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Research Article

Determination of Physicochemical, Cooking and Milling Characteristics of Four Nigerian Rice Varieties

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ABSTRACT

This research work determined the physicochemical, cooking and milling characteristics of four Nigerian rice varieties namely Illa from Southern, Abakaliki South-East, Jemila North and Ofada from West.The physiochemical, milling and cooking properties of rice are solely determining the preference, choice and economy of rice. The four rice varieties grown in different region in Nigeria were investigated for cooking, milling and physical, cooking and chemical characteristics. The result from axial dimension classified all the studied rice varieties as long grains. Illa rice recorded highest value (43.96 g) of 1000 grain weight while lowest value of 20.46 g was observed in Ofada rice. The variation in grain shape were not significant at (P>0.05) and all the tested varieties fall within the slender shapes. All the tested samples displayed good Milling behavior. Ofada rice elongated more than other varieties. The broken percentage was higher and lower in Illa rice (36.72%) and Abakaliki (28.78%) respectively. There were similarities in milling recovering of rice varieties, but Illa had highest expansion (swelling) capacity while Ofada had lowest swelling power. Amylose and gelatinization temperature showed a good relationship, Ofada rice with higher amylose content had lowest gelatinization temperature. The determined cooking time of the rice sample varied from 5.56 to 6.77 mins, Jemila rice will cook faster than other varieties. Illa rice had highest value (353.76%) of water absorption capacity, followed by Abakaliki rice with 185.76% Water Absorption Capacity and Ofada rice which had 158.62% WAC. The lowest value (155.60%) of Water Absorption Capacity was found in Jemila rice variety.

RESEARCH ARTICLE

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INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food which has been known as the leading food crop in the globe that is capable of feeding almost half of the global entire population (Pokhrel *et al.*, 2020 ; Singh *et al.*, 2005). Rice is most cultivated crop globally and it's rated as most important crop after wheat (Hettiarachchi *et al.*, 2017). Its origin belongs to the family of Poaceae and it is originated from ancient civilization native to Southeast Asia (Pokhrel *et al.*, 2020; Kim and Shim, 2014). Pokhrel *et al.* (2020) reported that virtually, 90% of the Oryza sativa produced and eaten in Asian whilst other eleven Asian Nations contributed 87% of world Oryza sativa production (Oko *et al.*, 2012). The rice varieties since time immemorial have been produced and consumed after ancient time and has been most helpful in the survival and food security of the world populace (Bhat and Riar, 2017 and Sharma *et al.*, 2020).

The cooked and consumed rice provides about 40% to 80% content of calorie intake among the populace (Tanveer *et al.*, 2016 and Sharma *et al.*, 2020). Some of rice cooking qualities that can be determined in terms of cooking time, elongation of the grains during cooking, major and minor diameter ratio after cooking also determines their economic values of any rice variety (Tanveer *et al.*, 2016). Rice cooking quality attributes solely depends upon on selected properties of starch content such as amylose and amylopectin ratio (Danbaba *et al.*, 2011 and Diako *et al.*, 2011). The most vital its properties of rice which solely influenced rice cooking behavior is amylose content (Ravi *et al.*, 2014 and Xie *et al.*, 2007). According to Tanveer *et al.*, (2016) rice variety with amylose content above 25% reported to absorbs more water and has a fluffy texture during and after cooking. Good rice qualities during and after cooking have been attributed to its linear elongation (Danbaba *et al.*, 2011 and Diako *et al.*, 2011). Rice variety which expands only along its major diameter (length) without corresponding expansion on the minor diameter (girth) is considered high-quality rice (Tanveer *et al.*, 2016). Rice varieties have been proven to have significant effect on their physical, chemical, morphology and cooking properties (Yadav *et al.*, 2007; Siyafutri *et al.*, 2016). According to Putri, (2012) and Han *et al.*, (2008) different cooking method profusely effect the characteristics and hydrolysis of Oryza sativa starch. Rice can be cooked in numerous ways to ensure good quality after cooking. The conventional approach for cooking rice consists of stovetop, boiling and steaming as was described in *liwet* method (Tanveer *et al.*, 2016 and Syafutri, 2015). The modern and conventional way of cooking rice was use of electric device rice-cooker. Each cooking method applied varied heat and cooking time (Larasati, 2012). Previously many authors have reported numerous works on rice more especially on the hysicochemical properties. Recently review of relevant literatures on rice showed that Shin *et al.* (2007); Cantral and Reeves, (2002); Imolehin and Wada, (2000); Prakash and Jamuna (2013); Nádvorníková *et al.* (2018); Pokhrel *et al.* (2020); Megha *et al.* (2019) determined the cooking characteristics and physicochemical properties of different rice varieties as effected by different cooking methods. The review showed that little or no work has been reported on the cooking and physicochemical properties of Nigerian local rice selected from different regions (North, South, West and East) of Nigerian. Therefore, the objective of this research work was to determine the grain qualities characteristics such as cooking properties and physicochemical properties of selected local Nigerian rice varieties.

MATERIALS and METHODS

Source of rice samples

Four locally processed rice varieties Ofada, Jemila, Abakaliki and Illa rice were sourced from DUfarm in Federal University of Agricultural Abeokute Ogun State, Da-Elgreen farm in Chikun Local Government Area Kaduna State, Modern Community Farm in Ministry of Agriculture, Ezzamgbo branch, Ebonyi State and Nature's farm, Illah Ugbolu Local Government Area, Delta State respectively. The mode of selection of the samples were based on variety with highest consumers patronage as revealed by a preliminary consumer survey of local and imported rice varieties sold in the market.

Preparation of the rice samples

The sourced paddy varieties were properly dry-cleaned to remove dirty, immature grain, unwanted and broken materials attached with the samples from the farm. The four locally processed rice varieties (Ofad, Jemila, Abakaliki and Illa) were cooked using the method reported (Alaka *et al.,* 2011). 20g of the samples was weighed into a 250 ml beaker, and 200 ml of water was added to cover it and placed on thermostatically controlled heating mantle at 95°C.

Determination of physical characteristics of rice varieties

Axial dimensions

Major diameter (*a*), minor diameter (*b*) and intermediate diameter (*c*) of the rice samples were determined using vernier caliper with 0.01 mm accuracy. The rice kernels were randomly handpicked and each of their dimensions were determined at three replications.

Thousand weight

One thousand rice kernel were selected randomly from each sample and weighed using Mettler Toledo electronic weighing balance with accuracy of 0.001 g.

Bulk density

Ratio of the mass of rice variety to its measured total volume which referred to as bulk density (ρb). It was determined by following equation (3.1) reported by Tanveer *et al.* (2016).

$$\rho_b = \frac{M_s}{V}\ (kg\ m^{-3}) \quad (1)$$

Where; $M_s$the mass of rice grain, $V$is the volume occupied.

Grain shape

Grain Shape is the major and minor diameter ratio of the locally selected rice varieties, was evaluated using the equation (2) reported as was by Pokhrel *et al.* (2020).

$$Grain\ shape = \frac{a}{b}(mm) \qquad (2)$$

Where: *a* = mean major diameter of milled rice (mm) and *b* = mean minor of milled rice (mm)

Determination of cooking and milling characteristics of rice

Required Optimum Cooking Time (OCT)

ROCT was measured using the method reported by Pokhrel *et al.* (2020) on evaluation of physicochemical and cooking properties of rice.

Water Uptake Ratio (WUR)

WUR was determined using the method and Equation (3) reported by Pokhrel e*t al.* (2020) on evaluation of physical and chemical and cooking characteristics of rice.

$$Water\ Uptake\ Ratio = \frac{Weight\ of\ kernel\ afer\ cooking\ (g)}{Weight\ of\ kernel\ before\ cooking\ (g)} \qquad (3)$$

Elongation Ratio *(ER)*

The elongation ratio *(ER)* was evaluated by the method and Equation (4) reported by Oko *et al.* (2012) on rice cooking quality and physical chemical properties.

$$Elongation\ Ratio = \frac{Average\ lenth\ of\ cooked\ rice\ (mm)}{Avetrage\ length\ of\ uncooked\ rice\ (mm)} \qquad (4)$$

Cooked Length *(CL)*

The length of cooked rice and breadth ratio was measured using the Equation (5) reported by Oko *et al.* (2012).

$$Cooked\ length = \frac{Length\ of\ cooked\ rice\ (mm)}{Breath\ of\ cooked\ rice\ (mm)} \qquad (5)$$

Dehusking / hulling *(%)*

The hulling percentage of rice sample was determine using the Equation (6) reported by Oko *et al.* (2012).

$$Hulling\ percentage(\%) = \frac{Weight\ of\ brown\ rice\ (g)}{Weight\ of\ rough\ rice\ (g)}\ x\ 100\% \qquad (6)$$

Broken Percentage *(BP)*

The broken percentage of the rice kernel varieties were measured using the Equation (7) reported by Ravi *et al.* (2014) on cooking and milling characteristics of rice.

$$Percentage\ broken(PB) = \frac{Weight\ of\ broken\ grain}{Weight\ of\ milled\ sample} x\ 100 \qquad (7)$$

Swelling Percentage (*SRI*)

The swelling ratio index of the rice kernel were determined by adopting the Equation (8) reported by Ravi *et al.*, (2014).

$$Swelling\ ratio\ index = \frac{Height\ of\ raw\ rice - height\ of\ cooking\ pot}{Height\ of\ cooked\ rice - height\ of\ ooking\ pot} x\ 100\% \qquad (8)$$

Milling recovery

The processed rice was weighed using electronic weighing balance to measure the milling recovery of the rice sample as was reported by Oko *et al.* (2012) and Shaeed *et al.* (2017) as modified by Pokhrel *et al.* (2020) in the Equation (9) below.

$$Milling\ recovery\ = \frac{Weight\ of\ milleed\ rice\ (g)}{Weight\ of\ sample\ paddy\ used\ (g)} x\ 100\% \qquad (9)$$

Determination of chemical properties of rice varieties

Amylose and Amylopectin Contents of rice varieties

The amylose content and amylopectin content were all determined by adopting the standard methods reported by Oko *et al.*, (2012).

Gelatinization time and gelatinization temperature at 90°C

The method reported by Alaka *et al.* (2011) was used to determine gelatinization time and gelatinization temperature of the processed rice samples.

Solubility (%)

The solubility of the sample was determined with method reported by Udensi and Onuora, (1992) using Equation (10).

$$Solubility = TSS(\%)\frac{(VsMe - Md)}{2MS1} x\ 100 \qquad (10)$$

Vs = Supernatant/ filtrate; *Md*= Empty dish mass; *Me* = Mass of Petri dish plus residual solid after evaporative drying; *Ms* = Mass of flour sample used for preparation of the dispersion.

Water Absorption Capacity

The method of Alaka *et al.* (2011) was used to measured water absorption capacity.

$$WAC(\%) = Final\ Volume\ of\ water - Initial\ Volume\ of\ Water\ Expressed\ incm^3 \quad (11)$$

Statistical analysis

The experiment was carried out in a completely random design. The results obtained were submitted to analysis of variance (ANOVA), with the means compared by Duncan's test at 5% of significance. All results were expressed as the mean value standard error (SE). Statistical analyses were performed using SPSS for Windows 8.0.

RESULTS AND DISCUSSION

Physical properties of rice varieties

The physical properties of grain axial dimensions and weight are of importance to those involved in many aspects of the rice processing industries and these are basic factors to determine rice grain quality. Thomas *et al.* (2013) revealed that physical properties are determined to provide an important data necessarily needed for the design and fabrication of equipment for bulk process and storage of rice varieties.

Table 1. Physical properties of rice varieties.

Properties	Illa	Abakaliki	Jemila	Ofada
Major diameter (mm)	8.34 (0.36)	7.89 (0.26)	7.75 (0.13)	6.88 (0.54)
Minor diameter (mm)	2.40 (0.44)	2.41 (1.41)	2.26 (0.21)	2.05(0.76)
Intermediate diameter (mm)	4.24 (1.43)	4.10 (0.90)	4.00 (2.01)	3.63 (3.09)
1000 grain weight (g)	43.96 (0.62)	36.44 (4.03)	30.00 (2.01)	20.46 (0.67)
Bulk density (g mm^{-3})	18.73 (0.99)	18.61 (0.62)	17.51 (0.48)	20.31 (1.20)
Grain shape	3.47 (0.88)	3.27 (0.65)	3.43 (3.05)	3.35 (0.09)
Porosity (%)	97.02 (0.50)	92.72 (2.50)	89.43 (2.01)	90.49 (0.67)

Note: The values in brackets are standard deviations of the replicated mean values of the samples.

From Table 1, major diameter (length) for Illa, Abakaliki, Jemila and Ofada rice were 8.34 mm, 7.89 mm, 7.75 mm and 6.88 mm, minor diameter (width) for Illa, Abakaliki, Jemila and Ofada were 2.40 mm, 2.41 mm, 2.26 mm and 2.05 mm and intermediate diameter (thickness) were 4.24 mm, 4.10 mm, 4.00 mm and 3.63 for Illa, Abakaliki, Jemila and Ofada rice varieties respectively. From the findings, Illa rice recorded higher value (8.34 mm), followed by Abakaliki rice which had 7.89 mm while Ofada rice had lowest value (6.88 mm) followed by Jemila rice (7.75 mm) of major diameter respectively. The whole rice varieties displayed non significance difference at ($P>0.05$) in terms of minor diameter (width). It is therefore observed that the longest and thicker grain were obtained from Illa rice (8.34mm) while widest were obtained from Abakaliki rice (2.41mm). Categories of rice grains according to Alaka *et al.* (2011) and Dipti *et al.* (2002) reported that grains whose major diameter (length) are longer than 6mm is a long grain, from 5mm to 6mm are medium and less than 5mm is short grain. For these reasons, rice varieties investigated were long grains. Consequently, they have higher market value as width and length of rice measures the rate of demand of rice grain. The major, minor and intermediate diameters characterized grain items of size and shape which varied many other rice properties such as sieving, dehulling, polishing, storage and cooking.

The 1000 grain weight reveals knowledge on the density of the sample. Grains of varied weight milled separately and are likely to retain differently moisture when it is cooked (Megha *et al.*, 2019). Rice grain of same weight is important for consistent grain quality (Megha *et al.*, 2019). The 1000 grain weight were 43.96 g for Illa rice, 36.44 g for Abakaliki rice, 30.00 g for Jemila rice and 20.46g for Ofada rice. Illa rice recorded highest value (43.96 g) of 1000 grain weight while lowest value of 20.46 g was observed in Ofada rice. The weight values of rice samples differ reasonably from each other at ($P<0.05$).

Bulk density (g mm^{-3}) of studied rice varieties were presented in Table 1, The Illa rice had 18.73 g mm^{-3}, Abakaliki rice had 18.61 g mm^{-3}, Jemila rice recorded 17.51 g mm^{-3} and Ofada rice had 20.31 g mm^{-3}. It was observed that Ofada rice samples had highest value (20.32 g mm^{-3}), followed Illa rice which had 18.73 g mm^{-3} of bulk density. Jemila rice had the lowest value (17.51 g mm^{-3}) of bulk density. The results obtained from the bulk density of the samples were similar with the report of Ajatta *et al.* (2016) and Malomo *et al.* (2012) on processed composite flour and yam-soy blend. The bulk density was varied by rice particle size and starch polymer structure. The Jemila rice sample with low bulk density (17.51 g mm^{-3}) are preferred in cooked rice as because it contributed to little dietary bulk, the smooth packaging and transportation of the rice samples (Aluge *et al.*, 2016).

The shape of rice sample length and width ratio) were 3.47 mm for Illa rice, 3.27 mm for Abakaliki rice, 3.43 mm for Jemila rice and 3.35mm for Ofada rice. The varieties were observed to be similar in shape. The variation in grain shape were not significant at ($P> 0.05$). According to the report of Alaka *et al.* (2011), rice sample with ratio greater than 3.0, ration between 2-3 and ratio less than 2 are categorized as slender, bold and round rice respectively. The result presented in the Table 1, revealed that all the investigated rice sample belongs to slender shape rice. It was observed that shape of rice grain varies its volume (Pokhrel *et al.*, 2020), and weight and the slandered rice sample was found to occupy more space than round rice sample during storage. It implies that slender rice varieties occupy more space during storage than same weight of round rice sample (Pokhrel *et al.*, 2020). One of the market values of rice sample is that if round cooked rice is dished with respect to volume instead of weight, the buyer will be advantaged whereas the seller will be favored if it were to be a slender shaped rice variety (Pokhrel *et al.*, 2020 and Alaka *et al.*, 2011). Size and shape of rice varied numerous properties of rice samples such as sieving, polishing, storage as well as cooking characteristics. The consumer preference for rice grain size and shape varied from one group to the other. Alaka *et al.* (2011) reported that higher class people prefer long slender grains whereas lower class people prefer theshort bold grains due its high-volume expansion characteristics. The grain size and shape of most new developed modern rice varieties are classified as slender shaped rice with crystalline appearance.

The table 1, presented the porosity of studied rice varieties. Illa rice had 97.02%, Abakaliki rice had 92.72%, Jemila rice 89.43% and Ofada rice 90.49%. Porosity index of voids was highest in Illa rice 97.02%, and least in Jemila rice 89.43%. Porosity of rice is mainly dependent on its density as bulk density of rice indicates the storage properties (Megha *et al.*, 2019). The bulk density, porosity and the roundness of the samples are correlated as the greater the bulk density and the lower the porosity of the samples. Porosity was remarkably varied by the degree of milling. The porosity of the tested rice varieties significantly differences at ($P>0.05$) confident interval.

Cooking and milling properties of rice varieties

Rice milling is one of the most vital operations in rice processing because it determines the economic value of rice grain. The numerous benefits of rice milling were to obtain an edible white rice kernel that will be enough for consumers and free from impurities (Singh *et al.*, 2005). Tanveer *et al.* (2016) reported that cooking time of rice grain is basically obtain when 90% of starch of the rice grain is no longer showing an opaque center (Dipti *et al.*, 2003).

Table 2. Cooking and Milling characteristics of rice varieties.

Properties	Illa	Abakaliki	Jemila	Ofada
Optimum cooking time (mins)	38	32	30	25
Water uptake ratio	6.12(1.34)	5.56(6.05)	5.84(0.911)	6.72(1.12)
Elongation ratio	1.34(0.94)	1.37(1.04)	1.51(1.12)	1.66(0.15)
Cooking length (mm)	5.5(2.13)	6.8(2.65)	4.28(4.05)	3.20(1.21)
Hulling percentage (%)	25.62(0.95)	18.42(0.76)	17.49(0.32)	13.25(0.53)
Broken percentage (%)	36.72(3.01)	28.78(2.05)	33.82(0.21)	36.67(0.95)
Swelling percentage (%)	62.79(4.05)	59.22(5.01)	56.86(1.23)	55.50(1.54)
Milling recovering (%)	15.71(2.04)	15.65(0.43)	14.16(3.05)	15.24(1.05)

Note: The values in brackets are standard deviations of the replicated mean values of the samples.

From Table 3, the amylose content of tested rice varieties which determine the gelatinization temperature, pasting behavior, viscoelastic parameters of rice samples were showed in Table 3. Furthermore, the amylose content of unprocessed rice varieties flour is an vital factor which determines the last use of numerous products such as noodles (Eke-Ejiofor and Nwiganale, 2016) and it also an important criteria in classifying rice systems (Merynda *et al.*, 2016). The amylose content for Illa, Abakaliki, Jemila and Ofada rice varieties were 23.73, 23.45, 24.42 and 25.64% respectively. Falade and Christopher (2015) reported low amylose content in rice samples provides softness, moistness, and chewiness to product textures. From the findings, it showed that Ofada rice had highest value (25.64%) of amylose content, followed by Jemila rice which recorded 24.42% of amylose content. The lowest value (23.45%) was found in Abakaliki rice followed by Illa rice sample with 23.73% amylose content. These findings of amylose content of the studied rice varieties were in line with the report of Eke-Ejiofor and Owuno (2012) on wheat flour. Amylose content of rice varieties was classified into four classes, very low (<10%), low (10-20%), moderately low (20-24%) and high (>25). it would produce no sticky rice, expand and became hard when it cold (Siyafutri *et al.*, 2016). Illa (23.73%), Abakaliki (23.45%) and Jemila (24.42%) with moderate amylose content had fluffier texture generally (Indrasari *et al.*, 2009). Based on this classification Ofada rice belongs to rice with high amylose content while other varieties belong to a rice moderate amylose content. From the findings, it was observed that amylose and starch content showed in different rice varieties maybe atributed to the application of fertilizer (nitrogen content), growing conditions, time and also location of the growing areas (Buresova *et al.*, 2010).

The amylopectin values of rice varieties studied were presented in Table 3. The amylopectin content of Illa rice, Abakaliki rice, Jemila rice and Ofada rice were 76.28%, 76.55%, 75.58% and 74.37% respectively. It was observed that Abakaliki rice sample had the highest value (76.55%) percentage of amylopectin and Ofada rice samples had the lowest value (74.37%) value of amylopectin. There is a slight significant variation among rice varieties tested at (P>0.05) in terms amylopectin content. From the report of Alaka *et al.,* (2011), it was revealed that amylopectin content of rice samples is a component of glucose molecules with a branched link and it has lower resistance to digestion. Rice sample with higher content of starch in form of amylopectin have the tendency of containing higher glycemic index (GI). Furthermore, food products with higher glycemic index (GI) can digest rapidly than those with lower GI values. Consequently, Ofada and Jemila rice are preferable due to their lower content of amylopectin and higher content of amylose which indicates relatively lower glycemic index (GI). Consequently, it be a perfect recommendation for a dieting diabetic patient (Frei and Becker, 2003; Alaka *et al.,* 2011).

The gelatinization temperature of studied rice varieties varied from 94.80°C for Illa rice, 84.78°C for Abakaliki rice, 83.13°C for Jemila rice and 82.38°C for Ofada rice sample. It influenced the water uptake and kernel elongation (Bhat and Riar, 2017). From the result presented in Table 3, it was observed that Illa rice had highest gelatinization temperature of 94.80°C whereas Ofada rice had lowest value (82.38°C) of gelatinization temperature. This finding is aligned with the report of Pokhrel *et al.* (2020) on cooking characteristics of rice varieties, practically, higher amylose content has less crystalline structure and has low gelatinization temperature, from this study Ofada rice sample had highest amylose content with lowest gelatinization temperature. Alaka *et al.* (2011) also stated that rice sample that contained high amylose content has moderate or low gelatinization temperature value although it was observed that rice with low or waxy amylose content reported to have higher or lower gelatinization temperature. Gelatinization temperature is solely dependent on the cooking time of the rice samples, according to Cuevas and Fitzgerald (2012) shorter cooking is mostly preferred as it save reasonable amount of energy and fuel.

The gelatinization time of the tested rice verities were presented in Table 3, the gelatinization time for Illa, Abakaliki, Jemila and Ofada rice were 6.77 mins, 5.70 mins, 5.56 mins and 5.70 mins respectively. It was observed that Illa rice had the highest value (6.77 mins) of gelatinization time while Abakaliki, Jemila and Ofada rice had similar values (5.70 mins, 5.56 mins and 5.70 mins) of gelatinization time. The changes in gelatinization time among the tested rice samples was attributed to varietal differences and independent of gelatinization temperature and cooking time. There was no significant difference at (P>0.05) among Abakaliki, Jemila and Ofada rice gelatinization time but Illa rice varied significantly at (P<0.05). This finding may be due to the type of starch contained in the tested rice samples (Alaka *et al.,* 2011).

From the result of chemical properties of cooked rice varieties presented in Table 3, the values for solubility index of tested rice samples were 10.69, 12.10, 9.54 and 10.01 for Illa, Abakaliki, Jemila and Ofada rice varieties. It was observed that Abakaliki rice had the highest value (12.10%) of solubility, followed by Illa rice which had 10.69% and Ofada rice had 10.01%. The lowest value (9.54%) was found in Jemila rice. These values of solubility index were varied more than the report of Eke-Ejiofor and Owuno (2012) on wheat flour and in range with the report of Eke-Ejiofor and Nwiganale (2016) on rice flour. The sample (Abakaliki rice) with higher solubility assosociated with the decreasing of its chain length of the starch molecules thereby decreasing the hydrogen bonds binding the granules together (Eke-Ejiofor and Nwiganale, 2016).

Water absorption capacity (WAC) is an important functional parameter that significally alters the gelatinization of starch contained in flour sample. Determining Water absorption capacity of processed flour is so important as it contribute immensely to development of new bio-products (Thomas *et al.*, 2014 and Bhat *et al.*, 2008). From the findings, it was observed that Illa rice had highest value (353.76%) of water absorption capacity this was attributed to the presence of hydrophobic amino acids which interferes with the ability of the rice starch to absorb water and increase in the amylose leaching and solubility and loss of starch crystalline structure, followed by Abakaliki rice with 185.76% WAC and Ofada rice which had 158.62% WAC. The lowest value (155.60%) of WAC was found in Jemila rice variety. The Illa rice variety varied significantly among other varieties at ($P>0.05$) confidence interval. This result was similar with the report of Racheal *et al.* (2014) on the reported functional and pasting properties of Nigerian local and imported rice varieties form Malaysia rice. The variation in the water content of the rice samples were associated with the presence of hydrophobic amino acids which interferes with the ability of the rice starch to absorb water (Ajatta *et al.*, 2016; Singh *et al.*, 2005). This result was associated with the loose amylose and amylopectin in the native starch granules and the weak binding force (Williams *et al.*, 2002 and Ihegwuagu *et al.*, 2009).

CONCLUSION

The four rice varieties grown in different region in Nigeria were evaluated for physical, cooking, milling and chemical characteristics. The result from axial dimension classified all the studied rice varieties as long grains. Illa rice recorded highest value (43.96 g) of 1000 grain weight while lowest value of 20.46 g was observed in Ofada rice. All the tested samples displayed good Milling behavior. Ofada rice elongated more than other varieties. The broken percentage was higher and lower in Illa rice (36.72%) and Abakaliki (28.78%) respectively. There are similarities in milling recovering of rice varieties but Illa had highest expansion (swelling) capacity while Ofada had lowest swelling power. Amylose and gelatinization temperature showed a good relationship, Ofada rice with higher amylose content had lowest gelatinization temperature. The cooking time of the rice sample varied from 5.56 min to 6.77 mins, Jemila rice will cook fast than other varieties. Illa rice had highest value (353.76%) of water absorption capacity, followed by Abakaliki rice with 185.76% WAC and Ofada rice which had 158.62% WAC. The lowest value (155.60%) of WAC was found in Jemila rice variety.

DECLARATION OF COMPETING INTEREST

The authors declareted that there is no conflict of interest during and afater this research.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Authors declare the contributions to the manuscript such as the following sections:
Patrick Ejike Ide: Investigation, formal analysis, writing - original draft, methodology, writing - original draft.
Omenogor Ikoko: Investigation, writing - original draft, data curation.
Helen Onyeaka: Methodology, validation and review, and editing.

ETHICS COMMITTEE DECISION

This article does not require any ethical committee decision.

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