

Functional and Micro-Structural Properties of Starch and Flour Produced from One Indigenous and Three Improved Local Rice (*Oryza sativa*) Varieties

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Abstract

Study on the functional and micro-structural quality of starch and flour obtained from four (4) varieties of rice was assessed. The quality aspect of the rice varieties was compared between local and improved variety (Faro 44, 52, 61 and Kwandala). The samples were processed to obtain flours and starches. The Proximate composition, micro-structure and functional attributes of the samples were analyzed. The percentage moisture contents in rice flours ranged from (8.39-8.68 %) while those of starches ranged from (8.68-9.98%). The percentage ash content of the flour samples analyzed ranged from (0.71-0.91%) while those of starches ranged from (0.49-0.64%). The percentage fat content of rice flour samples ranged from (1.55-2.15%) while those of starch ranged from (1.47-2.62%). The percentage protein content of rice flour ranged within (6.64-7.66%) while those of starches ranged between (6.99-7.88 %). The results of the CHO content of rice flour samples fell within (80.99-82.36%) while those of starches ranged from (80.50-81.51%). Starch yield content varied between (52.64-56.40%). The results of loose density and packed Bulk Density of rice flour ranged between (1.14-1.18g/mL) and (1.13-1.21g/mL), while loose bulk density and packed density of the rice starch ranged within (0.65-0.73g/ml) and (0.71-0.73g/mL). The results of Water Absorption Capacity of rice flour ranged within (1.58-1.86 g/g) while those of starch ranged between (1.90-1.99g/g). The results of Oil Absorption Capacity of rice flour ranged between (1.83-2.17g/g). While, those of starch ranged from (2.02-2.33g/g). The Gelling consistency of rice flour ranged between (16.32-35.54mm), meanwhile those of starch ranged from (17.05-60.35mm). Amylose content for rice flour ranged from (21.11-26.10 %) while those of starches ranged from (21.11-26.10%) and (21.35-25.14%). Amylopectin content of rice flours ranged from (20.09-23.67) while those of starches ranged from (19.94-23.70%). The granulated starch samples were polyhedral in shape with an average length - width of (4.96-6.56mm), while those of starch ranged from 5.55-5.77mm respectively. The rice starch to aid highest and lowest swelling power and solubility ranged between 24.43-33.02 °C and 11.50-18.23°C at 95°C, respectively.

Keywords: Rice, Flour, Proximate composition, Functional, Micro-structural properties.

INTRODUCTION

Rice is a universal staple food all over the world where almost half of the world population consumed rice (*Oryza sativa*), a significant grain crop in the developing world (Ebuehi and

Oyewole, 2008). About 20% of the dietary requirement comes from rice with a significant commodity in International trade (FAO, 2006). Although the quality of rice quality does not depend mainly on its sensory parameters but also comprises of its nutritional profile, microstructural and functional characteristics Jamal *et al.*, (2016). The majority of its use is in households, consumed white with stew, fried or jollof rice. Containing traces of metals which includes; copper, iron, zinc, and manganese and mineral content including calcium, magnesium, and phosphorus are found in rice. In addition it is a good source of riboflavin, thiamine and niacin. Rice is also rich source of dietary energy as reported by (FAO/WHO, 2018).

After bran is removed, the rice contains (12%) moisture content, (75 – 80%) starch with a small amount of percentage protein (roughly 10%), (FAO/WHO, 2018). However, the protein in rice is more easily digested because it contains all nine essential amino acids (Yousaf, 2019). Also, it contains a greater content of lysine (4%), its protein is readily digested and has a high protein efficiency ratio (FAO/WHO, 2018). A variety of novel meals developed from rice consist of breads, beverage, pudding etc. are now made with rice, particularly rice flour, thanks to its distinctive functional qualities (Kadan *et al.*, 2008). In order to make these unique foods, it is typically necessary to utilize rice products such as starch and flour high qualities (Kadan *et al.*, 2008), which may imply quality product, usage, value and customer acceptability of the improved cultivars (Kadan *et al.*, 2008; Falade *et al.*, 2014).

MATERIALS AND METHOD

Raw materials

The paddy rice varieties employed in this study which include Faro 44, 52, and 61 and indigenous local rice *Kwandala (Badankama)* which was purchased from the National Cereal Research Institute Badeggi Niger State and Kano Agricultural and Rural Development Authority (KNARDA).

Extraction of rice starch

The rice starch extract were carried out using alkaline extraction method as reported by Lawal *et al* (2011), where one kilogram (1 kg) of rice flour was blended in 1 L of (0.2%) sodium hydroxides (NaOH) solution. The admixture was homogenized on a magnetic stirrer for about 20min and the then allowed to stand for 24h at 25 °C to soften the endosperm. The resultant slurry was filtered and (0.2%) sodium hydroxide (NaOH) was added into the sample then stirred for the next three hours (3hrs) under ambient condition. This procedure was carried out twice in which the solid content was washed off using (0.2%) sodium hydroxides (NaOH). The steps where constantly repeated many times till the admixture washed out completely neutralized and subjected for protein test (Cardoso *et al.*, 2007). The yellow tailings formed were removed using acid method. The starch was dispersed in double stage then centrifuged for 10 min. The starch content was diluted with (1 L) of distilled water and centrifuged again. An isolated starch residue was collected and re-dried up in a hot air oven at (40 °C for 48 hrs). The processed starch was homogenized to obtain a uniform blend for a free flowing flour using an analytical grade homogenizer as reported by (Cardoso *et al.* 2007). The isolated starch powder was sieved using a 100 micron mesh sieve then packaged in zip-lock bags and stored ready for further analysis.

Determination of the Proximate Composition of Rice Varieties

Rice grain samples of each variety were ground into flour using a laboratory grade frictional milling machine (model, Yanmar HS-1000 E.H, Japan). The resultant moisture content was

analyzed using hot air oven at temperature of 105 ± 5 °C following a standard method of AOAC, (2012). The Protein, fat and dietary fibre content was analyzed following a standard methods of (association of analytical chemists 2012).

Determination of Functional properties of flour and starch obtained from rice

The functional properties of the flour and starch which including loose bulk density, packed bulk density, water absorption capacity, oil absorption capacity, swelling power, solubility and consistency of the flour and starch samples were analyzed using a method of Kraithong *et al.* (2018). Where measuring cylinder was filled with 100 mL of samples and the weighed taking using an analytical weighing scale for loose and packed bulk density expressed in weight by volume (g/mL) ratio. For water and oil absorption capacity, five grams (5 kg) of the samples of both flour and starch was suspended in 10 mL of distilled water and then centrifuged with 10 minutes rest for 3 consecutive times and the supernatant decanted and the tube was air dried and weighed. The swelling power and solubility of the samples were analyzed following a method of Collado and Corke (1999) by preparing a suspension of (0.5 g) sample into 45 mL distilled water and allow to heat from 55 - 95 °C in an interval of 5 minutes each and then maintained 30 min. the sample was rapidly cooled down and centrifuged (at 3000x g for 20 min). The resultant supernatants were evaporated off to near in hot air oven at a temperature of (100 °C for 20 min). The swelling power was expressed in weight of residue after centrifugation per weight of original sample and the mean difference of the weight evaporate off from the petri dish was expressed as the net solubility as described by Onwuka (2018).

Determination of the percentage Amylose, Amylo-pectin and Microstructure

The percentage Amylose was determined using the iodine colorimetric bond as reported by AOAC, (2012) where the samples was extracted and recorded at 620 nm (Shimadzu UV-2100 spectro-photometer). The microstructure of the flour and starch was analyzed using a illumination method reported by Falade *et al.* (2013). The digital-imaging of the samples subjected were acquired as the particle size distributions of starch granules as estimated by categorizing the particle size into four major groups which includes; very small (<5 mm), small (5-10 mm), medium (10-25 mm), large (>25 mm) as described by (Mweta, 2009).

Data analysis.

All data generated was analyzed in three replicates measurement and the average mean value (Mean \pm SD) was computed. All data obtained was analyzed using one way analysis of variance (ANOVA) using SPSS model (Version 2010). Least Significance Difference (LSD) was obtained used Fisher's test for Duncan multiple range comparison tests at $P < 0.05$ significant difference.

RESULTS AND DISCUSSION

Proximate composition of local white rice flours

The results of percentage moisture content obtained from rice flour falls within (8.39 - 8.686%) as showing in (Table 1). The results showed that there was no significant difference exist among the samples at ($p < 0.05$) in *Kwandala* (8.53%) and Faro 52 (8.56%), with a slight difference existing in in Faro 44 and Faro 61 (8.39%) at ($p < 0.05$) were sample coded Faro 61 had the least moisture content and Faro 44 (8.68%) had the highest moisture content. The results of percentage ash content of rice flour ranged from (0.71 - 0.91%). All the samples were significant at ($p < 0.05$) among all the samples analyzed. Faro 61 sample had a mean value of (0.71%) had the lowest mean value while sample coded *Kwandala* with a mean value of (0.91%) had the highest mean values. The percentage fat content obtained in rice flour ranged from

(1.55 - 2.15%). The sample coded Faro 61 had a mean value of (1.55%) were with the lowest percentage crude fat content followed by Faro 44 (2.15%) and the highest percentage crude fat content. The crude fibre content obtained from rice flour ranged between (0.69 - 1.08%) (Table 1) although, there was no noticeable significance among the samples in terms of the crude fat content. The crude protein contents of rice flour analyzed ranged between (6.64 - 7.66%) which varied significantly at ($p < 0.05$) among the samples analyzed for percentage protein content. Sample coded Faro 44 (6.64%) had the lowest value of protein content and sample coded *Kwandala* (7.66%) had the highest mean value respectively. The results of carbohydrate content of rice flour samples had a mean value ranged from (80.99 - 82.36%) as shown in (Table 1) which indicate that there was no significant difference among the samples at ($p < 0.05$) respectively, were sample coded *Kwandala* (80.99%) had the least carbohydrate content while sample coded Faro 61 (82.36%) had the highest percentage carbohydrate content as presented in (Table 4.1).

Proximate composition of local white rice starches

Table 2 showed the results of moisture content obtained in starch samples extracted from rice which had a mean value ranged between (8.68 - 9.98%). The results showed a significant difference exist among the samples at ($p < 0.05$) were sample coded *Kwandala* had a mean value of (8.68%) and the lowest moisture content among the rice starch. While, Faro 61 (9.98%) sample had the highest moisture content respectively. The result of ash content of rice starch analyzed ranged within (0.48 - 0.64%), were sample *kwandala* and Faro 44 were significantly different same at ($P > 0.05$) but significantly different at ($p < 0.05$) with sample coded Faro 52 (0.48%) and Faro 61 (0.49%) respectively. The Faro 52 (0.48%) had the lowest ash content whereas, sample *Kwandala* (0.64%) had the highest ash content among all the samples analyzed. The crude Fat contents of starch content extracted from rice had a mean value ranged from (1.47 - 2.62%) which showed that there was no significant difference among the samples analyzed at ($p < 0.05$). The percentage protein content of rice starch extracted had a mean value ranged from (6.99 - 7.88%). The sample coded Faro 44 (0.82%) had the least protein content among the starch samples isolated from rice grain and the sample coded *Kwandala* (7.88%) had the highest percentage protein content respectively. The percentage fibre content of starch isolated from rice grain ranged from (0.71 - 0.82%) which showed a significant difference at ($p < 0.05$) with the least value in sample coded Faro 61 and the highest mean value in sample coded Faro 44 (0.82%) in percentage crude fibre content. The results of the carbohydrate content of rice starch samples ranged from (80.62 - 81.51%) with a significant difference at ($p < 0.05$) in *Kwandala* and Faro 44 samples but significantly different at ($p < 0.05$) from Faro 61 (80.50%) and the least in carbohydrate content.

Functional properties of rice flours

Functional properties of rice flours produced from four different rice samples (*Kwandala*, Faro 44, Faro 52, and, Faro 61) as shown in Table 3. The loose bulk density of the rice flour ranged between (1.14-1.18 g/mL which showed no significant difference at ($p > 0.05$) in sample *Kwandala* with a mean value of (1.137 g/mL) and Faro 52 sample with a mean value of (1.150 g/mL) but, significantly different sample Faro 44 (1.180 g/mL) and sample coded Faro 61 (1.183 g/mL). The lowest value for *Kwandala* (1.137 g/mL) and highest for Faro 61(1.183g/mL). The packed density of rice flour ranged from (1.13 - 1.21g/mL Table 4. The Faro 44 (1.13 g/mL) sample showed a slight different at ($p < 0.05$) among all the other samples. The sample coded Faro 44 (1.13 g/mL) had the lowest mean value and sample Faro 61 had the highest mean value (1.21 g/mL). The (WAC) of the rice flour ranged within (1.58 and 1.86 g/g). The lowest value for Faro 61 (1.58g/g) and the highest value Faro 44 (1.863 g/g). The oil absorption capacities of the rice flours ranged between (1.83 and 2.17 g/g). The results showed

that there was no significant difference exist among the samples at ($p>0.05$) in *Kwandala* (1.98g/g) and Faro 44 (1.98g/g) samples but significantly different ($p<0.05$) in Faro 44 (1.98 g/g), Faro 52 (1.83 g/g) and, Faro 61 (2.17 g/g) samples. The lowest value (1.83g/g) for faro 52 and the highest value (2.17g/g) for faro 61 variety. The gel consistencies of rice the flour samples ranged within (16.32 and 35.54 mm). The *Kwandala* (35.54 mm) and Faro 52 (31.69 mm) significant difference but showed a significant difference ($p<0.05$) between Faro 44 (16.32mm) and Faro 61 (17.83mm) samples. The gel consistencies was observed to be lowest for Faro 44 (16.32mm) whereas *Kwandala* (35.54mm) showed highest value. The amylose content of the rice flours ranged between (21.11 and 26.10%). The results of amylopectin showed a significant difference at ($p<0.05$) between *Kwandala* (21.11%) and Faro 44 (22.46%) samples, but Faro 52 (25.92%) and, Faro 61 (26.10%) was not significant at ($p>0.05$). The percentage amylose was observed very low in Faro 44 (21.11%) and highest for Faro 61(26.10%). The amylopectin content of the rice flours ranged between 20.09 and 23.61%. The lowest value for Faro 61 (20.09%) and the highest value Faro 44 (23.40%). The amylopectin contents of rice from the samples *Kwandala*, Faro 44, Faro 52 and, Faro 61 were 22.03, 23.40, 23.67 and 20.09%, respectively. The results showed that there was a significant increase in amylopectin level at ($p<0.05$) in sample coded Faro 61 (20.09%) had the least amylopectin content while, Faro 52 (23.67%) had the highest amylopectin content respectively.

Functional Quality starch obtained from rice

The results of loose bulk density (LBD) of rice starch obtained from rice grains ranged within (0.65 and 0.73 g/mL) as shown in table 4. The results of the functional quality of rice starch showed a slight significant difference at ($p<0.05$) in all the samples analyzed. The value for loose bulk density was observed to be lowest for Faro 52 (0.65 g/mL) and highest for *Kwandala* (0.73 g/mL). The packed bulk densities of rice starches obtained in this study ranged between 0.71 and 0.77 g/ml). the results showed a significant difference between sample Faro 44 (0.77 g/mL) and Faro 52 (0.71g/mL) *Kwandala* (0.73g/mL), Faro 44 (0.77g/mL) but no significant different ($p<0.05$) was observed between *Kwandala* (0.73g/mL) and Faro 61 (0.75g/mL). The lowest value for Faro 52 (0.71g/mL) and highest for Faro 44 (0.77g/mL). The (WAC) of rice starch ranged from (1.90 and 1.99 g/g) but there was significant difference at ($p<0.05$) in sample *Kwandala* (1.90 g/g), Faro 44 (1.95 g/g) and Faro 61 (1.99 g/g) but differs in sample Faro 44 (1.95 g/g), Faro 52 (1.98 g/g) and Faro 61 (1.99 g/g). The lowest mean value of Faro 52 (1.90 g/g) was higher than the result obtained in Faro 61 (1.99 g/g).The oil absorption capacities of rice starch ranged between (2.02 and 2.33 g/g). *Kwandala*, Faro 44, Faro 52 and, Faro 61 were (2.02, 2.08, 2.15 and, 2.33 g/g) respectively. The result of rice starch showed that sample *Kwandala* (2.02 g/g) had the lowest mean value and highest in Faro 61 (2.33g/g). The gel consistency of rice starch ranged between 15.62 and 60.35mm Table 4.0. *Kwandala*, Faro 44, Faro 52 and, Faro 61 were 2.02, 2.08, 2.15 and, 2.33g/g respectively. The result obtained showed that sample Faro 52 (15.62 mm) had the lowest mean value whereas the *Kwandala* (60.35 mm) had the highest mean value of rice starch. The amylose content of the rice starch ranged within (21.31 and 25.14 %), *Kwandala*, Faro 44, Faro 52 and Faro 61 were 2.02, 2.08, 2.15 and, 2.33g/g respectively. The result showed a significant difference among the samples where *Kwandala* (21.31 %) had the lowest value of amylose and Faro 61 (25.14 %) had the highest. The amylopectin contents of rice starches study ranged from 19.94 and 23.70% Table 4.0. *Kwandala*, Faro 44, Faro 52 and, Faro 61 were (2.02, 2.08, 2.15 and 2.33 g/g) respectively showed a significant difference at ($p<0.05$) among the samples where, Faro 61 (19.94 %) had the lowest mean value while, Faro 52 (23.70%) had the highest.

Table 1: Proximate composition of indigenous rice flour

Samples	Moisture	Ash	Crude fat	Protein	Crude fibre	Carbohydrate
<i>Kwandala</i>	8.53 ^b ±0.03	0.91 ^a ±0.01	1.92 ^b ±0.08	7.66 ^a ±0.01	0.98 ^a ±0.03	80.99 ^a ±0.04
Faro 44	8.68 ^a ±0.03	0.86 ^b ±0.01	2.15 ^a ±0.05	6.64 ^d ±0.06	0.69 ^a ±0.59	81.66 ^a ±0.06
Faro 52	8.56 ^b ±0.03	0.76 ^c ±0.02	2.00 ^b ±0.05	6.78 ^c ±0.03	1.00 ^a ±0.01	81.89 ^a ±0.07
Faro 61	8.39 ^c ±0.01	0.71 ^d ±0.02	1.55 ^c ±0.05	6.98 ^b ±0.10	1.08 ^a ±0.02	82.36 ^a ±0.16

*Values Obtained are (means ±SD) standard deviation of three measurements

*Means with same superscript in same column are significantly different (p<0.05).

Table 2: Proximate composition of starch isolated from rice

Samples	(%) Moisture	(%) Ash	(%) Fat	(%) Fibre	(%) Protein	(%) Carbohydrate
<i>Kwandala</i>	8.68 ^c ±0.02	0.64 ^a ±0.00	2.15 ^c ±0.05	0.78 ^{ab} ±0.03	7.88 ^a ±0.09	80.62 ^c ±0.08
Faro 44	9.04 ^b ±0.04	0.57 ^b ±0.01	2.62 ^a ±0.06	0.82 ^a ±0.03	6.99 ^d ±0.01	80.77 ^b ±0.07
Faro 52	8.50 ^d ±0.02	0.48 ^c ±0.02	2.35 ^b ±0.05	0.76 ^b ±0.02	7.15 ^c ±0.05	81.51 ^a ±0.03
Faro 61	9.98 ^a ±0.02	0.49 ^c ±0.01	1.47 ^d ±0.03	0.71 ^c ±0.01	7.56 ^b ±0.08	80.50 ^c ±0.09

Values are means ±Standard deviation of 3 replicate. Means having different superscript in the same column are significantly different (p<0.05).

TABLE 3: Functional properties of rice flour

Samples	LD (g/ML)	Packed density (g/ML)	WAC (g/g)	OAC (g/g)	Gel consistency (mm)	Amylose (%)	Amylopectin (%)
<i>Kwandala</i>	1.14 ^b ±0.01	1.19 ^a ±0.04	1.78 ^b ±0.03	1.98 ^b ±0.02	35.54 ^a ±0.48	21.11 ^c ±0.23	22.03 ^c ±0.01
Faro 44	1.18 ^a ±0.01	1.13±0.02 ^b	1.86 ^a ±0.03	1.98 ^b ±0.03	16.32 ^c ±0.01	22.46 ^b ±0.37	23.40 ^b ±0.02
Faro 52	1.15 ^b ±0.01	1.18 ^a ±0.01	1.67 ^a ±0.02	1.83 ^c ±0.03	31.69 ^b ±1.54	25.92 ^a ±0.05	23.67 ^a ±0.02
Faro 61	1.18 ^a ±0.02	1.21 ^a ±0.01	1.58 ^d ±0.02	2.17 ^a ±0.03	17.83 ^c ±0.03 ^c	26.10 ^a ±0.02	20.09 ^d ±0.03

Values are means ±Standard deviation of 3 replicate. Means having different superscript in the same column are significantly different (p<0.05).

Table 4: Functional properties of rice starch fraction of rice

Samples	LBD (g/mL)	PBD (g/mL)	WAC (g/g)	OAC (g/g)	GC (mm)	Amylose (%)	AMP (%)
<i>Kwandala</i>	0.73 ^a ±0.05	0.73 ^{bc} ±0.01	1.90 ^c ±0.01	2.02 ^c ±0.03	60.35 ^a ±0.56	21.31 ^d ±0.02	20.13 ^c ±0.02
Faro 44	0.66 ^{ab} ±0.02	0.77 ^a ±0.02	1.95 ^b ±0.0	2.08 ^{bc} ±0.03	32.09 ^b ±1.74	22.77 ^c ±0.03	22.99 ^b ±0.02
Faro 52	0.65 ^b ±0.05	0.71 ^c ±0.01	1.98 ^{ab} ±0.02	2.15 ^b ±0.03	15.62 ^d ±0.02	24.78 ^b ±0.06	23.70 ^a ±0.04
Faro 61	0.72 ^{ab} ±0.04	0.75 ^{ab} ±0.02	1.99 ^a ±0.01	2.33 ^a ±0.08	17.05 ^c ±0.02	25.14 ^a ±0.02	19.94 ^d ±0.05

Values are means ±Standard deviation of 3 replicate. Means having different superscript in the same column are significantly different (p<0.05).

DISCUSSION

The proximate content of local white rice-flour

The results of the moisture contents obtained in the rice-flour showed an increase in the mean value of (8.39 and 8.68%) which confirmed with the findings of Ashogbon and Akintayo (2012) who obtained a mean value of (10.00-11.74%) and also similar to that reported by Falade *et al.* (2014) with an average mean value of (8.29 – 9.45%) for Nigerian rice cultivars processed. The difference that occurred in the percentage moisture content of the rice flour may be as a result of the varietal difference or the processing method involved. The amount of moisture in a given food is inversely related to the amount of its dry matter or nutrient content (Ibukun, 2018). High moisture content tends to cause spoilage of grains by developing mold and other bacteria therefore, reduced moisture content within the acceptable level would provide a long-term storage as reported Edeogu by *et al.* (2007).

The percentage ash contents of rice flour obtained ranged from (0.71 - 0.91%) which correspond closely with the values obtained by Ashogbon and Akintayo (2008) with the mean value obtained from his study ranged within (0.38 - 2.22%) for rice flours, while the results

disagreed with the findings of Oppong *et al.* (2020) who had a high percentage ash content of (2.00 - 2.22%) for indigenous rice flours. The results of percentage fat content of the rice flour samples ranged between (1.55 - 2.15%) obtained in this study was higher than the values obtained by Falade *et al.* (2014) (0.04 - 0.35%) in his findings using same Nigerian indigenous rice grains and Oko *et al.* (2012) also reported a fat content of (0.5 - 3.5%) from a similar study. The crude fibre contents of the rice flour analyzed in this study agreed with the findings of Oko *et al.* (2012) in their fibre content level. Additionally the mean value of the fibre content was lower than the value obtained by Oppong *et al.* (2020) which ranged within (0.49 - 2.84%) for the local rice flour samples. The low crude fibre of the rice flours can be attributed to the fact that the fibre in the hull was removed during processing. Dietary fiber is important due to its health benefits, such as it can help to manage weight, acting as a laxative, prevent constipation, lowers blood cholesterol level, regulates glucose levels and the high of colon cancer, cardiovascular diseases as well as prevalence of obesity (Zhao *et al.* 2018). The result of the percentage crude protein content of rice flour samples obtained had a mean value of (6.64 and 7.66%) which was reported higher than the obtained by Oludare *et al.* (2015) which may be attributed due to the physicochemical quality of indigenous rice flour samples as confirmed by the finding of Oppong *et al.* (2020) in a similar study obtained percentage protein content of (5.01 - 8.14%) of rice flour. The low crude protein contents of the rice flours might be attributed due to the difference in variety, genotype and the environmental factors where each samples are cultivated.

The values of the carbohydrate content starch samples obtained from rice had a mean value of (80.99 and 82.36%) which was significantly different from the findings of Oko *et al.* (2012) with a mean value of (51.53-86.82%) indigenous rice flour which showed a significant increase according to the findings reported by Oppong *et al.* (2020) with a carbohydrate content of (85.79-93.32%) of rice flour. A reduction in a carbohydrate content in the samples *Kwandala* prepared may be attributed due to the processing method applied and the over soaking which eventually breaks down the complex carbohydrates.

Proximate composition of local white rice starches

The values of the percentage moisture content starch extracted from a rice analyzed showed a moisture ranged from (8.68 - 9.98%) which was significantly lower than the mean value obtained from the results obtained by Ashogbon and Akintayo (2012) which had an average mean value of (10-11.74%) indigenous Nigerian rice starch extracted, but slightly higher than the results obtained by Falade *et al.* (2014) who reported a mean values of (8.29-9.45%) among the Nigerian rice cultivars analyzed. The ash content of the rice starch obtained from this study had a mean value ranged from (0.48 - 0.64%) which agrees with the findings of Barichello (2019) who reported an average mean value ranged from (0.4 - 0.7%) in the isolated rice starch samples, but higher in the result reported by Ashogbon and Akintayo (2012) who reported the values of (0.20 - 0.24%) among some Nigerian rice starch. The percentage crude fat content of rice starch obtained in this study agreed with the early findings reported by (Oko and Onyekwere, 2018) with the mean value ranged from (1.5 - 3.5%) among five selected low-land rice cultivars grown in south eastern state of Nigeria. The protein content of rice starch obtained from this study agreed with the reports of the previous literature on rice starch quality extracted using alkaline-traditional steeping method containing a residual percentage protein with an average mean value ranged from (6.3 - 9.5%) as recorded by Derycke *et al.*, (2015). The result of the crude fibre content of rice starch analyzed ranged from (0.71 - 0.82%) which was lower compared to (1.0 - 2.0%) obtained from five local rice varieties reported according to (Oko and Onyekwere, 2010) respectively. The carbohydrate contents of the rice starch analyzed is in agreement with the results obtained by (Alaka and Okaka, 2018),

who reported the values in the range of (75.00 - 81.00%). Furthermore, Oko and Onyekwere, (2018) reports that the mean value for the carbohydrate content range between (51.53 - 85.57%) for the five local rice varieties grown in Nigeria.

The Functional quality of rice flour

Result of the present study showed that the loose bulk density obtained was high than the result obtained according to the findings reported by Okoye and Mazi (2019) with a maximum mean value of (0.98 g/ml). The bulk density reflects the relative volume of packaging material, the higher the bulk density implies the dense packing weight of the flour as reported by (Lawal *et al.*, 2011). The increased loose bulk density in sample (D) which was due to an increase in moisture content of rice flour samples.

The packed bulk density of rice flours obtained showed that there was a significant increase in the packed density of the samples analyze which was reported to be higher than the results obtained by Falade *et al.* (2014) for six different Nigerian rice flour samples. Consequently, the fara 44 and sample had the lowest mean PBD which implies that large storage space could be required to accommodate the bulk density per per-weight when compared with the sample C and D as presented Table 3. The values for water absorption capacity (1.58 -b 1.86 g/g) in this study was in agreement with the research conducted by (Oppong *et al.* 2020) with the mean value in the range of (1.39 - 2.49 g/g), but significantly higher compared with the results obtained by (Chinma *et al.* 2018) who reported the values of (1.26 - 1.35 g/g) for the functional properties of the five varieties of Nigerian flours (Lawal and Adebowale, 2004). An average mean values of oil absorption capacities of the rice flour ranged from (1.83 - 2.17 g/g) which was slightly lower than the result obtained by Oppong *et al.* (2020), this may be attributed due to nature of the samples, method of processing as well as the season of the year in which the product was processed. The values for gel consistencies of the rice flour (16.32 - 35.54 mm) were similar to the findings of Falade *et al.* (2014) who reported a values of (16.00 - 27.00 mm) respectively for hard gel and (39.0 - 64.00 mm) for soft gel, but lower than the finding of Okeleye (2005) who reported the values of 63-78mm for medium soft gel consistency for upland rice varieties in Nigeria. Samples *Kwandala* and *Faro 52* samples with higher values of (35.54 and 31.69 mm) showed soft gel consistency due to the weak bond of the rice flour, whereas *Faro 44* and *Faro 61* samples with low values (16.32 and 17.83 mm) flour samples showed hard gel consistency due to their tightly packed structure. The difference exist in the gel consistency of the rice flour sample must have occurred due to the relative amounts of protein content, carbohydrate as well as the percentage fat content that made up the interaction between the components. The gel consistencies with high amylose content could be a good index for cooked rice textural properties a reported by (Huaisan *et al.*, 2009). The percentage mean value for amylose content of the rice flour ranged within (21.11 and 26.10%) but significantly lower compared with the research conducted by (Oludare, 2015) where he obtained the mean values ranged within (27.7 - 36.59%) for three physicochemical properties of Nigerian rice flours, with a higher mean value compared with the findings carried out by (Oppong *et al.* 2020) for an indigenous rice flour samples respectively.

Functional quality of rice starch extracted from rice

The mean value of the loose bulk-density of rice starch obtained in this study ranged from (0.65 - 0.73 g/ml) as shown in Table 4.0, were significantly higher as reported by (Ashogbon and Akintayo, 2012) with a mean value range from (0.41 - 0.56 g/ml) for some rice Nigerian cultivars. The difference in bulk densities may be due to the particle size of the products which may contributes to the pack designed and type of packaging materials for a better handling, transportation and storage (Iwe and Onadi, 2011). The result of packed bulk-density of rice

starches obtained in this study (0.71 and 0.77 g/ml) were slightly higher the mean value obtained in literature reported by (Falade *et al.* 2014) which ranged within 90.40 - 0.43 g/mL) for some six Nigerian rice varieties.

The values of the water absorption capacity of rice starches 1.90 and 1.99g/g were similar to the values of Okeleye (2015) that varied from 1.9 and 2.3g/g for upland Nigerian rice varieties. The gel consistency of rice starches ranged between 15.62 and 60.35mm. The values were in accordance with the work of Falade *et al.* (2014) were the result obtained had a mean value of (16.00 and 17.00 mm) for hard gel and (55.00 and 96.00 mm) for soft gel consistence respectively.

Kwandala and Faro 44 samples had soft gel consistency as 60.35 and 32.09 mm of the rice starches due to their low weak bonding, respectively, whereas Faro samples 52 and Faro 61 samples had hard gel consistency as 15.62 and 17.05mm due to the tightly packed structure. *Kwandala* and Faro 44 samples that showed soft gel may be preferred by consumers due to their tender texture (Cagampang, 1973). The variation in the gel consistency of rice starch were attributed due to the presence of relative amount of protein, carbohydrates and lipids reaction in the starch composition and the rate of chemical reaction.

The mean value of amylose content of rice starches obtained in this study (21.31 and 25.14%) were lower compared with that obtained earlier by Ashogbon and akintayo, (2012) with a mean value of (21.88 - 26.04%) for Nigerian rice starches and similar results were also obtained by Juliano (2017) who reported 20 and 25 for intermediate rice starch. Faro 61 sample had the highest percentage amylose content of (>25%) had the high expansion volume when subjected to cooking effects which makes it soft and tender, separate when cooked which eventually became hard when rapidly cooled down due to it tightly packed structures (strong bonds). Therefore, absorbed high amount of energy to during digestion process (Juliano, 2016), while intermediate amylose varieties in sample *Kwandala*, Faro 44 and Faro 52 cooked soft but not sticky as a result of reinforcements of the starchy amylose molecules (Bao, 2019).

The amylopectin contents of rice starches study ranged from 19.94 and 23.70%. The amylopectin content of Faro 52 sample increased by cooking and this is due to the fact that the reduction in starch content which was originally low compared to other rice, after cooking is low. The increase in amylopectin content after cooking could be responsible for high viscosity of the Faro 52 sample.

CONCLUSION

According to the results of this investigation revealed that indigenous rice variety used as a control was compared with the improved variety which indicates a high nutritional value over the improved local rice in terms protein and ash contents. The starch isolates from both the indigenous and improved local rice had restricted functionality of the flour and starch such as swelling index and solubility ratio. The proximate compositions, function and pasting properties of these indigenous and improved local rice indicated that this flour and the starch extracted from the rice gains could have a wider industrial application as well as none food utilization such as in adhesive industry, paper industry, binding agent and textile industries. The results showed that indigenous rice could be highly nutritious among the commonly consumed staple crops providing some of the major essential nutrients required.

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