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Full Length Research Paper

Proximate composition, mineral nutrients and functional properties of Digang, NERICA-1 and NERICA-2 rice varieties from Ghana

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The proximate composition, mineral nutrients and functional properties of flours of three rice varieties from Ghana were investigated. Moisture ranged from 11.65% in NERICA-2 to 12.23% in NERICA-1. Ash was in the range of 0.55% in NERICA-2 to 0.90% in NERICA-1. NERICA-2 had the highest crude protein content (8.13%) while NERICA-1 had the least (7.43%). For crude fat, NERICA-2 recorded the highest amount (0.77%) while the lowest (0.14%) was recorded for Digang. NERICA-2 had the highest crude fibre (0.87%) and the least (0.67%) was obtained for NERICA-1. Carbohydrate content of the rice varieties ranged between 78.03% in NERICA-2 and 78.25% in Digang. NERICA-1 had the highest calcium content (84.01mg/100 g) and the least (81.26mg/100 g) was found in NERICA-2. NERICA-2 had the highest magnesium content (82.97mg/100g) and the least (63.53 mg/100g) was found in NERICA-1. The phosphorus content ranged from 67.71mg/100 gin NERICA-1 to 94.93mg/100 gin NERICA-2 and the iron content ranged from 42.94mg/100g in NERICA-2 to 47.35mg/100 gin NERICA-1. The functional properties of the rice flours ranged from 131.99% (NERICA-2) to 148.08% (Digang) water absorption capacity; 4.16 (NERICA-2) to 6.25 (NERICA-1) swelling capacity and 5.94% (NERICA-1) to 7.66% (NERICA-2) solubility. The results obtained are promising for use of these rice varieties to improve food security.

Keywords: Proximate composition, functional properties, food security.

INTRODUCTION

Rice (*Oryza sativa*) is one of the most important cereals in human nutrition, consumed by about 75% of the global

population (Anjum et al., 2007) and its flour is a good substitute to wheat flour (Kemashalini et al., 2018). It is grown in over 100 countries on every continent except Antarctica (Shayo et al., 2006). It has a high proportion of lysine and high protein digestibility (Chaudhari et al., 2018).

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It has rightly been considered as the queen among cereals for its nutritional quality and higher digestibility (Anjum et al., 2007).

In Ghana, rice has become one of the most important staple foods (Mbatchou and Dawda, 2013). The objective of this study was to analyze the nutrients (proximate and mineral) contents and functional properties of the three selected varieties. The analysis of the nutrient contents will enable the nutritional value of the rice varieties to be known and the functional properties will help to know products for which these rice varieties could be used for. This will help improve food security.

MATERIALS AND METHODS

Source of raw materials

The rice varieties used in this study were obtained from the Savannah Agricultural Research Institute, Tamale in the Northern Region of Ghana.

Rice flour preparation

The rice samples were dehulled and ground into fine flour with a laboratory miller (Cyclotec 1093 Sample Mill, Tecator, Sweden).

Analysis of samples

The milled rice samples were analysed for their proximate nutrient composition, calorie contents, mineral nutrient concentrations and functional properties.

Proximate nutrients

Moisture, ash, crude protein (%N x 6.25), crude fat and crude fibre were determined by AOAC (1990). Total percentage carbohydrate was obtained by the difference method as reported by Onyeike et al. (1995).

Calorie content

Calorie content (kCal/100 g flour) was obtained by multiplying the mean values of crude protein, crude fat and carbohydrate by 4, 9 and 4 respectively and taking the sum of the products (Onyeike et al. 1995).

Minerals determination

Calcium, magnesium and iron were determined by the method of Agte et al. (1995) and phosphorus was obtained by the method of Juo (1978).

Functional properties determination

Water absorption capacity (WAC)

WAC was determined at 25°C according to the method of Yamazaki (1953) as modified by Medcalf and Gilles (1965). An aqueous suspension was made by adding 2 g of the rice flour to 40 ml of water in a pre-weighed 50 ml graduated centrifuge tube. The suspension was agitated for 1 hour on a Griffin flask shaker (Griffin and George LTD, Great Britain) after which it was centrifuged for 10 minutes at 2200 rpm. The free water was decanted from the wet sample, drained for 10 minutes by inverting the centrifuge tubes over filter papers and the wet sample was weighed. WAC was calculated as the weight of water bound by 100 g flour. The WAC was calculated as:

$$\% \text{ WAC} = \frac{\text{weight of bound water} \times 100}{\text{weight of sample (dry basis)}}$$

Solubility and swelling capacity

Solubility and swelling capacity were determined based on the modification of the method of Leach et al. (1959). One gram of the flour sample was transferred into a pre-weighed graduated centrifuge tube (50 ml). Distilled water was added to give a total volume of 40 ml. The suspension was stirred just uniformly and sufficiently avoiding excessive speed. The suspension was heated at 85°C in a thermostatically regulated temperature water bath for 30 minutes with constant stirring. The centrifuge tube was removed, wiped dry on the outside and cooled to room temperature. It was then centrifuged for 15 minutes at 2200 rpm. The free water was decanted, evaporated and the residue was weighed. The sedimented paste was also weighed. Percent solubility and swelling capacity were calculated as follows:

$$\% \text{ Solubility} = \frac{\text{weight of residue} \times 100}{\text{weight of sample}}$$

$$\text{Swelling capacity} = \frac{\text{weight of sediment} \times 100}{\text{weight of sample on dry basis} \times (100 - \% \text{ solubility})}$$

Statistical analysis

The statistical analysis of data was by one-way ANOVA at $p \leq 0.05$ using ASSISTAT Version 7.7 en (2017).

Table 1. Proximate (%) and energy (kCal/100g) composition of rice flours

Constituent	Rice Variety		
	Digang	NERICA-1	NERICA-2
Moisture (%)	12.22 ^a (±0.19)	12.23 ^a (±0.01)	11.65 ^b (±0.24)
Ash (%)	0.83 ^a (±0.01)	0.90 ^a (±0.02)	0.55 ^b (±0.06)
Crude protein (%)	7.63 ^b (±0.32)	7.43 ^b (±0.09)	8.13 ^a (±0.18)
Crude fat (%)	0.14 ^b (±0.01)	0.65 ^a (±0.01)	0.77 ^a (±0.01)
Crude fibre (%)	0.72 ^b (±0.01)	0.67 ^c (±0.01)	0.87 ^a (±0.01)
Carbohydrate (%)	78.25 ^a (±0.43)	78.12 ^a (±0.11)	78.03 ^a (±0.16)
Energy (kCal/100g)	345.61 ^c (±0.72)	348.31 ^b (±0.30)	351.58 ^a (±3.11)

Values are means ± standard deviation of triplicate determinations. Values in the same row with different superscript letters differ significantly ($p \leq 0.05$).

RESULTS

Proximate composition and calorie contents of rice flours

The proximate nutrients composition and calorie content of the rice flours are presented (Table 1). The moisture content ranged between 11.65% in NERICA-2 and 12.23% in NERICA-1. There was no significant difference ($p > 0.05$) between the moisture content of NERICA-1 and Digang. The moisture contents of NERICA-1 and Digang were significantly higher ($p \leq 0.05$) than the moisture content of NERICA-2. The ash content of the rice flours ranged between 0.55% (NERICA-2) and 0.90% (NERICA-1). While Digang and NERICA-1 did not differ significantly ($p > 0.05$) in ash content from each other, their ash contents were significantly higher ($p \leq 0.05$) than the ash content of NERICA-2. Crude protein content varied between 7.43% in NERICA-1 and 8.13% in NERICA-2. NERICA-2 had a significantly higher ($p \leq 0.05$) crude protein content than Digang and NERICA-1 which did not differ significantly ($p > 0.05$) in crude protein content from each other. The crude fat content ranged from 0.14% to 0.77% with Digang having the least amount of crude fat and NERICA-2 having the highest amount of crude fat. NERICA-1 and NERICA-2 did not differ significantly ($p > 0.05$) in crude fat content from each other. Digang had a significantly lower ($p \leq 0.05$) crude fat content than NERICA-1 and NERICA-2. The crude fibre values for the rice flours fell between 0.67% (NERICA-1) and 0.87% (NERICA-2). The crude fibre content of NERICA-2 was significantly higher ($p \leq 0.05$) than the crude fibre content of both Digang and NERICA-1. Digang also had a significantly higher ($p \leq 0.05$) crude fibre content than NERICA-1. Digang had the highest carbohydrate content of 78.25% followed by NERICA-1 (78.12%) and the least amount of carbohydrate was obtained for NERICA-2 (78.03%). The carbohydrates content of the rice flours did not differ significantly ($p > 0.05$) from each other. NERICA-2

had the highest amount of energy among the three flours (351.58 kCal/100g) followed by NERICA-1 (348.31 kCal/100g) and the least amount of energy was obtained in Digang (345.61 kCal/100g). The energy content of NERICA-2 was significantly higher ($p \leq 0.05$) than the energy content of both NERICA-1 and Digang. Digang also had a significantly lower ($p \leq 0.05$) energy content than NERICA-1.

Mineral contents of rice flours

Calcium, magnesium, phosphorus and iron contents of the rice flours are shown (Table 2). The results reveal that NERICA-1 had the highest amount of calcium (84.01 mg/100g) followed by Digang (83.46 mg/100g) and the least was obtained in NERICA-2 (81.26 mg/100g). The calcium contents of the rice flours did not differ significantly ($p > 0.05$) from each other. The magnesium content of the rice flours varied between 63.53 mg/100g in NERICA-1 to 82.97 mg/100g in NERICA-2. NERICA-2 had a significantly higher ($p \leq 0.05$) magnesium content than both Digang and NERICA-1. The magnesium content of Digang was also significantly higher ($p \leq 0.05$) than NERICA-1. Phosphorus content of the rice flours ranged between 67.71 mg/100g (NERICA-1) and 94.93 mg/100g (NERICA-2). NERICA-2 had a significantly higher ($p \leq 0.05$) phosphorus content than both Digang and NERICA-1. The phosphorus content of Digang was also significantly higher than the phosphorus content of NERICA-1. The iron content of the three rice flours did not differ significantly ($p > 0.05$) from each other. The iron content ranged between 42.94 mg/100g in NERICA-2 and 47.35 mg/100g in NERICA-1.

Functional properties

The functional properties of the rice flours are shown (Table 3). Water absorption capacity was highest in Digang (148.08%), followed by NERICA-1 (143.14%) and the least

Table 2. Mineral composition of rice flours

Mineral (mg/100 g)	Rice Variety		
	Digang	NERICA-1	NERICA-2
Calcium	83.46 ^a (±2.46)	84.01 ^a (±2.54)	81.26 ^a (±2.34)
Magnesium	67.42 ^b (±1.04)	63.53 ^c (±0.42)	82.97 ^a (±3.86)
Phosphorus	73.15 ^b (±2.56)	67.71 ^c (±2.56)	94.93 ^a (±1.54)
Iron	46.47 ^a (±3.56)	47.35 ^a (±3.26)	42.94 ^a (±0.04)

Values are means ± standard deviation of triplicate determinations. Values in the same row with different superscript letters differ significantly ($p \leq 0.05$).

Table 3. Functional properties of rice flours

Functional property	Rice Variety		
	Digang	NERICA-1	NERICA-2
WAC (%)	148.08 ^a (±3.00)	143.14 ^a (±7.49)	131.99 ^b (±1.15)
Solubility (%)	7.64 ^a (±0.22)	5.94 ^a (±0.03)	7.66 ^a (±1.66)
Swelling capacity	6.25 ^a (±0.01)	6.41 ^a (±0.32)	4.16 ^b (±0.07)

Values are means ± standard deviation of triplicate determinations. Values in the same row with different superscript letters differ significantly ($p \leq 0.05$).

was obtained in NERICA-2 (131.99%). While Digang and NERICA-1 did not differ significantly ($p \leq 0.05$) in their water absorption capacities, their water absorption capacities were significantly higher ($p \leq 0.05$) than the water absorption capacity of NERICA-2. The rice flours did not exhibit significant differences ($p > 0.05$) in their solubility values. The solubility of the rice flours was within the range of 5.94 % in NERICA-1 to 7.66% in NERICA-2. For the swelling capacity, the values varied between 4.16 (NERICA-2) and 6.41 (NERICA-1). NERICA-1 and Digang did not differ significantly ($p > 0.05$) in their swelling capacity values. The swelling capacity of NERICA-2 was significantly lower ($p \leq 0.05$) than the swelling capacity values of NERICA-1 and Digang.

DISCUSSION

Proximate composition and calorie contents

Moisture

Moisture content serves as an index of flour storability (Joy and Ledogo, 2016). Low moisture content gives better shelf life (Joy and Ledogo, 2016) and enhanced keeping quality under storage (Alaka et al., 2011). All the rice varieties contained less than 14% moisture which meets the moisture content requirement for safe storage of rice (Deviga et al., 2016; Simonelli et al., 2017). The contents

of moisture obtained in this study are close to the range of values reported by Cameron and Wang (2005) (9.00 – 11.00%), Maisont and Narkrugsa (2009) (10.52 – 12.26%), Diako et al. (2011) (11.20 – 12.20%), Thomas et al. (2013) (10.04 – 12.88%), Kariyawasam et al. (2016) (11.20 – 11.90%) and Salim et al. (2017) (11.85 - 12.05%).

Ash

Ash content in rice reflects the mineral elements (Mbatchou and Dawda, 2013). Ash content indicates the composition of inorganic constituents after organic materials and moisture have been removed by incineration (Iwe et al., 2016). The content of ash in all the rice varieties fell below 1.00%. The range of ash values obtained in this study fell within the range of values obtained by Shayo et al. (2006) (0.18 - 0.97%) but below the result reported by Islam et al. (2012) (1.77%).

Crude protein content

Proteins form the basic building blocks for cells and tissue repairs in the body (Mbatchou and Dawda, 2013). Crude protein values obtained fall slightly below the results obtained by Islam et al. (2012) (8.50%). The differences in crude protein content might be due to varietal differences (Kennedy and Burlingame, 2003).

Crude fat content

The content of crude fat for all the rice varieties fell below 1.00%. The range of crude fat values obtained in this study fell below the value obtained by Islam et al. (2012) (2.80%). Shayo et al. (2006) reported a range of crude fat values (0.57 – 0.85%). While Digang had a crude fat value falling far below this range, NERICA-1 and NERICA-2 had crude fat values falling within this range. The low fat content in the rice flours may be due to the fact that cereals store energy in the form of starch rather than lipids (Iweet al., 2016). The low crude fat levels may be beneficial in ensuring longer shelf life for these rice varieties because all fats and fat-containing foods contain some unsaturated fatty acids and hence are potentially susceptible to oxidative rancidity (Iwe et al., 2016).

Crude fibre content

The content of fibre for all the rice varieties fell below 1.00%. The range of crude fibre values obtained in this study fell below the value obtained by Islam et al. (2012) (1.23%). Shaye et al. (2006) reported a range of crude fibre values (0.29 – 0.73%). While NERICA-2 had a crude fibre value above this range, Digang and NERICA-1 had crude fibre values falling within this range.

Carbohydrate content

The rice flours in this study had very high amounts of carbohydrates, which might mainly be starch (Rosniyana et al., 1995; Adaduzzaman et al., 2013). The range of values of carbohydrates obtained in this study compare favourably with the result obtained by Islam et al. (2012) (77.31%).

Calorie content

Energy value of food measures its value to the body as a fuel for metabolic processes and it measures the chemical energy inherent in the bonds of the organic compounds of the food such as the protein, carbohydrates and fat (Kariyawasam et al., 2016). NERICA-2 provides the highest amount of energy, followed by NERICA-1 and Digang supplies the least amount of energy. The studied rice varieties are good sources of energy.

Mineral nutrients

Calcium

Differences in calcium contents among the flours may be due to differences in the rate of calcium uptake by each plant. Calcium contents obtained in this study compare favourably with the results obtained by Ebuehi and

Oyewole (2007) (80 mg/100g). Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. In children, calcium deficiency causes rickets and in adults, it causes osteomalacia and may also contribute to osteoporosis (Soetan et al., 2010).

Magnesium

Magnesium helps in the formation of bones and teeth and assists in the absorption of calcium and potassium. It is also needed for cellular metabolism and energy production through its help with enzyme activity (Mbatchou and Dawda, 2013). The range of values of magnesium obtained in this research is close to the range of values obtained by Ebuehi and Oyewole (2007) (67.0 – 82.0).

Phosphorus

The concentration of phosphorus in Digang and NERICA-2 rice flours are close to the values reported by Ebuehi and Oyewole (2007) (73.0 – 94.00 mg/100g). NERICA-1 recorded a phosphorus value far below this range. The phosphorus content in NERICA-1 falling far below the values obtained by Ebuehi and Oyewole (2007) may be due to factors such as differences in the environment, soil and variety (Zhou et al., 2002). Phosphorus functions as a constituent of bones, teeth, adenosine triphosphate (ATP), phosphorylated metabolic intermediates and nucleic acids (Soetan et al., 2010).

Iron

Iron is essential for the formation of haemoglobin in red blood cells (Alaka et al., 2011). The values of iron obtained in this work are comparable to the values (42.9 – 46.3 mg/100g) obtained by Ebuehi and Oyewole (2007).

Functional properties

Water absorption capacity

While Digang and NERICA-1 had water absorption capacity falling far above the result obtained by Islam et al. (2012) (125.38%), NERICA-2 had a water absorption capacity slightly above the results obtained by Islam et al. (2012) (131.99% versus 125.38%). The results denote the possession of more water binding sites in Digang and NERICA-1 than in NERICA-2. Water absorption characteristics represent the ability of a product to associate with water under limiting conditions such as in doughs and pastes (Gianni, 1993). It is important for flours as they swell and impart characteristics such as body thickness and viscosity (Falade and Adebisi, 2015). High water absorption capacity is advantageous when preparing

food items like bread and sausages to maintain freshness and for easy handling (Bhat et al., 2008).

Solubility

All the rice flours recorded higher solubility values than commercial rice flour (3.80%) (Noitang et al. 2009). While Digang and NERICA-2 had values which were more than two-fold that of commercial rice flour as reported by Noitang et al. (2009), NERICA-1 recorded a solubility value more than one and a half times that of commercial rice flour as reported by Noitang et al. (2009). High solubility of flour suggests that the flour is digestible (Appiah et al., 2011). This means NERICA-2 is more digestible among the studied rice flours (because of its comparatively high solubility) and therefore could be more suitable for infant food formulations.

Swelling capacity

Swelling capacity gives an indication of the increase in the volume of flour following water absorption (Ojo and Ade-Omowaye, 2015). Flours with good swelling capacities are used for thickening of soups, sauces and gravies (Oraka and Okoye, 2017). The swelling capacity values obtained in this study fell below that of commercial rice flour (7.7 g/g) (Noitang et al., 2009). NERICA-1 and Digang recorded swelling capacity values close to that reported by Noitang et al. (2009) but the swelling capacity value of NERICA-2 fell far below the result reported by Noitang et al. (2009). Among the studied flours, NERICA-1 had the highest swelling capacity, being more than one and a half fold that of NERICA-2 and may be the best among the rice flours for use in food products which require swelling such as noodles.

CONCLUSION

The three rice varieties showed variation in nutrient content and functional properties. The nutrient content analysis shows that the potential exists to select nutritionally superior rice varieties to help improve food security. The functional properties study shows that besides being consumed as a whole grain, rice can potentially be used as a functional ingredient in formulated products to play a wide array of functional roles in the form of flours.

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REFERENCES

- Agte VV, Gokhale MK, Paknikar KM, Chiplonkar SA (1995). Assessment of pearl millet vs rice-based diets for bioavailability of four trace metals. *Plant Foods for Human Nutrition* 48(2): 149-158.
- Alaka IC, Ituma, JOS, Ekwu FC (2011). Physical and chemical properties of some selected rice varieties in Ebonyi State. *Nigerian Journal of Biotechnology* 22: 40-46.
- Anjum FM, Prasha I, Bugti MA, Butt MS (2007). Mineral composition of different rice varieties and their milling fractions. *Pakistan Journal of Agricultural Sciences* 44(2): 332-336.
- AOAC (1990). Official Methods of Analysis (15th edition). Association of Official Analytical Chemists, AOAC Pub., USA.
- Appiah F, Oduro I, Ellis WO (2011). Functional properties of *Artocarpus altilis* pulp flour as affected by fermentation. *Agriculture and Biology Journal of North America* 2(5): 773-779.
- Asaduzzaman M, Haque ME, Rahman J, Hasan SMK, Ali MA, Akter MS, Ahmed M (2013). Comparisons of physicochemical, total phenol, flavonoid content and functional properties of six cultivars of aromatic rice in Bangladesh. *African Journal of Food Science* 7(8): 198-203.
- Bhat R, Sridhar KR, Young C, Bhagwath AA, Ganesh S (2008). Composition and functional properties of raw and electron beam irradiated *Mucunapruriens* seeds. *International Journal of Food Science and Technology* 43(8): 1338-1351.
- Cameron DK, Wang Y (2005). A better understanding of factors that affect the hardness and stickiness of Long-Grain rice. *Cereal Chemistry* 82(2): 113-119.
- Chaudhari PR, Tamrakar N, Singh L, Tandon A, Sharma D (2018). Rice nutritional and medicinal properties: A review article. *Journal of Pharmacognosy and Phytochemistry* 7(2): 150-156.
- Deviga D, Vijayalakshmi J, Rahman AA (2016). Determination of storage loss in rice with respect to moisture loss in Food Corporation of India. *International Journal of Latest Trends in Engineering and Technology, Special Issue* 36-41.
- Diako C, Sakyi-Dawson E, Bediako-Amoah B, Saalia FK, Manful JT (2011). Cooking characteristics and variations in nutrient content of some new scented rice varieties in Ghana. *Annals: Food Science and Technology* 12(1): 39-44.
- Ebuehi OAT, Oyewole AC (2007). Effect of cooking and soaking on physical characteristics, nutrient composition and sensory evaluation of indigenous and foreign rice varieties in Nigeria. *African Journal of Biotechnology* 6(8): 1016 – 1020.
- Falade KO, Adebisi AO (2015). Effect of γ -irradiation on cooking, functional and pasting properties of Bambara groundnut (*Vigna subterranea* [L.] Verdc.) cultivars. *Journal of Food Processing Engineering* 38(5): 452-466.
- Giami SY (1993). Effect of processing on the proximate composition and functional properties of cowpea (*Vigna unguiculata*) flour. *Food Chemistry* 47(2): 153-158.
- Islam MZ, Taneya MLJ, Shams-Ud-Din M, Syduzzaman M, Hosque MM (2012). Physicochemical and functional properties of Brown Rice (*Oryza sativa*) and wheat (*Triticum aestivum*) flour and quality of composite biscuit made thereof. *The Agriculturists* 10(2): 20-28.
- Iwe MO, Onyeukwu U, Agiriga AN (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food and Agriculture* 2: 1142409.
- Joy E, Ledogo N (2016). 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): 80-84.
- Juo ASR (1978). Selected methods for soil and plant analysis. *International Institute of Tropical Agriculture (Manual series No.1, 2nd Edition)* pp. 38-39.
- Kariyawasam TI, Godakumbura PI, Prashantha MAB, Premakumara GAS (2016). Proximate composition, calorie content and heavy metals (As, Cd, Pb) of selected Sri Lankan traditional rice (*Oryza sativa* L.) varieties. *Procedia Food Science* 6: 253- 256.

- Kemashalini K, Prasantha BDR, Chandrasiri KAKL (2018). Physico-chemical properties of high and low amylose rice flour. *Advances in Food Science and Engineering* 2(4): 115-124.
- Kennedy G, Burlingame B (2003). Analysis of food composition data on rice from a plant genetic resources perspective. *Food Chemistry* 80(4): 589-596.
- Maisont S, Narkrugsa W (2009). Effects of some physicochemical properties of paddy rice varieties on puffing qualities by microwave "ORIGINAL". *Kasetsart Journal (Natural Science)* 43(3): 566-575.
- Mbatchou VC, Dawda S. (2013). The nutritional composition of four rice varieties grown and used in different food preparations in Kassena-Nankana District, Ghana. *International Journal of Research in Chemistry and Environment* 3(1): 308-315.
- Noitang S, Sooksai SA, Fopphow T, Petsom A (2009). Proximate analysis and physico-chemical properties of flour from the seeds of the China Chestnut, *Sterculiamonosperma* Ventenat. *Pakistan Journal of Biological Sciences* 12(19): 1314-1319.
- Ojo MO, Ade-Omowaye BIO(2015). Some functional and physical properties of selected underutilized hard to cook legumes in Nigeria. *American Journal of Food Science and Nutrition* 2(5): 73-81.
- Onyeike EN, Olungwe T, Uwakwe AA (1995). Effect of heat treatment and defatting on the proximate composition of some Nigerian local soup thickeners. *Food Chemistry* 53(2): 173-175.
- Oraka CO, Okoye JI (2017). Effect of heat processing treatments on the chemical composition and functional properties of Lima bean (*Phaseolus lunatus*) flour. *American Journal of Food Science and Nutrition* 1(1): 14-24.
- Rosniyana A, Ajimilah NH, Hajar RI, Norin SAS (1995). Chemical composition and physico-chemical properties of Mahsuri mutant and Basmati rice. *Malaysian Agricultural Research and Development Institute Research Journal* 23(2): 177-181.
- Salim R, Nazir F, Yousf N, Amin F (2017). Chemical composition of different rice cultivars grown in North India. *International Journal of Chemical Studies* 5(6): 1929-1930.
- Shayo NB, Mamiro P, Nyaruhucha CNM, Mamboleo T (2006). Physico-chemical and grain cooking characteristics of selected rice cultivars grown in Morogoro. *Tanzania Journal of Science* 32(1): 29-35.
- Simonelli C, Galassi L, Cormegna M, Bianchi P (2017). Chemical, physical, textural and sensory evaluation on Italian rice varieties. *Universal Journal of Agricultural Research* 5(2): 104-112.
- Soetan KO, Olaiya CO, Oyewole OE (2010). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science* 4(5): 200-222.
- Thomas R, Wan-Nadiah WA, Bhat R (2013). Physicochemical properties, proximate composition, and cooking qualities of locally grown and imported rice varieties marketed in Penang, Malaysia. *International Food Research Journal* 20(3): 1679-1685.
- Zhou Z, Robards K, Helliwell S, Blanchard C (2002). Composition and functional properties of rice. *International Journal of Food Science and Technology* 37(8): 849 – 868.