12.5	69.0	79.0
ITA 132	11.6	6.7	11.9	73.4	79.0
ITA 175	11.4	7.6	15.3	65.5	74.0
TOX1768	11.4	7.7	11.0	73.3	78.0
ITA 222	11.3	7.6	26.1	73.2	43.0
ITA 234	11.2	7.1	25.2	73.3	48.0
TOX 711	11.3	7.7	27.2	77.0	39
TOX 894	11.2	8.3	27.3	73.2	38
LSD	**0.04**	**0.28**	**1.42**	**1.52**	**3.93**

Each value is the mean of three samples