ISSN 1996-3343

Asian Journal of Applied Sciences

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OPEN ACCESS Asian Journal of Applied Sciences

ISSN 1996-3343
DOI: 10.3923/ajaps.2019.52.60

Research Article
Production and Quality Evaluation of Instant Rice from Three Local Rice Varieties in Ebonyi State

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Abstract

Background and Objective: Instant rice is rice that has been precooked, dehydrated and can be rehydrated in a relatively shorter period of time than the normal time for cooking. The aim for instant rice is to shorten the cooking time of rice which add value and increase consumer acceptability of the product. **Materials and Methods:** Three local rice varieties (*Akujie*, *Igbo* and *Mass*) and three processing methods (boiling, fissuring and pressing) were used for instant rice processing. The boiled samples were prepared by boiling rice between 100-105°C for 12 min, freezing for 24 h before oven drying at 50°C. The fissured samples were prepared by dry heating (130-140°C) the rice, boiling for 12 min and drying at 50°C. Pressed samples were prepared by pressing the rice between rolls after boiling (12 min) and then dried at 50°C to 10% moisture content. All the samples were reconstituted by boiling (1:1.5 rice-to-water ratio) for 6 min and used for analysis. **Results:** The results obtained were statistically analyzed using one way ANOVA at p<0.05. The proximate composition results revealed that fissured *Akujie* rice (RFA) had highest (p<0.05) crude protein (9.30%) and moisture contents (78.90%) but lowest (p<0.05) fat (0.25%) and crude fibre (0.65%) contents. *Akujie* rice (RBA) contained highest (p<0.05) crude fibre (0.73%) and carbohydrate contents (84.55%) but lowest (p<0.05) moisture (7.60%) content pressed *Igbo* rice (RPM) had highest (p<0.05) fat (0.60%) and least ash (0.50%) contents. The functional properties results showed that RBI (boiled *Igbo* rice) had highest (p<0.05) bulk density (0.79%), rehydration ratio (2.20) and volume expansion (2.83%), RFI (fissured *Igbo* rice) had the lowest (p<0.05) bulk density (0.59%) rehydration ratio (1.95%) but highest in oil absorption capacity (2.00%). The sensory evaluation revealed that the boiled samples were the most accepted instant rice at the "like moderately" level. The *Akujie* rice variety was the most preferred in terms of sensory attributes like appearance, taste, flavour and overall acceptability. **Conclusion:** In summary, the instant rice produced reconstituted within six minutes of boiling, RBI had the best functional properties while RBA was the most preferred. Therefore instant rice of acceptable quality could be produced from local rice varieties in Abonyi state.

Key words: Instant rice, boiling, fissuring, pressing and varieties.

Citation: N.A. Obeta, A.N. Ukom and O.I. Ossai, 2019. Production and quality evaluation of instant rice from three local rice varieties in Ebonyi state. Asian J. Applied Sci., 12: 52-60.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Government of Nigeria has in recent times made concerted effort to boost the production and distribution of locally rice in the country in a move to achieve self-sufficiency in rice production[1]. However, one of the major reasons for low consumer acceptance and patronage of the locally processed rice is the comparatively lower quality level occasioned by the presence of impurities, long time of cooking, poor packaging and distribution. Lack of adequate technology in rice processing to meet International Standard lead to imported rice dominating rice trade in Nigeria[2]. Rice being a major staple in Nigeria, a huge potential market for locally produced rice exist in urban centres if quality standards in processing technology are improved. Quality improvement is a major challenge to extend the product concept of being modern and convenience.

Rice is the seed of the grass species *Oryza sativa* (Asian rice), grass family Poaceae (formally *Graminae*) or *Oryza glaberrima* (African rice). It is the seed of the monocotyledonous family of some 600 genera and around 10,000 species[2,3]. *Oryza sativa* is the most commonly grown species throughout the world today[4]. Rice is ranked as the world's number one human food crop among all the worldwide-cultivated cereals[5]. It stands out, constituting the basic food for large number of human beings, sustaining more than half and up to two-third of the world population[6,7]. Rice is an economically important food crop with nutritional diversification that helps in poverty alleviation[8]. Though the original parental species of rice are native to Asia[9] especially south-east Asia and certain parts of Africa but centuries of trade and exportation have made this rice specie common in many cultures worldwide[10].

Rice is grown in more than 100 countries (e.g., China, India, Indonesia, Vietnam and Thailand amongst others) under widely differing climatic conditions and is particularly productive in tropical regions with abundant moisture. Rice farmers choose varieties adapted to the region. Other conditions like the length of growing season, soil, altitude and for paddy rice, the depth of water in the fields are also taken into consideration. In Nigeria it is grown in all the ecological zones, with different varieties possessing adaptation traits for each ecology[11,12].

Instant rice also known as minute rice, is rice that has been precooked, dehydrated and can be rehydrated and made ready for consumption in a relatively short period of time, either by the addition of hot water or and microwave cooking[13]. Regular rice requires above15 min to cook while instant rice may take[14] 5-10 min.

The major rice producing nations of the world all have well developed with abundance publications on instant rice products. In Nigeria however, local rice has a very low esteem with few research works and no industrial or technology processing yet developed. This work is aimed at motivating entrepreneurial and industrial applications for instant local rice production in Nigeria since rice is a major staple food in Nigeria.

MATERIALS AND METHODS

Source of material: Three local parboiled rice varieties namely; *Igbo*, *Akujie* and *Mass* were purchased from Eke market Afikpo in Afikpo north Local Government Area of Ebonyi state, Nigeria. The processing of instant rice was carried out in the food processing laboratory Michael Okpara University of Agriculture Umudike, Abia state. Also, all chemicals/reagents and equipment used for the chemical analysis were of analytical grade.

Sample preparation: Boiling, fissuring and pressing methods were used in producing instant rice from local rice (Igbo, Akujie and Mass) varieties. Boiling method as described by Rewthong *et al.*[14] was used. Rice (1 kg) was washed to remove dust and dirt, soaked in water (2000 mL) at ambient temperature for 10 min, afterward, the rice was boiled (at a ratio of rice-to-water 1:1.3 V/V) for 12 min in order to completely gelatinize its starch. It was cooled for 12 min and frozen (in sealed containers at -18°C for 24 h) prior to drying in hot air oven at 50°C to a constant weight.

The fissuring method as described by Lin and Jacops[15] was used. The rice (1 kg) was first fissured using hot air (130-140°C) for 10 min. The fissured rice was then completely gelatinized by boiling (at a ratio of rice-to-water 1:1.3 V/V) for 12 min. Thereafter, the rice was dried at 50°C to a constant weight using a hot air dryer.

The pressing method as described by Linn *et al.*[16] was used. The rice (1 kg) was washed and soaked in (2000 mL) water for 10 min at 50°C and then vegetable oil (1.00% by weight) was added to prevent the rice grains from sticking to each other during the boiling and pressing processes. The rice was boiled (as in boiled sample above), exposed to hot air (70°C) and pressed between rolls without producing cracks and fissures in it. The rolled rice was then dried at 50°C to a constant weight using a hot air dryer.

The instant rice samples were reconstituted by boiling in water in a rice-to-water ratio of 1:1.5 for 5-7 min and used for sensory evaluation.

Proximate analysis: Proximate analysis of the instant rice samples were done: moisture (gravimetric method), lipids (continuous solvent extraction in a Soxhlet reflux apparatus), ash (furnace incineration gravimetric method), protein (micro-Kjedahl method), fibre (digestion reagent) and carbohydrate (by estimation using arithmetic difference) were determined according to AOAC[17].

Functional properties determination

Volume expansion: The volume expansion of the instant rice samples were measured following the method of Kongseree *et al.*[18] with slight modifications. A 10 g sample of each instant rice product was placed in a volumetric cylinder and the volume noted. Water at a temperature of 95°C was added and the expanded volume was measured every 2 min for 40 min:

$$\text{Volume expansion} = \frac{\text{Volume of reconstituted product (mL)}}{\text{Starting volume of the sample (mL)}}$$

Rehydration ratio: The rehydration ratio was measured following the method of Prasert and Suwannaporn[19]. A 100 mL of water at 95°C were added to 10 g of instant rice samples. Excess water was dabbed away by draining and the samples were weighed every 2 min for 40 min. The rehydration ratio was calculated thus:

$$\text{Rehydration ratio} = \frac{\text{Weight of instant rice after absorption of water (g)}}{\text{Starting dry weight (g)}}$$

Oil absorption capacity: This was determined as the weight of oil absorbed and held by one gram of the instant rice sample as described by Onwuka[20]. One gram of instant rice sample was weighed and put into a weighed centrifugal tube, 10 mL of vegetable oil was added to the tube and mixed very well. The mixture was allowed to stand for 30 min at room temperature. Afterward, the mixture was centrifuged at 3500 rpm for 15 min. The supernatant was discarded and the residue in the centrifugal tubes was allowed to drain completely and its content was weighed. The oil absorption capacity of the sample was expressed in terms of the weight of oil absorbed and held by the sample:

$$\text{OAC} = \frac{W_2 - W_1}{W}$$

Where:

W = Weight of sample
W_1 = Weight of empty tube
W_2 = Weight of tube+absorbed oil

Bulk Density (BD): The bulk density was determined as described by Onwuka[20]. Ten gram of the sample was weighed into a measuring cylinder and the apparent volume was read off (in mL). The sample was tapped for 5 min and the final volume taken:

$$\text{Bulking density} = \frac{\text{Weight of sample (g)}}{\text{Volume of sample (mL)}}$$

Starch analysis: The starch content was determined in duplicates by the simplified assay method developed by Juliano[21] using the starch-iodine blue method. The instant rice samples were ground into flour and then 2 mL dispersed in water by first treating it with ethanol and sodium hydroxide. The solution was heated for 1 h or allowed to set at room temperature. The pH was then adjusted to 7.00 by adding water. A solution of iodine was added. The colour intensity of the amylose-iodine complex was measured with a spectrophotometer.

Sensory analysis: The method described by Iwe[22] was used. The organoleptic properties of the cooked instant rice samples were tasted by 20 panellists randomly selected from the staff and students of Michael Okpara University of Agriculture Umudike. The untrained panellists were instructed prior to the exercise.

All samples were put on different uniform plates and served to the panellists with portable water to rinse their mouth after each tasting so as not to interfere with the taste of the preceding samples. Quality attributes such as appearance, taste, aroma, texture and general acceptability of the products were scored using a 9-point hedonic scale. The degree of likeness was expressed as follows: Like extremely 9, like very much 8, like moderately 7, like slightly 6, neither like nor dislike 5, dislike slightly 4, dislike moderately 3, dislike very much 2, dislike extremely 1. Like extremely to like slightly constitute good while dislike slightly to dislike extremely constitute poor. Neither like nor dislike indicated that the product was either good or bad.

Statistical analysis: The data obtained from the proximate analysis, functional analysis and sensory evaluation was subjected to one-way Analysis of Variance (ANOVA) of a Randomized Complete Block Design (RCBD) using the SPSS[23] procedure version 16 for personal computers. Treatment means were separated using Duncan Multiple Range test at 95% confidence level.

RESULTS AND DISCUSSION

The instant rice produced from three different local rice varieties (Akujie, Igbo and Mass) using three processing methods were shown in Fig. 1-3. Figure 1 showed that instant rice produced using the fissuring method were all translucent. Also the rice grains were not broken notwithstanding the presence of cracks on them.

Instant rice produced through boiling showed grains that were not broken although they were noticeable cracks in them as shown in Fig. 2.

Figure 3 showed instant rice produced by fissuring method. The cracks on the grains were as result of breakages.

Proximate result: Result of the proximate analysis of the instant rice samples was shown in Table 1. The crude protein content of the samples ranged from 5.20-9.30%. Crude protein value was highest (p<0.05) in fissured samples (RFA, RFI and RFM) when compared to the boiled (RBA, RBI and RBM) and the pressed samples (RFA, RFI and RFM) of the same varieties. The fat content of the samples ranged from 0.25-0.60%. Sample RPI (Pressed *mass* rice) had the highest (p<0.05) score and lowest in sample RFA (Fissured Akujie rice). The mass variety had the highest fat content value in all the processing methods Crude fibre content of the samples ranged from 0.50-0.75%. It was highest in sample RPM (pressed Mass rice) and lowest in RPI (pressed *Igbo* rice). There was no significant difference (p>0.05) between samples RBM and RPA Igbo rice variety was significantly(p<0.05) lowest when compared with other two varieties.

The ash content of the samples ranged from 0.50-1.50%. Akujie rice samples (RFA, RBA and RPA) had the same and highest score which varies (p<0.05) from the values in the other two varieties samples.

The ash content of the samples ranged from 0.50-1.50%. Akujie rice samples (RFA, RBA and RPA) had the same and highest score which varied (p<0.05) from the values in the other two varieties samples. The processing method did not affect the value of ash content.

The moisture content of the instant rice samples ranged from 6.00-9.40%. The Akujie rice samples had highest moisture content in all the processing methods, it was followed by the Igbo rice and then the mass.

Carbohydrate content of the instant rice samples ranged from 76.90-86.10% with highest (p<0.05) value in mass rice variety and lowest in Akujie rice variety in all the processing methods.

The starch content of the instant rice products ranged from 20.68-45.30%. The starch content was highest in RPI (Pressed Igbo rice) and lowest in RBM (Boiled Mass rice).The boiling had the lowest (p<0.05) starch content followed by fissured and then the pressed varieties.

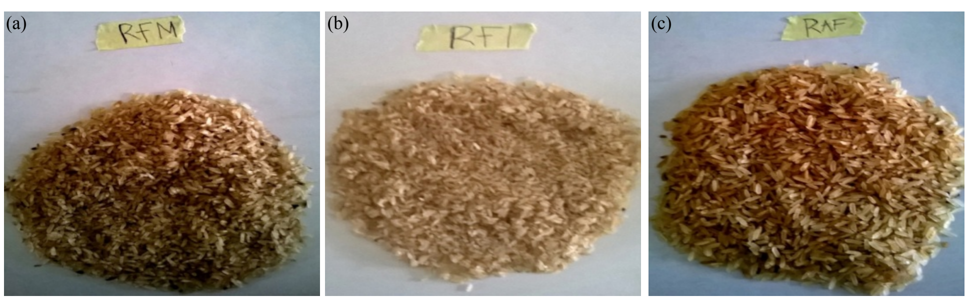

Fig. 1(a-c): Instant rice produced from fissuring method

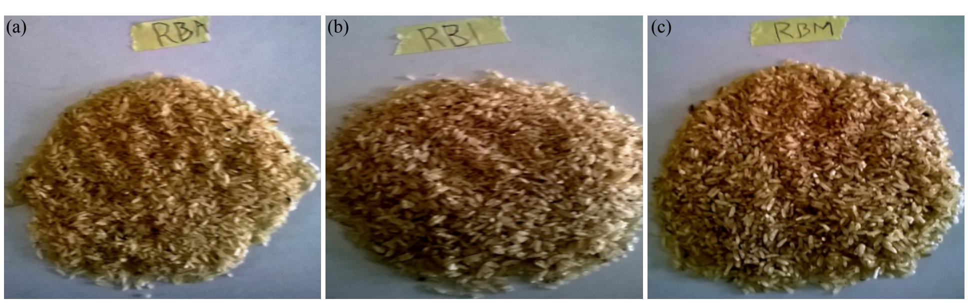

Fig. 2(a-c): Instant rice produced by boiling method

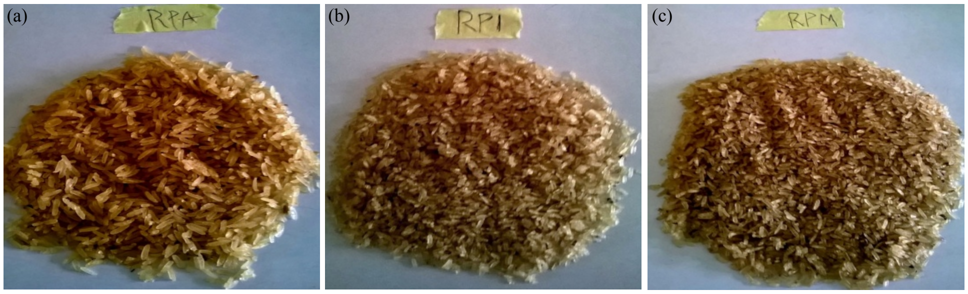

Fig. 3(a-c): Instant rice produced using the boiling method

Table 1: Result of proximate composition of Instant rice samples (%)

Samples	Crude protein	Ether extract	Crude fibre	ASH	Moisture content	Carbohydrate	Starch content
RFA	9.30 ± 0.00^{a}	0.25 ± 0.07^{e}	0.65 ± 0.00^{d}	1.50 ± 0.00^{a}	9.40 ± 0.00^{a}	78.90 ± 0.07^{f}	32.10 ± 0.00^{cd}
RFI	8.15 ± 0.00^{c}	0.30 ± 0.00^{de}	0.50 ± 0.00^{f}	1.00 ± 0.00^{b}	8.70 ± 0.14^{b}	81.35 ± 0.14^{d}	35.40 ± 0.00^{b}
RFM	8.20 ± 0.07^{c}	0.40 ± 0.00^{cd}	0.60 ± 0.00^{e}	1.00 ± 0.00^{b}	7.10 ± 0.14^{e}	82.70 ± 0.21^{c}	24.68 ± 0.32^{g}
RBA	8.95 ± 0.07^{b}	0.35 ± 0.07^{cde}	0.73 ± 0.04^{ab}	1.50 ± 0.00^{a}	7.60 ± 0.00^{d}	80.88 ± 0.18^{e}	27.00 ± 0.00^{f}
RBI	6.75 ± 0.00^{e}	0.35 ± 0.07^{cde}	0.60 ± 0.00^{e}	1.45 ± 0.07^{a}	6.30 ± 0.14^{f}	84.55 ± 20.14^{b}	31.60 ± 0.28^{d}
RBM	6.40 ± 0.00^{f}	0.40 ± 0.00^{cd}	0.70 ± 0.00^{bc}	0.60 ± 0.14^{c}	6.00 ± 0.00^{g}	86.00 ± 0.00^{a}	20.68 ± 0.32^{h}
RPA	7.80 ± 0.00^{d}	0.45 ± 0.07^{bc}	0.70 ± 0.00^{bc}	1.50 ± 0.00^{a}	8.80 ± 0.00^{b}	76.90 ± 0.00^{g}	32.20 ± 0.14^{c}
RPI	5.20 ± 0.28^{h}	0.55 ± 0.07^{ab}	0.68 ± 0.04^{cd}	1.10 ± 0.14^{b}	7.80 ± 0.00^{c}	81.63 ± 0.04^{d}	45.30 ± 0.42^{a}
RPM	5.65 ± 0.00^{g}	0.60 ± 0.00^{a}	0.75 ± 0.00^{a}	0.50 ± 0.00^{c}	6.30 ± 0.14^{f}	86.10 ± 0.50^{a}	28.80 ± 0.00^{e}

Means in the same column with different superscript are significantly different at $p<0.05$, RFA: Fissured Akujie rice, RBA: Boiled Akujie rice, RPA: Pressed Akujie rice, RFI: Fissured Igbo rice, RBI: Boiled Igbo rice, RPI: Pressed Igbo rice, RFM: Fissured Mass rice, RBM: Boiled Mass rice, RPM: Pressed Mass rice

Table 2: Functional properties of instant rice samples

Samples	Bulk density (g mL^{-1})	Oil absorption capacity (g mL^{-1})	Rehydration ratio	Volume expansion (g)
RFA	0.67 ± 0.00^{c}	2.20 ± 0.00^{b}	1.75 ± 0.07^{g}	2.25 ± 0.00^{d}
RFI	0.59 ± 0.00^{d}	2.00 ± 0.00^{bc}	1.95 ± 0.01^{f}	2.43 ± 0.00^{b}
RFM	0.77 ± 0.00^{b}	2.60 ± 0.28^{a}	1.87 ± 0.00^{h}	2.22 ± 0.00^{d}
RBA	0.77 ± 0.00^{b}	1.75 ± 0.07^{d}	2.09 ± 0.00^{c}	2.31 ± 0.00^{c}
RBI	0.79 ± 0.01^{a}	2.20 ± 0.00^{b}	2.20 ± 0.00^{a}	2.83 ± 0.00^{a}
RBM	0.79 ± 0.00^{a}	1.80 ± 0.00^{cd}	2.18 ± 0.01^{b}	2.33 ± 0.00^{c}
RPA	0.67 ± 0.00^{c}	1.60 ± 0.00^{de}	1.96 ± 0.00^{e}	2.22 ± 0.00^{d}
RPI	0.59 ± 0.00^{d}	1.40 ± 0.00^{e}	2.00 ± 0.01^{d}	2.04 ± 0.05^{e}
RPM	0.77 ± 0.00^{b}	1.40 ± 0.00^{e}	1.99 ± 0.00^{d}	1.90 ± 0.05^{f}

Means in the same column with different superscript are significantly different at $p<0.05$, RFA: Fissured Akujie rice, RBA: Boiled Akujie rice, RPA: Pressed Akujie rice, RFI: Fissured Igbo rice, RBI: Boiled Igbo rice, RPI: Pressed Igbo rice, RFM: Fissured Mass rice, RBM: Boiled Mass rice, RPM: Pressed Mass rice

Functional properties of the instant rice products: Table 2 showed the result of functional properties of the instant rice products. The bulk density values of the samples ranged from 0.59-0.79 g mL^{-1} and were statistically different ($p<0.05$) from each other. Boiled samples of all the varieties had ($p<0.05$) highest scores but fissured and pressed samples were not significantly ($p<0.05$) different from each other in all the samples. Oil absorption capacity values ranged from 1.40-2.60. Sample RFM had the highest ($p<0.05$) oil absorption capacity value while samples RPI (1.40) and RFM (1.40) had the lowest values. Fissured rice samples had highest ($p<0.05$) oil absorption capacity than the boiled and pressed samples.

Rehydration ratio values ranged from 1.75-2.20%. Sample RBI (Boiled Igbo rice) had the highest water rehydration ratio while sample RFM had the lowest. Boiled sample showed higher rehydration ratio than the fissured and pressed samples.

Volume expansion values ranged from 1.90-2.83 g samples RBI had the highest ($p<0.05$) value while sample RPM the lowest. Boiled samples of the different varieties had ($p<0.05$) higher volume expansion value when compared to the other samples.

The results of the analysis of sensory evaluation were shown in Table 3. Appearance mean values reported ranged from 4.75-7.35. Sample RBA (7.35) had the highest scores at the "like moderately" level. Sample RFI (4.75) had the lowest scores at the "neither like nor dislike" level. Generally, the appearance scores of the samples were high.

Table 3: Result of sensory analysis of instant rice products

Samples	Appearance	Taste	Texture	Flavour	Chewability	Overall acceptability
RFA	6.10 ± 1.77^{bc}	6.45 ± 1.73^{ab}	6.15 ± 1.84^{abc}	5.60 ± 1.79^{ab}	6.20 ± 1.74^{ab}	6.00 ± 1.84^{ab}
RFI	4.75 ± 1.97^{d}	5.30 ± 2.11^{bc}	5.10 ± 1.83^{bc}	5.40 ± 1.57^{ab}	4.65 ± 1.84^{c}	5.35 ± 1.84^{bc}
RFM	5.20 ± 2.21^{cd}	5.05 ± 2.06^{c}	4.95 ± 2.01^{c}	4.85 ± 2.03^{b}	4.00 ± 2.32^{c}	4.75 ± 2.02^{c}
RBA	7.35 ± 0.20^{a}	6.80 ± 0.95^{a}	6.25 ± 1.50^{ab}	6.35 ± 1.64^{a}	6.15 ± 1.95^{ab}	6.90 ± 1.12^{a}
RBI	6.60 ± 1.19^{ab}	6.40 ± 1.57^{ab}	5.95 ± 1.28^{abc}	6.35 ± 1.42^{a}	6.30 ± 1.26^{a}	6.55 ± 1.05^{a}
RBM	6.85 ± 1.42^{ab}	6.65 ± 1.27^{a}	6.00 ± 1.75^{abc}	6.55 ± 1.50^{a}	6.40 ± 1.47^{a}	7.05 ± 1.40^{a}
RPA	6.25 ± 1.74^{bc}	6.30 ± 1.95^{ab}	6.50 ± 1.54^{a}	6.30 ± 1.87^{a}	6.15 ± 1.95^{ab}	6.30 ± 2.08^{ab}
RPI	6.80 ± 1.54^{ab}	6.60 ± 1.82^{a}	6.75 ± 1.94^{a}	6.45 ± 1.82^{a}	5.90 ± 2.15^{ab}	6.90 ± 1.37^{a}
RPM	5.25 ± 2.22^{cd}	5.10 ± 2.15^{c}	4.90 ± 2.05^{c}	4.95 ± 2.16^{b}	4.95 ± 2.16^{bc}	5.30 ± 2.23^{bc}

Means in the same column with different superscript are significantly different at $p<0.05$, RFA: Fissured Akujie rice, RBA: Boiled Akujie rice, RPA: Pressed Akujie rice, RFI: Fissured Igbo rice, RBI: Boiled Igbo rice, RPI: Pressed Igbo rice, RFM: Fissured Mass rice, RBM: Boiled Mass rice, RPM: Pressed Mass rice

The mean taste scores reported ranged from 5.05-6.80. Sample RBA (6.80) was the most preferred for taste at the "like moderately" level. The RFM (5.05) was the least preferred at the "neither like nor dislike" level.

In terms of texture, the mean scores reported ranged from 4.90-6.75. Sample RPI (6.75) was the most preferred for texture at the "like moderately" level. Sample RPM (4.90) was the least preferred at the neither like nor dislike level. Mean scores reported for flavour ranged from 4.85-6.55. Sample RBM was the most preferred for flavour at the "like moderately" level. Sample RFM was the least preferred at the "neither like nor dislike" level.

In terms of chewability, the mean scores reported ranged from 4.00-6.40. Sample RBM was the most preferred for chewability at the "like moderately" level. Sample RFM was the least preferred at the "dislike slightly" level.

In terms of overall acceptability, the mean scores reported ranged from 4.75-7.05. Samples RBA, RBM, RBI, RPI were the most preferred at the "like moderately" level. Sample RFM was the least preferred at the "neither like nor dislike" level.

DISCUSSION

Instant rice grains produced using fissuring and boiling were translucent because of its completely gelatinized starch molecules.

The higher protein content of the fissured rice when compared to the boiled and pressed samples was as a result higher retention of protein in dry samples. The boiled and pressed were subjected to washing and soaking during treatment which encouraged leaching of soluble protein molecules. Dry heating before cooking denatures the protein and making it less soluble as a result complex formation[24]. Samadi and Yu[25] also reported that dry heating does not affect the protein fraction and protein molecular structure but dry heating reduces protein solubility and so encourage protein retention[26,27]. The protein content range (5.20-9.30%) in this work was generally higher than the value (5.25%) reported by Ali *et al.*[28] for instant rice from scented rice (*Kalijira*). However, it was similar to the values (6.55-8.40%) reported by Ibukun[29] for paddy rice. Protein plays an important role in cooked rice texture, because the protein forms a complex with starch and imparts starch granule swelling. Starch granule swelling affected both the intensity of viscosity (amylose leaching out of the granules) and the rate of starch gelatinization[30].

The fat content of the instant rice processed using the pressing method (RPA, RPI, RPM) were significantly high ($p<0.05$) due to the vegetable oil added to it during the processing. The vegetable oil acted as a surfactant to prevent the grains from sticking together. Generally, fat content of rice samples were minute. Minute rice, a popular instant white rice brand in Europe was reported in August, 2016 to have 0 g fat content. This makes local rice varieties a better source of dietary fats. Ohta *et al.*[31] reported that the triacylglycerols and phospholipids contained in grains decrease significantly when hot air dryer at 50°C is applied in drying the samples. This explained why the fat content of the instant rice products was low.

Crude fibre is the insoluble residue of an acid hydrolysis followed by an alkaline hydrolysis. This residue contains true cellulose and insoluble lignin. Generally, the crude fibre content of the instant rice samples was low (0.50-0.75%). Ali *et al.*[28] reported crude fibre content of 0.21, 0.22 and 0.22%, for instant rice from scented rice (Kalijira variety) processed by boiling, steaming and pressure cooking, respectively. The crude fibre content (1.00-2.00%) reported by Oko *et al.*[5] in the study of local and newly introduced rice varieties grown in Ebonyi state, Nigeria was higher than the result from this work. From the result, the ash content differed according to the rice varieties used. Ash content of a food sample gives an idea of the mineral elements present in the food sample[32]. The ash content of the produced instant rice especially the Akujie variety is high compared to other research work. Ali *et al.*[28]

reported the ash content of scented instant rice processed using the boiling, steaming and pressure-cooking method as 0.48, 0.47 and 0.48%, respectively. Oko *et al.*[5] also reported similar values for ash content of local and newly introduced rice varieties grown in Ebonyi state, Nigeria.

The low moisture content of the instant rice (6.00-9.40%) indicates low water activity (a_w). This variation in moisture content may be as a result of differences in the rate of drying by the different samples. The report of this work is similar to that of Ali *et al.*[28], in which it recorded 9.15% as the highest moisture content. Also according to Smanalieva *et al.*[33] report, moisture content is an important quality index of grains and moisture content ranging from 9-11% is safe for storage, instant rice samples produced fall within the range indicating no difficulty in storing.

This high carbohydrate content (76.90-86.00%) may be attributed to its low moisture content[34]. The values reported was higher than the values by Ali *et al.*[28] who had 84.97% as the highest carbohydrate content for instant rice produced from scented rice (Kalijira). These scores obtained were higher than the values (75.37-76.37%) reported by Edeogu *et al.*[35] who analyzed the proximate compositions of staple food crops in Ebonyi state.

The starch content which was lowest in boiled samples may be as a result of leaching of soluble starch during the boiling. Also the fissured samples exposed to high temperature may have resulted to hydrolysis of some of the starch molecule. The starch content (20.68-45.30%) from this work was lower than the range of values (64.21-65.84%.) reported by Ali *et al.*[28]. The variation in the starch content obtained could be as a result of differences in the processing methods and the rice variety used. Starch as the major storage carbohydrate of cereals form an important part of our nutrition. Its unique properties is important for the textural properties of many foods, in particularly bread and other baked products[36].

The significantly high bulk density of the boiled samples were as a result of water absorption Other inherent factors which could be responsible for these variations in bulk density include; texture, density, particle size and packing arrangement[37].

Pressing exposes the protein molecules making them easier for binding with the oil. The gelatinized rice which is translucent may be difficult to bind with oil. The ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired. Optimum OAC facilitate and enhance flavour and mouth feel qualities in food[38].

The freezing operation used in the boiling method could be the reason for the high rehydration ratio. This fact was corroborated by the work of Prapluettrakul *et al.*[39], who reported that the instant rice cooked in an electric cooker and frozen for 24 h had the highest water rehydration ratio. However, the rehydration ratio values reported by Prapluettrakul *et al.*[39] for instant rice developed for young children, ranged from 2.20-5.80%, much higher than the results obtained in this work. According to Lawal *et al.*[40], the swelling capacity is a measure of the ability of starch to hydrate under specific conditions such as temperature and water availability.

Rehydration ratio of the samples were significantly lower than the values (2.68-3.15%) reported by Anjum *et al.*[41] for local rice varieties in Pakistan (Irri-6, Irri-9, Sarsha and DR-83).

The volume expansion values (1.90-2.83 g) were high compared to other similar research findings. Igbo rice variety was significantly higher than the mass and Akujie this may indicate higher water absorption rate. Prapluettrakul *et al.*[39] reported lower volume expansion values which ranged from 1.25-2.6%. Chukwuemeka *et al.*[42] also reported higher volume expansion range ratio for five rice varieties produced in Ohaukwu local government area, Ebonyi state which ranged from 1.67-3.67%.

The high sensory scores for the boiled sample was as a result of the translucent colour and the fact that grains were not broken. The fissured sample had low score in appearance because the grains were not washed and soaked before processing leading to dull appearance. Appearance is an important criterion in determination of acceptability as it is associated with aesthetic value of product[43]. Boiled samples scored highest in taste due to better development of taste with boiling also the pressed scored moderately highly probably because of boiling and also the oil inclusion. Fat is a good carrier of flavour which also affect the mouth feel and so the taste. Akujie samples had highest texture acceptability score in all the processing methods. The texture indicated the doneness of the rice product. Mass had the least flavour acceptable score. Mass has a characteristic odour which is unpleasant to many.

Overall acceptability showed rice varieties processed using the boiling method, compared to the other two processing methods (Fissuring and Pressing) was the most preferred at the "like moderately" level. This makes it the most acceptable processing method to be used The Akujie rice specie was also the most preferred at the "like moderately" level. Therefore, Akujie species was the most accepted rice variety compared to other rice species (Mass and Igbo) used.

CONCLUSION

The study showed that the proximate composition of instant rice produced from the Akujie specie using the fissuring method (RFA) had the highest scores for protein while the instant rice produced from Igbo rice specie using the pressing method had the highest fat content. The total starch content was highest in RPM.

The functional properties of the samples showed that samples RBI and RBM had the highest scores in terms of bulk density. Oil absorption capacity scores were highest in sample RBI. The rehydration ratio of the samples was high. However, sample RBI had the highest rehydration ratio. Volume expansion was highest in RBI.

After comprehensive evaluation, the optimal processing method recommended is the boiling method. The Akujie rice variety was the most preferred in terms of sensory attributes like appearance, taste, flavour and overall acceptability. This made it the best rice specie when compared with the other two varieties (Mass and Igbo). The information from this study should spur more detailed research works on the commercial production and distribution of the instant rice from local varieties as a viable entrepreneurial venture.

SIGNIFICANCE STATEMENT

This study discovered that local rice varieties from Ebonyi state, Nigeria could successfully be proceed into instant rice products. The products showed variations in proximate composition, functional properties and sensory evaluation. Boiled Akujie rice was most preferred with over all acceptability of like moderately. This study will help investors to commercially produce instant rice from local varieties in Ebonyi state and so encourage entrepreneurial adventure. It will also motivate local rice farmers to increase cultivation which will lead to food security.

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