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Determination of the functional properties of some Nigerian and imported rice varieties

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Rice flour,
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Nigerian rice.

Abstract — This study determined the comparative study of the functional properties of some Nigerian and imported rice varieties. The result showed a significant difference in functional properties at ($p>0.05$). Illa (Nigerian) rice had the highest Water Absorption Capacity (WAC) (353.76%) and Oil Absorption Capacity (OAC) (218.32%) than the imported rice variety. The bulk density of both samples had less significantly different values. The percentage values of dispersibility (75.00%) were higher in Ofada (Nigerian) rice. Nigerian rice had a higher swelling index (10.91%). The amylopectin contents of tested rice varieties were 76.26, 76.55, 75.58, 74.37, and 77.55% for Illa, Abakaliki, Jemila, Ofada, and Imported rice, respectively. The result revealed that Imported rice had the highest value (77.55%) of amylopectin, followed by Abakaliki rice which recorded 76.55%, and Illa rice variety from the Southern region had 76.28%. In comparison, the Ofada rice sample had the lowest value (74.37%) of amylopectin content, followed by Jemila rice which recorded 75.58% of amylopectin content. The amylose content for Illa, Abakaliki, Jemila, Ofada, and Imported rice varieties was 23.73, 23.45, 24.42, 25.64, and 22.45%, respectively. Rice flour, with low amylose content, gives moistness, chewiness, and softness to the textures of the product. It showed that Ofada rice had the highest value (25.64%) of amylose content, followed by Jemila rice which recorded 24.42% of amylose content. The lowest value (22.45%) was found in imported rice, followed by Abakaliki rice with 23.45% and Illa rice sample with 23.73% of amylose content. It can be concluded that Nigerian rice is compared handsomely with imported rice in terms of functional properties, which determines the end-use and general acceptability of flour samples.

Subject Classification (2020):

1. Introduction

According to [1], the quantities that determine the applications and final uses of numerous food products' materials are known as functional properties. Their use in industries and food production depends on their various functional properties [2,3]. Foods' essential physicochemical properties are their functional properties, which reflect the intricate interactions between food components' structures, molecular conformations, compositions, and physicochemical properties with the nature of

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the environment and conditions in which these are measured and associated [4,7]. Functional properties are highly needed to predict likely and precisely determine how new carbohydrates, such as starch and sugars, fibre, and fat, may react in food systems, as well as to establish whether such can be used to stimulate or replace common protein, carbohydrate, fat, and fibre [5,7].

The functionality of rice starch is the arrangement of properties which influence rice characteristics and procedural effectiveness. These properties vary significantly for various agricultural products and processes, and this may be calculated by chemical process or evaluation testing [1]. Functional properties may be categorized corresponding to the method of design on three main groups. According to [1], these categories includes; firstly, properties that are concerned with the protein composition and rheological characteristics, properties that are concerned with hydration, and lastly, properties that are concerned with the protein surface.

Functional characteristics also determine the behaviour of ingredients in the preparation and cooking of food, and how the finished products are affected by finished food materials, as regards how it looks, feel, and tastes. According to [1,4], functional characteristics' parameters include, but are not limited to, water absorption capacity, oil absorption capacity, swelling power, foam capacity, emulsion stability, foam stability, emulsion activity, and others.

The most important cereal for humans is rice (*Oryza sativa L.*), which feeds almost half of the world's population as a staple food and has dominated its position as one of the world's leading food crops [8,10]. While it remained an important economic crop for household food security, ceremonies, nutritional diversification, income generation, and employment, it supplied 23% of the world's calorie supply [8]. Rice is widely cultivated worldwide and is the second most important cereal crop in terms of cultivation after wheat, mainly in Nigeria [11]. It belongs to the family of Poaceae, and its domestication started from ancient civilisation native to Southeast Asia [9]. After cooking, rice is mostly consumed as a whole grain, accounting for between 40% and 80% of calories [12]. Since the beginning of time, rice landraces have been grown and consumed, and they play a crucial role in ensuring food security and livelihood [9,13]. The rice landraces have varied agro-morphological characteristics, and some of the landraces are prosperous in terms of yield [14]. According to [9], the traditional landraces have been used for their higher nutritional value than the hybrid and have been used as alternative medicine in treatments of some different diseases like diarrhoea, fever, vomiting, haemorrhage, burns, improve eyesight, vocal clarity, fertility [9].

Rice consumption and demand are anticipated to rise in tandem with Nigeria's expanding population. According to estimates, Nigeria consumes 40 kilograms of rice per person each year [15,16]. National demand for rice was estimated to be 6. Three million metric tons in 2016, while the domestic supply was 2.3 million metric tons [16,17]. Imports were anticipated to fill the deficit of 4 million metric tons. The importation of rice is bad for Nigeria's economy because it means that the country will run out of foreign exchange (forex) earnings and run out of money. [16]. Even though a wide range of rice varieties are grown in Nigeria, the country is increasingly influenced by imported rice varieties from other countries. The "Aroso" variety of parboiled rice is one popular foreign variety produced in Thailand and is widely consumed in Nigeria [8]. The need to mechanise the process and make local rice more competitive with almighty imported rice is recognised, primarily considering understanding some of its pasting and functional properties. Other research literature has revealed that Nigeria's local domestic rice varieties exhibit numerous benefits that are superior to imported rice [18]. Although Nigerians are aware of locally produced rice, most consumers are more familiar with rice imported from other countries [19,20].

2. Materials and Methods

2.1. Source of Rice Samples

The rice samples used for this research work were four Nigerian rice selected from four regions (North, South, East, and West) and imported (Indonesian) rice. The selection is determined based on patronage preference. The four local Nigerian rice were Ofada from West obtained from Du farm in Federal University of Agricultural Abeokute, Ogun State, Illah (FARRO 44) from South obtained from Nature's farm, Illah Ugbolu Local Government Area, Delta State, Jemila (FARRO 44) from North obtained from Da-Elgreen farm in Chikun Local Government Area, Kaduna State and Abakaliki (NERICA) rice from South-East obtained from Modery Community Farm in Ministry of Agriculture, Ezzamgbo branch, Ebonyi State while the imported rice was obtained from DU farm, Federal University of Agricultural Abeokute, Ogun State.

2.2. Preparation of Samples

The rice grains that were sourced were cleaned, sorted, and washed. The dried rice grains were milled using an attrition mill, and the milled grains were sieved using a 300 μm mesh-size sieve to obtain fine flour. They were steeped in water for 12 hours, drained, and dried in a hot air oven at 700C [3]. The processed flour was packaged with the proper label in an airtight plastic container and moved to various laboratories, where the properties were determined.

2.3 Determination of Functional Properties of Nigerian and Imported Rice Varieties

2.3.1 Oil Absorption Capacity

A centrifuge tube containing 1 gram of flour and 10 ml of refined corn oil was set to room temperature for 60 minutes. It was centrifuged for 20 minutes at 1600 g. The free oil's volume was measured and poured. The amount of fat absorbed by 100 grams of dried flour was measured as ml of oil bound to it. [21].

2.3.2 Water Absorption Capacity

The mixture of 1 g of flour with 10 ml refined corn oil in a centrifuge tube was allowed to stand at room temperature of 30 ± 2 °C for 60 mins. It was shaken on a platform tube rocker for 1 minute at room temperature. The sample was allowed to stand for 30 minutes and centrifuged at 1200 g for 30 minutes. The volume of free water was read directly from the centrifuge tube [21,22].

2.3.3 Swelling Power

The flour sample was divided into three grams, according to [23], and each portion of the dried flour was transferred into clean, dry, and calibrated 50 ml cylinders. The volumes of the flour samples were recorded after they had been slightly levelled. Each sample was diluted with 30 ml of distilled water, and the cylinder was left to swirl and stand for 60 minutes before the swelling power (volume change) was measured at 15 minutes. At each volume raised, the swelling power of each flour sample was calculated after 15 minutes.

2.3.4 Solubility

To determine solubility, 1 g (db) of flour was mixed with up to 10 ml of distilled water in a 5 ml measuring cylinder using the cold-water extraction method. The sample was allowed for 60 minutes with 10 minutes of stirring. After 2 ml of the supernatant was measured in a dry Petri dish, evaporated to dryness, and reweighed, the sample was allowed to settle for 15 minutes. The total soluble solids, which was determined using the equation presented in [24], was the change in mass.

$$Solubility = TSS(\%) \frac{VsMe - Md}{2MS1} 100 \quad (4.1)$$

TSS is the total soluble solute; Vs is the total filtrate or supernatant; Md is the mass of a dry, empty Petri dish; while Me is the mass of the Petri dish in addition to the solid that remained after evaporative drying.

2.3.4 Determination of Dispersibility

This was determined by the method described by [25]. To reach the 100 ml mark, distilled water was added to a 200 ml measuring cylinder in which ten grams of each sample were suspended. The setup was subtracted from 100 after being vigorously stirred. The percentage of dispersibility was used to describe the difference.

$$\text{Dispersibility} = 100 - \text{Volumes of Settled Particle} \quad (4.2)$$

2.4 Determination of Amylose and Amylopectin

The ISO 6647 method was used to estimate amylose and amylopectin [26]. In a 50 ml conical flask, 100 mg (db) of the sample was treated with 1 mL of ethyl alcohol, slowly stirred, treated with 9 mL of 1 N sodium hydroxide, and heated for 10 minutes with occasional stirring in boiling water. After being chilled to room temperature, the sample was transferred to a volumetric flask of 100 millilitres, washed, transferred, and finally filled to volume with water. After taking 5 ml of the dispersion, 50 ml of water and 1 ml of 1 N acetic acid were added, and the entire mixture was shaken; 2 mL of a solution of 2% potassium iodide and 0.2% iodine were added, diluted with water to volume, and kept at 27 °C for 20 minutes. A blank (without a sample) UV-2010 spectrophotometer from Hitachi, Japan, read the colour at 620 nm. To estimate the amount of amylose in the unidentified sample, a regression equation was created.

3. Results and Discussion

3.1 Functional Properties of Nigerian and Imported Rice Flour

The functionality of foods is the characteristics of food ingredients other than nutritional quality, which significantly influences its utilisation [27,28]. It is presented in Table 1 and Figure 1.

3.2 Water Absorption Capacity

Table 1 and Figure 1 present the functional properties of Nigerian and imported rice flour varieties. It was found that the values of WAC for Illa, Abakaliki, Jemila, Ofada, and Imported rice flour varieties were 353.76, 185.79, 155.60, 158.62, and 216.80%, respectively.

Table 1. Comparison of functional properties of milled Nigerian and imported rice flour

Properties	Illa Rice	Abakaliki Rice	Jemila Rice	Ofada Rice	Imported Rice
WAC (%)	353.76 ± 12.64	185.79 ± 3.28	155.60 ± 7.68	158.62 ± 1.68	216.80 ± 15.42
OAC (%)	218.32 ± 0.75	175.65 ± 0.43	170.56 ± 1.15	115.54 ± 0.64	187.64 ± 2.05
Bulk density	0.10 ± 0.00	0.25 ± 0.07	0.25 ± 0.07	0.20 ± 0.00	0.10 ± 0.00
Dispersibility (%)	53.00 ± 0.00	72.00 ± 1.41	73.50 ± 2.12	75.00 ± 0.00	70.50 ± 0.70
Swelling power	8.36 ± 0.15	10.40 ± 0.30	10.39 ± 0.42	10.91 ± 0.01	8.69 ± 0.37
Solubility index	10.69 ± 0.22	12.10 ± 0.42	9.54 ± 0.52	10.01 ± 0.26	12.34 ± 0.27
Amylose (%)	23.73 ± 0.39	23.45 ± 0.01	24.42 ± 0.03	25.64 ± 0.01	22.45 ± 0.01
Amylopectin (%)	76.28 ± 0.39	76.55 ± 0.01	75.58 ± 0.03	74.37 ± 0.01	77.55 ± 0.01

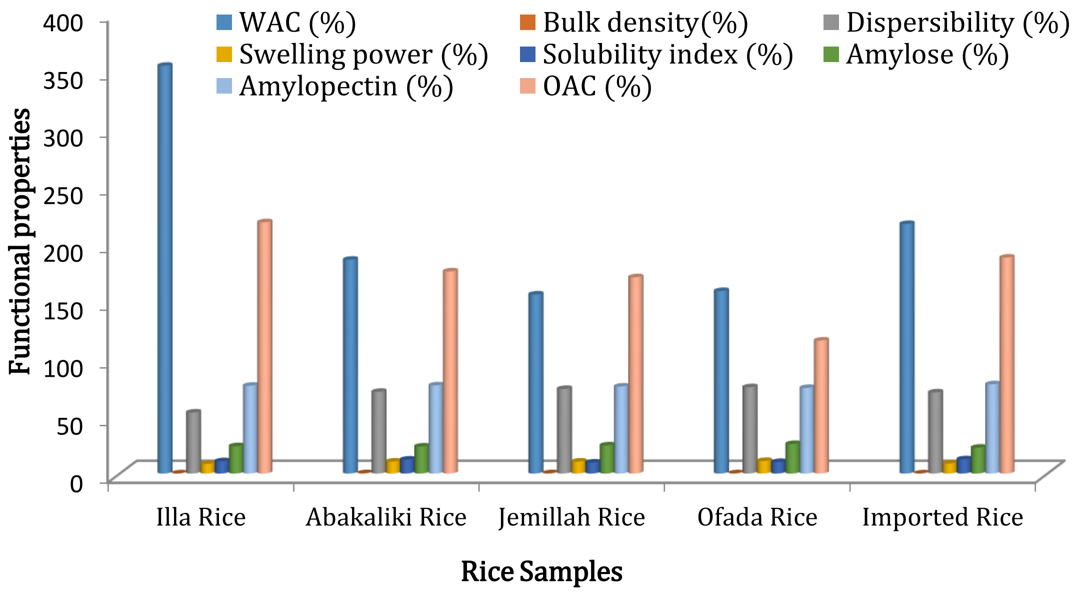

Figure 1. Comparison of functional properties of milled Nigerian and imported rice flour

During the gelatinisation of starch, water has a significant impact on a variety of significant changes as well as other functional properties. It is important to determine WAC because it helps make bread and soups, among other foods [29,31]. The findings showed that Illa rice had the highest value (353.76%) of water absorption capacity, followed by imported rice with 216.80% WAC, and Abakaliki rice which had 185.79% WAC. The lowest value (155.60%) of WAC was found in the varieties of Jemila rice, followed by Ofada rice, which recorded 158.62% WAC. These findings were comparable to the report [29] on the functional and pasting properties of Malaysia's imported and locally grown exotic rice varieties. Rice flour flours may differ in their capacity to absorb water due to the presence of hydrophobic amino acids, which hinder the rice starch's ability to absorb water [27,31]. The loose association of amylose and amylopectin in the native starch granules and their weak binding forces may be to blame for this effect [32,33].

3.3 Oil Absorption Capacity

The results of the OAC of investigated rice flour varieties are presented in Table 1. The values of Illa, Abakaliki, Jemila, Ofada, and Imported rice flour varieties were 218.32, 175.65, 170.56, 115.54, and 187.64 %. The findings showed that Illa rice had the highest value (218.32%), followed by imported rice which had 187.64%, and Abakaliki rice which recorded 175.65% of OAC. The lowest value (115.54%) of OAC was noticed in Ofada rice, followed by Jemila rice flour with 170.56 OAC. Oil absorption capacity measures proteins' capability to bind fat physically by capillary gravitation. It can influence the oil retention in food products and determine the level of flavour retention and mouth feel [29,34]. The difference in OAC of Illa, Abakaliki, Jemila, Ofada, and Imported rice varieties could be attributed to the amylose and amylopectin ratio variation and their chain length distribution [29,35].

3.4 Bulk Density

The bulk densities of studied rice varieties are presented in Table 1. The Illa rice had 0.10g/ml, Abakaliki rice had 0.25g/ml, Jemila rice recorded 0.25g/ml, and Ofada rice had 0.20g/ml, and Imported rice recorded at 0.10g/ml. It was observed that Abakaliki and Jemila rice flour had the highest value (0.25g/ml), followed by Ofada rice which had 0.20g/ml of bulk density. Illa and Imported rice had the lowest value (0.10g/ml) of bulk density. The bulk densities obtained were within the range discussed in [27,36] for composite flour and yam-soy blend. Particle size and starch polymer structure influence bulk density. The starch polymers' fluid structure may cause a low bulk density. In rice flour, the samples (Illa and imported rice) with a low bulk density (0.10g/ml) are preferred because they are easier to package and transport [37].

3.5 Dispersibility

The results of the investigated rice flour are presented in Table 1. The values obtained for Illa, Abakaliki, Jemila, Ofada, and imported rice varieties were 53.00, 72.00, 73.50, 75.00, and 70.50%, respectively. The dispersibility of Ofada rice flour (75.00%) was the highest, followed by Jemila rice sample flour with 73.50%, and Abakaliki had 72.00% of dispersibility. The lowest value (53.00%) was observed in the Illa rice sample, followed by imported rice with 70.50% of dispersibility. The values obtained in the research were higher to compare the report of [35] on rice flour and very similar to what [39] reported on wheat composite flour. Varietal differences may be to blame for the differences in studied rice flour's dispersibility. The tendency of flour to detach from water molecules and reveal its hydrophobic action is determined by the property of dispersibility. The rice samples (Ofada and Jemila) with the highest values (75.00% and 73.50%) of dispersibility were easily reconstituting to give fine consistent dough during mixing [40].

3.6 Swelling Power

Table 1 displays the swelling power result, which indicates the degree to which a flour sample expands relative to its initial volume when soaked in water. Illa rice had 8.36% swelling power, and Abakaliki rice recorded 10.40%, Jemila rice was observed to be 10.39% swelling power and Ofada rice from western Nigeria had 10.91% of swelling power, and imported rice had 8.69% of swelling power. This result obtained in swelling power of varieties of rice flour tested was like [41] reported on wheat composite flour and higher than the report of [38] on rice flour. Swelling power is a weight measurement of swollen starch granules and their occluded water; therefore, it measures hydration capacity. The swollen starch granules' water retention is frequently linked to food quality. The Nigerian rice flour recorded better values of swelling power than almighty imported rice flour. Consequently, Nigerian rice varieties are preferred to imported rice.

3.7 Solubility Index

From the result of functional properties presented in Table 1, the values for the solubility index of tested rice samples were 10.69, 12.10, 9.54, 10.01, and 12.34% for Illa, Abakaliki, Jemila, Ofada, and Imported rice flour varieties. It was observed that imported rice had the highest solubility value (12.34%), followed by Abakaliki rice, which had 12.20%, and Illa rice, which had 10.69%. The lowest value (9.54%) was found in Jemila rice, followed by Ofada rice which recorded 10.01%. These solubility index values were higher than the report of [41] on wheat flour and in range with the report of [38] on rice flour. The shorter chain lengths of the starch molecules in the sample (Imported rice) would weaken the hydrogen bonds that hold the granules together, resulting in the sample's higher solubility [38].

3.8 Amylose

The result of the amylose content of tested rice flour varieties which determine the gelatinisation temperature, pasting behaviour, and viscoelastic properties of flour samples, were presented in Table 1. The amount of amylose in the raw materials is a significant factor in determining the product's intended use [38]. The amylose contents for Illa, Abakaliki, Jemila, Ofada, and Imported rice varieties were 23.73, 23.45, 24.42, 25.64, and 22.45%, respectively. According to [42], low-amylose rice flour provides moistness, softness, and chewiness to product textures. The findings showed that Ofada rice had the highest value (25.64%) of amylose content, followed by Jemila rice, which recorded 24.42% of amylose content. The lowest value (22.45%) was found in imported rice, followed by Abakaliki rice with 23.45% and Illa rice sample with 23.73% of amylose content. These values of amylose content of the studied rice varieties agreed with the report of [41] on wheat flour. The rice will become stickier the less amylose it contains. When cooked, the extremely low amylose content of sticky or glutinous rice causes it to be sticky [43]. When properly cooked, rice samples with an amylose content of 25% do not stick to one another [43]. These outcomes demonstrated that the rice samples analysed did not contain gluten. There are four types of non-sticky rice: rice with a high amylose content (25 to 33 per cent), rice with a medium amylose content (20 to 25 per cent), and rice with a low amylose content (9 to 20 per cent). Moreover, rice with very little amylose (between 2 and 9 per cent) [44]. Ofada rice falls into rice with a high amylose content, while other varieties fall into rice with a medium amylose content. The application of fertiliser (nitrogen content), the time of year, the location of the growing areas, and the amylose and starch content of various rice varieties could be to blame [45].

3.9 Amylopectin

The amylopectin content of tested rice varieties was 76.26, 76.55, 75.58, 74.37, and 77.55% for Illa, Abakaliki, Jemila, Ofada, and Imported rice, respectively. These findings agreed with what [41] reported on wheat flour. The result revealed that Imported rice had the highest value (77.55%) of amylopectin, followed by Abakaliki rice which recorded 76.55% and the Illa rice sample from the Southern region had 76.28%. In comparison, the Ofada rice sample had the lowest value (74.37%) of amylopectin content, followed by Jemila rice which recorded 75.58% of amylopectin content. The higher the content of amylopectin, the stickier the rice will be. Their distinct origins could be the cause of the observed difference. The present investigation has revealed that amylopectin is influenced by flour's starch and amylose content. This means that one is influenced by the other, and both properties are necessary for food preparation and development. Starch's high viscosity and waxiness are caused by amylopectin [46].

4. Conclusion

The investigation conducted on four different Nigerian rice and one imported rice variety showed a significant difference in functional properties at ($p>0.05$). Illa (Nigerian) rice had the highest WAC (353.76%) and OAC (218.32%) than the imported rice variety. The bulk density of both samples had less significantly different vales. The percentage values of dispersibility (75.00%) were higher in Ofada (Nigerian) rice. Nigerian (Ofada) rice had a higher swelling index (10.91%), the amylose value (rice) had the highest value (25.64%), while the amylopectin value (77.55%) was found to be more prominent in imported rice. It can be concluded that Nigerian rice is compared handsomely with imported rice in terms of functional properties, determining the end-use of flour samples.

Author Contributions

All the authors contributed equally to the paper. They all read and approved the last version of the paper.

Conflict of Interest

The authors declare no conflict of interest.

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References

[1] H. Twinomuhwezi, C. G. Awuchi, M. Rachael, *Comparative study of the proximate composition and functional properties of composite flours of amaranth, rice, millet, and soybean*, American Journal of Food Science and Nutrition, 6(1), (2020) 6-19.

[2] O. Oluwole, T. Akinwale, T. Adesioye, O. Odediran, J. Anuoluwatelemi, O. Ibidapo, F. Owolabi, S. Owolabi, S. Kosoko, *Some of the functional properties of flours from the commonly consumed selected Nigerian food crops*, International Research Journal of Agricultural and Food Sciences, 1(5), (2016) 92-98.

[3] M. O. Iwe, U. Onyeukwu, A. N. Agiriga, F. Yildiz, *Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour*, Cogent Food & Agriculture, 2(1), (2016) 1-10.

[4] C. G. Awuchi, V. S. Igwe, C. K. Echeta, *The functional properties of foods and flours*, International Journal of Advanced Academic Research, 5(11), (2019) 139-160.

[5] S. Chandra, S. Samsher, *Assessment of functional properties of different flours*, African Journal of Agricultural Research, 8(38), (2013) 4849-4852.

[6] M. Kaur, N. Singh, *Relationships between the selected properties of seeds, flours, and starches from different chickpea cultivars*, International Journal of Food Properties, 9(4), (2006) 597-608.

[7] M. Siddiq, M. Nasir, R. Ravi, K. D. Dolan, S. M. Butt, *The effect of defatted maize germ addition on the functional and textural properties of wheat flour*, International Journal of Food Properties, 12(4), (2009), 860-870.

[8] J. C. Anuonye, C. E. Chinma, J. Olukayode, A. Suleiman, *Nutrient composition, amylose content and pasting characteristics of some elite accessions of NERICA rice*, Journal of Food Technology Research, 3(1), (2016) 36-47.

[9] A. Pokhrel, A. Dhakal, S. Sharma, A. Poudel, *Evaluation of physicochemical and cooking characteristics of rice (Oryza sativa L.) landraces of Lamjung and Tanahun districts, Nepal*, International Journal of Food Science, 2020, Article ID: 1589150, 1-11.

[10] N. Singh, L. Kaur, N. S. Sodhi, K. S. Sekhon, *Physicochemical, cooking and textural properties of milled rice from different Indian rice cultivars*, Food Chemistry, 89(2), (2005) 253–259.

[11] A. O. Oko, B. E. Ubi, N. Dambaba, *Rice cooking quality and physic-chemical characteristics: A comparative analysis of selected local and newly introduced rice varieties in Ebonyi state, Nigeria*, Food and Public Health, 2(1), (2012) 43–49.

[12] R. Thomas, W. N.. Wan Abdullah, R. Bhat, *Physiochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia*, International Food Research Journal, 20(3), (2013) 1345–1351.

[13] F. M. Bhat, C. S. Riar, *Physicochemical, cooking, and textural characteristics of grains of different rice (Oryza sativa L.) cultivars of temperate region of India and their interrelationships*, Journal of Texture Studies, 48(2), (2017) 160–170.

[14] S. Sharma, A. Pokhrel, A. Dhakal, A. Poudel, *Agro-morphological characterisation of rice (Oryza Sativa l.) landraces of Lamjung and Tanahun district, Nepal*, Annals of Plant Sciences, 9(2), (2020) 3731–3741.

[15] O. O. Adekoyeni, S. A. Fagbemi, A. R. Ismaila, *Ofada rice identity, physical qualities and processing technology options for upgrading: A review,* Annual Research & Review in Biology, 23(2), (2018) 1-9.

[16] A. M. Abbas, I. G. Agada, O. Kolade, *Impacts of rice importation on Nigeria's economy*, Journal of Scientific Agriculture, 2, (2018) 71-75.

[17] FMARD, *The Agriculture Promotion Policy (2016-2020),* Federal Ministry of Agriculture and Rural Development, Abuja FCT, Nigeria, 2016.

[18] C. Diako, E. Sakyi-Dawson, B. Bediako-Amoa, F. K. Saalia, J. T. Manful, *Consumer perceptions, knowledge and preferences for aromatic rice types in Ghana*, Nature and Science*,* 8(12), (2010) 12-19.

[19] F. Apori-Buabeng, *Market organisation and consumers' perception of locally produced rice in the Ashanti region of Ghana,* Master's Thesis, Kwame Nkrumah University of Science & Technology (2009) Kumasi, Ghana.

[20] F. D. Wireko-Manu, C. Amamoo, *Comparative studies on proximate and some mineral composition of selected local rice varieties and imported rice brands in Ghana*, Agriculture and Food Sciences Research, 4(1), (2017) 1-7.

[21] G. I. Onwuka, Food analysis and instrumentation theory and practice, Naphtali Prints, Lagos, 2005.

[22] P. E. Ide, P. C. Eze, C. N. Eze, *Comparative studies on the proximate composition and functional properties of mucuna Sloane bean flour varieties*, Journal of Asian Scientific Research, 9(11), (2019) 185-192.

[23] U. J. Ukpabi, C. Ndimele, *Evaluation of the quality of gari produced in Imo State, Nigeria*, Nigeria Food Journal, 8, (1990) 105 – 110.

[24] B. A. Udensi, J. O. Onuora, *Chemical and functional properties of soybean flours in the Nigerian market*, Book of Abstract, 16th Annual Conf. NIFST, Enugu, (1992) 26 – 30.

[25] E. R. Ohizua, A. A. Adeola, M. A. Idowu, O. P. Sobukola, T. A. Afolabi, R. O. Ishola, S. O. Ayansina, T. O. Oyekale, A. Falomo, *Nutrient composition, functional and pasting properties of unripe cooking banana, pigeon pea and sweetpotato flour blends*, Food Science & Nutrition, 5(3), (2017) 750-762.

[26] K. K. Singh, T. K. Goswami, *Thermal properties of cumin seeds,* Journal of Food Engineering, 45(4) (2000) 181- 187.

[27] M. A. Ajatta, S. A. Akinola, O. F. Osundahunsi, *Proximate, functional and pasting properties of composite flours made from wheat, breadfruit and cassava starch*, Applied Tropical Agriculture, 21(3), (2016) 158-165.

[28] A. Mahajan, S. Dua, *Salts and pH-induced changes in functional properties of amaranth (Amaranthus tricolor l.) seed meal*, Cereal Chemistry, 79(6), (2002) 834–837.

[29] R. Thomas, R. Bhat, Y. T. Kuang, W. N. Wan Abdullah*, Functional and pasting properties of locally grown and imported exotic rice varieties of Malaysia*, Food Science and Technology Research, 20(2), (2014) 469-477.

[30] R. Bhat, K. R. Sridhar, C. C. Young, A. A. Bhagwath, S. Ganesh, *Composition and functional properties of raw and electron beam irradiated Mucuna pruriens* seeds, International Journal of Food Science and Technology, 43, (2008) 1338-1351.

[31] M. Kaur, N. Singh, *Studies on functional, thermal, and pasting properties of flours from different chickpea (Cicer arietinum L.) cultivars*, Food Chemistry, 91(3), (2005) 403-411.

[32] P. Williams, Y. Pan, V. Poulson, New Applications for Rice Flour, Rice CRC Final Research Report, 2005.

[33] N. E. Ihegwuagu, M. O. Omojola, M. O. Emeje, O. O. Kunle, *Isolation and evaluation of some physicochemical properties of Parkia biglobosa starch*, Pure and Applied Chemistry, 81(1), (2009) 97-104.

[34] S. B. Fasoyiro, S. R. Akande, K. A. Arowora, O. O. Sodeko, P. O. Sulaiman, C. O. Olapade, C. E. Odiri, *Physico-chemical and sensory properties of pigeon pea (Cajanus cajan) flours*, African Journal of Food Science, 4(3), (2010) 120-126.

[35] O. S. Lawal, K. O. Adebowale, B. M. Ogunsanwo, L. L. Barba, N. S. Ilo, *Oxidized and acid thinned starch derivatives of hybrid maize: functional characteristics, wide–angle X-ray diffractometry and thermal properties*, International Journal of Biological Macromolecules, 35(1-2), (2005) 71-79.

[36] O. Malomo, O. A. B. Ogunmoyela, O. O. Adekoyeni, O. Jimoh, S. O. Oluwajoba, M. O. Sobanwa, *Rheological and functional properties of soy – poundo yam flour*, International Journal of Food Science and Nutrition Engineering, 2(6), (2012) 101-107.

[37] O. O. Aluge, S. A. Akinola, O. F. Osundahunsi, *Effect of malted sorghum on quality characteristics of wheat-sorghum-soybean flour for potential use in confectionaries,* Food and Nutrition Sciences, 7(13), (2016) 1241-1252.

[38] J. Eke-Ejiofor, L. Nwiganale, *The effect of variety and processing methods on the functional and chemical properties of rice flour*, International Journal of Nutrition and Food Sciences, 5(1), (2016) 80-84.

[39] A. A. Adebowale, M. T. Adegoke, S. A. Sanni, M. O. Adegunwa, G. O. Fetuga, *Functional properties and biscuit making potentials of sorghum – wheat flour composite*, American Journal of Food Technology, 7(6), (2012) 372-379.

[40] A. A. Adebowale, L. O. Sanni, M. O. Onitilo, *Chemical composition and pasting properties of Tapioca grits from different cassava varieties and roasting methods*, African Journal of Food Science, 2, (2008) 77-82.

[41] J. Eke-Ejiofor, F. Owuno, *Functional and pasting properties of wheat/three-leaved yam (Dioscoreadumetorum) composite flour blend*, Global Research Journal of Agricultural and Biological Science, 3(4), (2012) 330-335.

[42] K. O. Falade, A. S. Christopher, *Physical, functional, pasting and thermal properties of flours and starches of six Nigerian rice cultivars*, Food Hydrocolloids, 44, (2015) 478–490.

[43] S. Susiyanti, R. Rusmana, Y. Maryani, S. Sjaifuddin, N. Krisdianto, M. A. Syabana, *The physicochemical properties of several Indonesian rice varieties*, Biotropia, 27(1), (2020) 41 – 50.

[44] A. Masniawati, N. A. M. Asrul, E. Johannes, M. Asnady, *Characterization of rice physicochemical properties local rice germplasm from Tana Toraja regency of South Sulawesi*, in: D. Tahir (Eds.), Journal of Physics: Conference Series, The 2nd International Conference on Science (ICOS), Makassar, Indonesia, 2017, Volume 979, Article ID: 12005.

[45] I. Buresova, I. Sedlackova, O. Famera, J. Lipavsky, *Effect of growing conditions on starch and protein content in triticale grain and amylose content in starch,* Plant Soil Environs, 56(3), (2010) 99–104.

[46] J. Eke-Ejiofor, D. B. Kiin-Kabari, *Chemical, pasting, functional and sensory properties of Sweet and Irish potato chips*, Nigerian Food Journal, 28(2), (2010) 47-54.