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Grain quality characteristics of *Ofada* rice (*Oryza sativa* L.): Cooking and eating quality

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Abstract: A study was conducted to evaluate the cooking and eating quality of *Ofada* rice. Quality parameters measured were; volume increase, grain elongation (GE), water uptake (WU), cooking time (CT), solids in cooking gruel (SCW), gelatinization temperature (GT) and amylose content (AC). The result showed that *Ofada* rice had high cooked rice volume with length and breadth increase of 152.54% and 87.85% respectively. GE ratio ranged from 1.24-1.75 with *Ofada* 10 having the lowest value and *Ofada* 11 having the highest value. The highest length/breadth ratio of cooked rice (3.68) was recorded by *Ofada* 8, while *Ofada* 3 had the lowest (2.49). GE index ranged from 0.99-1.44 with *Ofada* 10 having the lowest value and *Ofadas* 4 and 11 having the highest value. WU ratio, CT, SCW and AC of *Ofada* rice samples ranged from 174.0-211.0, 17-24 min, 0.8-2.1%, and 19.77-24.13% respectively. The GT were low to intermediate. There was significant positive correlation between AC and WU ratio, while significant positive association was observed between length/breadth ratio and AC. Based on the result of the study, *Ofada* rice have good cooking and eating quality, hence selection for improvement based on this parameters will be a right step in the right direction.

Keywords: *Ofada* rice, grain length, amylose, water uptake, cooking and eating property

Introduction

Rice is the only cereal crop cooked and consumed mainly as whole grains, and quality considerations are much more important than for any other food crop (Hossain *et al*., 2009). Although production, harvesting and postharvest operations affect overall quality of milled rice, variety remains the most important determinant of market and end-use qualities. Quality desired in rice vary from one geographical region to another and consumer demand certain varieties and favors specific quality traits of milled rice for home cooking (Juliano *et al*., 1964; Azeez and Shafi, 1966). For instance, in japonica rice eating countries, low amylose, short grain is preferred since after cooking it becomes soft and sticky. However, in indica rice consuming countries, long grain with intermediate amylose and gelatinization temperature is preferred since it become soft and fluffy after cooking (Hossain *et al*., 2009).

Ofada is a generic name used to describe all rice varieties produced in the rice producing areas of Ogun State and its environs, southwestern part of Nigeria. *Ofada* rice grain quality has assumed much greater importance as its demand for local and export consumption are on the increase and consumers are placing much emphasis on the quality of the milled rice. The need to improve quality of locally processed rice in Nigeria to make it more competitive with imported rice cannot be over emphasized. Several factors ranging from poor production and post-harvest practices, poor physical and cooking qualities, presence foreign materials in milled rice has been attributed to the variable quality in locally processed rice.

Research results during the past decades indicates that cooking quality is directly related to the physical and chemical characteristics of the starch in the endosperm; namely amylose-amylopectin ratio, gelatinization temperature, and gel consistency (Little *et al*., 1958; Webb, 1980; Juliano, 1985; Unnevehr *et al*., 1992; Tan *et al*., 1999). Maintaining rice grain quality to meet the diverse interest groups in the rice sub-sector currently represents a major challenges of rice development in many rice producing areas of the world. Much of these challenges, Tan *et al*. (1999) observed, stems from the poor cooking and eating quality of many widely adopted rice varieties. Though, few research results has been published on the characteristics of *Ofada* rice (Otegbayo *et al*., 2001; Ebuehi and Oyewole, 2007; Adebowale

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et al., 2010), little or no information is available on the cooking and eating characteristics of all the varieties cultivated in all the *Ofada* rice producing areas of Nigeria. Thus, the present investigation was undertaken to evaluate cooking and eating quality of *Ofada* rice varieties in four states in the Southwestern part of Nigeria.

Materials and Methods

The experiment was carried out at the Grain Quality Laboratory of the Rice Research Division of the National Cereals Research Institute (NCRI), Badeggi, Niger State, Nigeria. Twelve (12) *Ofada* rice samples representing the conventionally known *Ofada* varieties were collected by PrOpCom (Promoting Pro-poor Opportunities through Commodity and Service Markets, Abuja) were studied for cooking and eating quality and compared with two popular released varieties, FARO 11 and FARO 46.

Sample preparation

Laboratory parboiling technique

Water was heated to boiling point in a vessel provided with lid, and rough rice (500 g of each sample) previously cleaned was put into it and stirred such that the final temperature was 75^{o}C and left over night on a wooden laboratory bench. After 18 hrs the water was drained out, and soaked rice was steammed in a laboratory parboiler (locally fabricated by NCRI). After steaming, it was sprayed out on a tray and allowed to air-dry (32±2^{o}C) in the laboratory before milling.

Evaluation of dimensional changes during cooking

Milled rice length (L_1) and breadth ($W_{1)}$ were measured by randomly picking whole grains and measured with a digital calipers and 1000-kernel weight (W_{T1}) measured using sensitive balance. For cooking test, individual milled rice kernel of the *Ofada* along with checks were taken separately in a labeled test tubes without pre-soaking and placed in a water bath which was maintained at boiling temperature for 16 minutes. After cooking, the test tubes were cooled under running tap water for 2 minutes (Hossain *et al.*, 2009). Cooked rice were taken out of the test tubes and excess water removed by blotting on a filter paper. Cooked rice length (L_2) and breadth (W_2) were measured as described above. For each of the L_1, L_2, W_1 and W_2, the mean of 10 measurement was taken. The ratio of the average length of cooked rice (L_2) to the average length of raw kernel (L_1) was calculated as grain elongation (GE) ratio. Weight (W_{T2}) of cooked rice was measured as described above and water up take (WU) ration calculated as W_{T2}/W_{T1} (Cruz and Khush, 2000).

Gelatinization temperature

Gelatinization temperature (GT) was indexed by alkali spreading test (Little, *et al*., 1958). The degree of spreading of individual milled rice kernel in a weak alkali solution (1.7% KOH) at room temperature (32±2^{o}C) was evaluated on a 7-point numerical scale (Jennings *et al*., 1979; IRRI, 1980); Khush *et al*., 1979). Each test was conducted three times, each time, 10 intact milled grains were placed on a petridish to which 15 ml of 1.7% KOH was added. The grains were carefully separated from each other and incubated at ambient temperature for 23 hrs to allow spreading of the grains. Grains swollen to the extent of a cottony center and a cloudy collar were given an alkali spread value (ASV) score 4 and used as check for scoring the rest of the samples in the population. Grains that were unaffected were give ASV of 1, and grains that were dispersed and disappeared completely were given a score of 10. A low ASV correspond to a high gelatinization temperature, conversely, a high ASV indicates a low GT.

Cooking time and solids in cooking water

Minimum cooking time was determined by parallel plates method (Bhattacharya and Sowbhagya, 1971) in which 10 grains were pressed between 2 glass plates every two minutes until at least 90% no longer has opaque center. Solids in cooking gruel was determined by drying 10 ml of aliquot at 120^{o}C to a constant weight (IRRI, 1981).

Amylose content

A simplified procedure of Juliano (1971) was used for amylose content analysis. 100 mg of rice powder was mixed with 1ml of 95% ethanol and 9 ml of 1N NaOH in a 100 ml volumetric flask. The content were heated on a boiling water bath to gelatinize the starch. After one hour cooling, distilled water was added and content mixed. For each set of the run, low, intermediate and high amylose standard varieties were included as checks. 5 ml of the gelatinized starch solution was measured into volumetric flask and 1 ml of 1N acetic acid, 2 ml iodine solution were added and volume made up with distilled water. Content are then stirred and allowed to stand for 20 min. before absorbance measure at 620 mu with a spectrophotometer (Model AA-6650, Shimadzu Co. Japan). All results were subjected to descriptive statistical analysis using Microsoft Window Excel 2007.

Results and Discussions

Volume change during cooking

The dimensional changes during rice cooking is presented in Table 1. During cooking, rice kernels absorb water and increase in volume through increase in length or breadth (Hogan and Plank, 1958). Breadth wise increase is not desirable, whereas, length wise increase without increase in girth is desirable characteristics in high quality premium rice (Khush *et al*., 1979; Sidhu, 1989; Hossain *et al*., 2009). In the present study, length of cooked rice ranged from 9.67 to 13.84 mm with a mean value of 11.49 mm and the highest length was recorded for *Ofada* 8 and the least for *Ofada* 3 (Table 1). Except for *Ofada 3* and 9, all other entries showed a comparable kernel length increase during cooking to that of the check FARO 11 (11.16 mm). Shobha (2003) and Hossain *et al*. (2009) reported kernel length after cooking of some hybrids rice ranging from 8.84 to 12.73 mm and 10.20 to 12.40 mm respectively. Some varieties elongate more than others upon hydration and starch gelatinization without increase in girth, this is considered a desirable cooking quality traits in most high quality rice of the world. *Basmati* rice of India and Pakistan, *Bahra* of Afghanistan, *Domsiah* of Iran, *Bashful* of Bangladesh, and D25-4 from Myanmar are reported to elongate 100% upon cooking, and are considered high quality rice internationally (Kumar, 1989). In this study, *Ofada* rice elongate 152.54% with a less (87.85%) width increase. The largest width increase during cooking was recorded in *Ofada* 3 (3.89 mm) and the lowest for *Ofada* 1 (3.42 mm). When compared with the controls, all *Ofada* rice samples showed highly comparable width increase with FARO 11 (3.79 mm) and FARO 46 (3.56 mm). High expansion breadth wise is not a desirable quality attributes in high quality rice required to command premium in the market. The length/width ratio of cooked rice was highest for *Ofada* 8 (3.68) and lowest for *Ofada* 3 (2.49). In a study on 20 new plant type genotypes, Sandeep (2003) and Hossain *et al*. (2009) reported kernel length/width ratio of cooked rice ranging from 2.04 to 3.95 and 2.39 to 5.07 respectively. A low value Hossain *et al*. (2009) observed indicates poor cooking quality. All *Ofada* rice samples in this study has medium length/width ratio (Table 1) and therefore possesses good cooking qualities. Significant correlation has been established between length/width ratio with grain elongation during cooking (Deosankar and Nerkar, 1994). GE ratio is defined as the ratio of the length of cooked rice grain to the length of milled rice grain (L_2/L_1). It has been reported that GE ratio is a better index of cooking quality than GE index ($A/(L_1/W_1)$) (Pilaiyar, 1988). In the present study, *Ofada* rice samples are seen to have intermediate to high elongation ratio (Table 1). *Ofada* 11 recorded the highest (1.75) and the lowest of 1.24 was recorded for *Ofada* 10. *Ofadas* 1,2,3,4,5, 8,11 and 12 showed a higher elongation than the check FARO 11 (1.59) and FARO 46 (1.58). Hossain, *et al*. (2009) reported kernel elongation ratio of 20 newly identified inter sub-specific (*indica/ japonica*) rice hybrids ranged from 1.51 to 1.82,

Table 1. Change in dimensional characteristics of *Ofada* rice during cooking in excess water

Ofada/Checks	L_1 (mm)	L_2 (mm)	W_1 (mm)	W_2 (mm)	L_2/L_1	L_2/W_2 (A)	$A(L_1/W_1)$
Ofada 1	6.41	11.14	2.82	3.42	1.74	3.26	1.44
Ofada 2	6.30	10.16	3.01	3.69	1.61	2.75	1.32
Ofada 3	5.90	9.67	3.21	3.89	1.64	2.49	1.35
Ofada 4	6.91	12.01	3.00	3.76	1.74	3.19	1.39
Ofada 5	6.81	11.68	3.12	3.77	1.72	3.10	1.42
Ofada 6	7.22	11.23	3.21	3.68	1.56	3.05	1.36
Ofada 7	7.60	12.00	3.00	3.48	1.58	3.45	1.36
Ofada 8	8.00	13.84	3.10	3.78	1.73	3.68	1.43
Ofada 9	7.60	10.72	3.00	3.67	1.41	3.19	1.26
Ofada 10	9.00	11.12	3.00	3.76	1.24	2.96	0.99
Ofada 11	6.91	12.07	3.10	3.74	1.75	3.22	1.44
Ofada 12	7.00	12.18	3.00	3.69	1.74	3.30	1.42
Mean	7.14	11.49	3.05	3.70	1.61	3.11	1.33
FARO 11	7.00	11.16	3.11	3.79	1.59	2.97	1.32
FARO 46	8.01	12.66	2.68	3.56	1.58	3.56	1.19

Result is mean of three replication.

Table 2. Cooking and eating characteristics of *Ofada* rice varieties

Ofada/Checks	Water uptake (%)	Cooking time (min)	Solid in cooking water (%)	Gelatinization temperature*	Amylose content (%)
Ofada 1	184	17	1.20	Low	23.12
Ofada 2	193	18	0.90	Low	20.67
Ofada 3	186	22	2.10	Low	21.00
Ofada 4	176	21	1.40	Low	22.53
Ofada 5	183	18	1.70	Low	24.13
Ofada 6	194	19	1.10	Low	19.98
Ofada 7	180	24	1.00	Low	21.86
Ofada 8	174	22	0.80	Intermediate	23.56
Ofada 9	199	22	0.80	Intermediate	20.13
Ofada 10	200	21	1.10	Intermediate	20.67
Ofada 11	211	22	1.41	Low	21.21
Ofada 12	196	23	1.52	Low	19.77
Mean	189.7	20.8	1.25	NA	21.55
FARO 11	178	19	0.50	Intermediate	20.11
FARO 46	194	20	0.60	Intermediate	21.56

*based on 1.7% KOH spread. NA = Not applicable.

Table 3. Correlation coefficients among cooked rice dimension and cooking quality of *Ofada* rice

Variables	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9
Grain length (V_1)	1.00								
Grain width (V_2)	-0.10	1.00							
L/W Ratio (V_3)	0.95	-0.36	1.00						
Grain elongation ratio (V_4)	-0.65	0.03	-0.63	1.00					
Grain elongation index (V_5)	-0.64	0.08	-0.64	0.95	1.00				
Water uptake (V_6)	0.23	-0.62	0.39	0.18	0.15	1.00			
Cooking time (V_7)	0.35	0.18	0.29	-0.12	-0.08	0.33	1.00		
Solid in cooking water (V_8)	-0.55	0.38	-0.61	0.37	0.24	-0.26	0.01	1.00	
Amylose content (V_9)	-0.08	-0.15	-0.04	0.48	0.41	0.28	-0.31	0.09	1.00

while Shobha (2003) reported 1.70 to 2.00 in nine released hybrid rice varieties in India. Contrary to the observation of Pilaiyar (1988) that GE ratio is a better index of quality than GE index, Kumar (1989) concluded after studying the genetics of height and cooking quality traits in basmati rice that GE index was a more reliable measure of kernel elongation during cooking. In this study all the samples give high GE index ranging from 0.99 in *Ofada* 10 to 1.44 in *Ofada* 11, with a mean value of 1.33. All the *Ofada* rice samples had a comparable GE index with hybrid rice varieties reported by Hossain *et al*. (2009) which ranged from 0.80 to 1.67.

Water uptake during cooking

The extent of water absorbed by rice during cooking is considered an economic quality as it give some estimate of the volume increase during cooking. WU shows a positive significant influence on grain elongation (Sood and Siddiq, 1986). While Bhattacharya and Sowbhagya (1971) observed that the WU during cooking correlate significantly (r = -0.84**, n=20) with optimum cooking time. In the present study, WU ranged from 174 to 211% with a mean value of 189.7%. Generally, rice WU attributes varied between 194 to 250% (Sood and Siddiq, 1986). But, Hogan and Plank (1958) in a study of the hydration characteristics of rice as influenced by variety and drying method, observed that short and medium grain varieties have higher water absorption than long grain types. The current study is on long grain types and therefore ranged between 174 and 211%. The mean WU was 189.7 indicating moderate quality for this character (Table 2). Earlier study indicates that good cooking rice varieties have WU value ranging from 175 to 275%. All the Ofada rice samples had WU within this range, indicating good cooking quality. At a higher WU (300 to 570%), majority of rice shows pasty appearance (Hossain, *et al*, 2009) which is not favorable for cooking and eating quality.

Cooking time

Cooking time for rice is the time when 90% of the starch in the grain no longer show opaque center when pressed between two glass plates. Rice differ in optimum cooking time in excess water between 15 to 25 minutes without pre-soaking (Juliano *et al*., 1981). The present study indicate that *Ofada* rice cooks in excess water after a period ranging from 17 to 24 min, and on the average 20.8 min. The lower the cooking time the better in terms of fuel and energy consumption during cooking. The cooking times are comparable with the control varieties (Table 2) and falls within the reported value of 10-25min by Adeyemi *et al*. (1986) and Rhagavendra and Juliano (1971). This result is contrary to the report of Otegbayo *et al*. (2001) who reported cooking time of 52 and 56 min in two local rice varieties from the same region where this samples are collected.

Gelatinization temperature

The time required for cooking is determined by the gelatinization temperature (GT). It is the temperature at which 90% of rice starch granules swell irreversibly in hot water with loss of crystalline structure and birefringence (Little, *et al*., 1958). GT of rice are classified as low (55-69^{o}C), intermediate (70-74^{o}C), and high (> 74^{o}C) (Cruz and Khush, 2000). 75% of the *Ofada* rice samples (1 to 7, 11 & 12) show low GT when indexed by alkali digestion test (Little *et al*., 1958). *Ofadas* 8, 9 and 10 shows intermediate GT as the checks (Table 2).

Solids in cooking water

Solids released by rice into cooking water has also been considered as a cooking quality attributes (Juliano, 1985). Solids in cooking water may be correlated with amylose content (r = -0.82) and may be related to stickiness of cooked rice (Juliano and Pascual, 1980). In the current study, solid loss ranged from 0.80% in *Ofada* 8 and 9 to 2.10% in *Ofada* 3 and on the average 1.25% (Table 2). With the low solids in cooking gruel, *Ofada* rice may cook without burning under the cooking sauce pan. The slightly higher solids recorded in *Ofada* cooking water than the checks may be attributed to the processing techniques of *Ofada* rice.

Amylose content

Many of the cooking and eating characteristics of rice are influenced by the ratio of two kinds of starches; amylose and amylopectin in the rice grain (Sanjiva *et al*., 1952). Rice with high amylose content show high volume expansion during cooking and cook dry, less tender and become harder upon cooling (Juliano, 1985). While low amylose varieties cook moist and sticky. Rice are grouped based on their amylose content into waxy (0 – 2%), very low (3-9%), intermediate (20-25%) and high (>25%) (Cruz and Khush, 2000). From this experiment, amylose content of *Ofada* is seen to range from 19.77% for *Ofada* 12 to 24.13% for *Ofada* 5, with an average of 21.55% (Table 2). This results indicates that *Ofada* rice varieties have intermediate amylose content, and therefore, may cook dry, fluffy, less tender and become harder upon cooking. Nigerian rice consumer demand long grain, that is free from foreign matter and cook fluffy and tender. This may likely be why demand for *Ofada* rice especially among the natives of the Southwestern Nigeria both within and outside Nigeria is increasing.

Correlation studies between the physicochemical characteristics and cooking qualities revealed positive correlation between AC and WU which indicate that at high amylose level, rice varieties will absorb more water (Table 3). This positive correlation between amylose content with WU was also reported by Hossain *et al*. (1987), but Vanaja and Babu (2003) found a negative association between these two quality traits. There was a significantly positive association between length/width ratio with amylose content in this study (Table 3). This result is contrary to the finding of Vanaja and Babu (2003). This implies that selection for improvement of *Ofada* based on amylose content will result in a correlated improvement in related cooking and eating qualities.

Conclusion

Based on the results obtained from this study, *Ofada* rice was observed to have good cooking and eating characteristics, thus signifying the high demand for the rice. It can also be concluded from the result of grain elongation during cooking, water uptake, solid loss during cooking, amylose content and gelatinization that *Ofada* compared favorably with the checks and therefore, *Ofada* rice may cook dry, fluffy, less tender and become harder upon cooking which is the quality demanded by most Nigerian consumers, and this may attract premium price for *Ofada*.

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