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Characterization and utilization of nixtamalised rice flours in the production of cake

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Abstract

In an attempt to provide an alternate rice processing technique and enhance its nutritional quality, Faro 52 (Upland) and Nerica 8 (Lowland) rice grains were subjected to nixtamalisation involving cooking and soaking in a lime solution. The proximate composition, functional properties and pasting characteristics of the nixtamalised and non-nixtamalised rice flours were evaluated. Cakes produced with the rice flours were also subjected to sensory evaluation. Nixtamalisation significantly increased the protein content of upland (NUPRF) and lowland (NLLRF) rice flours by 28.19% and 27.80%, respectively. Nixtamalisation also enhanced the water absorption capacity of the rice flours, while the oil absorption capacity increased significantly. Pasting viscosities of all the nixtamalised flours were lower than their non-nixtamalised samples, while the pasting temperature increased. Nixtamalised rice cakes were not significantly different in colour, texture, flavour and overall acceptability from non-nixtamalised rice cakes. Nixtamalisation may be beneficial in rice processing for enhanced nutritional content and functionality, and the flour may be useful as a thickener and binder in food systems and the production of acceptable cakes.

1. Introduction

The cake is a confectionary consumed globally in the form of ready-to-eat snacks. It is popularly made from wheat flour and other ingredients such as sugar, margarine, eggs and water. Concerted efforts have been geared towards producing cakes and other confectionaries from composite blends of wheat and non-wheat flours or the use of entirely non-wheat flours from cereal, legumes, roots and tubers (Mishra and Chandra, 2012; Man *et al*., 2014). This is to reduce dependence on wheat with accompanying huge foreign exchange expended on its importation to non-producing countries like Nigeria. Furthermore, there is a need to provide an alternate cake for celiac patients and promote the utilisation of indigenous food crops. Celiac disease is a gluten-sensitive enteropathy with symptoms such as diarrhoea, abdominal pain, cramping and distention and may lead to the deficiency of nutritionally important vitamins and minerals if not treated (Hussein *et al*., 2012). Rice has been reported to be a valuable replacement for wheat since it is gluten-free, contains low sodium and high digestible carbohydrates (Yimaki *et al*., 1991; Das *et al*., 2013).

Rice processing techniques such as parboiling, milling, washing/rinsing and cooking; reduce the nutritional value of rice. For instance, the bran layer of rice removed during milling has a high percentage of oil, protein, vitamins and minerals (Sobhan, 2014). This shows that the nutrients contained in the bran layer and other parts of the rice are mostly lost during processing. This nutrient reduction has led to improvements in rice technology through the development of a variety of approaches such as breeding, genetic modification and fortification. These are notable techniques that have been successfully employed in improving the nutritional quality of not only rice but other grains in the cereal family. One other technique which has been widely accepted as a means of improving the nutritional value of grains (such as corn and oats) is nixtamalisation (Sefa-Dedeh *et al*., 2004).

Nixtamalisation involving treating cereals with alkaline solution has been reported to offer nutritional benefits such as increased nutritional value, the impartation of deeper flavour, improved protein quality and release of otherwise bound mineral elements in cereal grains (Ocheme *et al*., 2010). Harnadex-Becerra *et al*. (2016) observed increased calcium to phosphorus ratio in nixtamalised corn-sorghum flour blends.

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Research studies have shown a relationship between calcium intake and degenerative diseases like arthritis and rheumatism; nixtamalisation has been noted as one of the processing methods that enhances the availability of dietary calcium in foods (Gutiérrez-Cortez *et al*., 2013; Chen *et al*., 2014; Devika and Sherry, 2016). Increased antioxidants and nutrients have also been reported in nixtamalised Lagkitan corn (Cayetano *et al*., 2019). Hydrolysis of the ester bond linking ferulic acid with cell wall components in maize has been enhanced with nixtamalisation thereby improving the bioavailability of this phenolic compound (Salinas-Moreno *et al*., 2017). Nixtamalisation has been used widely because of its positive effects; however, the application has been almost limited to maize grain. Therefore, nixtamalisation of rice and further utilization of the nixtamal is intended to provide an alternative treatment of rice that would help to improve its nutritional quality and flavour and enhance food product development. This work aimed at characterization and utilization of nixtamalised rice flour in the production of gluten-free cake.

2. Materials and methods

Rice samples; upland (Faro 52) and lowland (Nerica 8) were obtained from Agricultural Development Program (ADP) office at Ado-Ekiti, Ekiti State, 7.6124° N, 5.2371° E, Nigeria. Food grade $Ca(OH)_2$ (lime) was purchased from Turraco Industrial Limited Mushin, Lagos, Nigeria.

2.1 Production of rice flour

Upland and lowland rice grains (paddy) were separately cooked in 1% lime solution ($CaOH_2$) for 30 mins at atmospheric conditions, cooled and later steeped in the same cooking solution for 12 hrs. The cooking solution was discarded and the resulting nixtamal was washed four times with tap water to remove the bran and excess lime followed by drying (sun-drying), winnowing, milling and pulverising into flour (Mendez-Montealvo *et al.,* 2007). The control sample, non-nixtamalised rice flour was prepared using the same method, excluding the addition of lime into the solution.

2.2 Preparation of rice cake

The nixtamalised and non-nixtamalised rice flours were separately used in the production of cakes following the procedure described by Oyeyinka *et al*. (2014) with little modification. The cakes were prepared by rubbing margarine (100 g) and sugar (100 g) continuously through mixing in a bowl until they become creamy and fluffy. Eggs (2 whole eggs) were added one at a time and whipped well after each addition. Rice flour (250 g) and baking powder (2 g) was added into the creamed butter and egg mixture, mixed thoroughly until the batter is well blended. Each sample cup previously lined with paper liners were filled with about 3 tablespoons of batter and baked in a preheated (175°C) oven (PBs 118SF Genlab Widnes, England) for about 18 to 20 mins. The cakes were later cooled to ambient temperature and packed in polyethylene bags until use.

2.3 Determination of the proximate composition of flour and cake

Nixtamalised and non-nixtamalised rice flours and cake produced were analysed for proximate composition. Moisture, crude fat, fibre, protein and ash content were determined according to the standard methods of AOAC, (2012). Carbohydrate was calculated by difference.

2.4 Sensory evaluation of cake

Sensory properties of nixtamalised and non-nixtamalised rice cakes were determined using twenty-member semi-trained panellists selected on the basis of their familiarity with the product and their consistency in scoring. The cakes were evaluated for aroma, taste, crispiness, colour, texture and overall acceptability using a 9-point Hedonic scale from like extremely (9) to dislike extremely (1).

2.5 Determination of functional properties of rice flour

2.5.1 Water and oil absorption capacity (WAC and OAC)

Water and oil absorption capacities were determined by the method described by Chandra *et al.* (2015) with little adjustment. Approximately 1 g of flour sample was mixed with 10 mL of distilled water to form a suspension and stirred on a magnetic stirrer (78HW-1) for 5 min. The mixture was centrifuged (GL16C BBPAN Scientific and Instrument Co Ltd) for 30 mins at 3000 rpm and the supernatant was decanted. Water absorption capacity was expressed as percent gram of water absorbed per gram of flour. OAC was determined by replacing water with Kings vegetable oil.

2.5.2 Swelling capacity

The swelling capacity of the flours was determined by the method described by Chandra *et al*. (2015). A 100 mL graduated cylinder was filled with the sample to 10 mL mark, distilled water was added to 50 mL mark, the top of the cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 mins and left to stand for a further 8 mins. The volume occupied by the sample was used to calculate the swelling capacity.

2.5.3 Bulk density

The bulk density (BD) of the rice flours were determined using the method described by (Ocheme *et al.,* 2010). Approximately 50 g (W) flour sample was weighed into 100 mL measuring cylinder, tapped gently until there is no diminution and the volume (V) noted. The bulk density was calculated thus;

$$\text{BD (g/cm}^3) = \frac{W}{V}$$

2.5.4 Pasting property of flours

The pasting property of the rice flours was determined using a Rapid Viscosity Analyzer (Newport Scientific Pty Ltd. Warriewood NSW 2102, Australia). Rice flour samples were added to 25 mL of distilled water to prepare 8% suspension on a dry weight basis (w/v). Each suspension was heated to 50°C, and after 1 min of equilibration, it was then heated up to 95°C at 12.2°C/min and held for 2.5 min at 95°C. It was then cooled to 50°C at 11.8°C/min and kept for 2 mins at 50°C. Viscosity was measured in RVA (IITA, 2001).

2.6 Statistical analysis

Data were recorded in triplicates and analysed using Analysis of Variance (ANOVA). Means were separated by the New Duncan Multiple range test using Statistical Package for Social Sciences (SPSS) version 21. Significance was accepted at 5% level of probability.

3. Results and discussion

3.1 Proximate composition of rice flours and cakes

The proximate composition of nixtamalised and non-nixtamalised upland (NUPRF and UPRF) and lowland (NLLRF and LLRF) rice flours respectively are presented in Table 1. The proximate composition of the rice flours varied significantly ($p \leq 0.05$) and Nixtamalisation affected it. The ranges of value of moisture, protein, ash, fibre, fat and carbohydrate content in the flours are 8.30-8.97%, 7.45-9.92%, 1.09-1.50%, 0.93-1.28%, 2.06-2.97% and 76.33-79.38% respectively. Among the varieties, upland rice (Faro 52) is significantly higher in proteins and carbohydrate, while it is lower in moisture content (this may confer higher storability) than its lowland rice (Nerica 8) counterpart. Nixtamalisation increased the protein content of the rice flour significantly by 27.80% and 28.19% in lowland (NLLRF) and upland (NUPRF) rice flours respectively. Lime treatment also increased the ash content of lowland rice flour, while there was no change observed in the value of ash content of upland rice. Musita *et al*. (2018) reported higher protein content in nixtamalised corn flour from 3.177% to 4.406%. Ocheme *et al*. (2010) also reported increased protein, ash, and crude fibre in millet flour after cooking in a lime solution. Nixtamalisation has also been reported to enhance the ash content of quality protein maize significantly (Milán-Corrillo *et al*., 2004). The values of crude protein of the non-nixtamalised rice flour used in this study compared well with values of 7.43% reported for Ghanaian Nerica 1 rice flour (Eshun *et al*., 2019), it is however lower than the ranges of 7.50-9.60% for some selected rice varieties (Zubair *et al*., 2012; Jamal *et al*., 2016).

The proximate composition of rice cake differed significantly among the variety and lime treatment (Table 2). The moisture content of the cake samples ranged between 14.63-17.79%, while the protein and fat have the ranges of 14.54-17.19% and 22.37-23.70% respectively. Nixtamalised rice cake is higher in protein content than the non-nixtamalised rice cake samples. The range of protein obtained in the cake samples compared well with the value of 16.33% reported for brown rice cake (Asimah *et al*., 2016). The protein content of the cake obtained in this study is however higher than 6.57% protein for cakes produced from wheat flour (Asimah *et al*., 2016).

3.2 Functional properties of rice flours

Functional properties of nixtamalised and non-nixtamalised rice flours are shown in Figure 1. There was generally no significant difference in the water absorption capacity (WAC) of the flour samples among variety and lime treatment. Although there were increases in the WAC of the nixtamalised samples compared to their non-nixtamalised samples. The oil absorption capacity (OAC) of the rice flours however increased significantly with lime treatment. Nixtamalised rice flours may be a better thickening and binding

Table 1. Proximate composition of rice flours (%)

Sample	Moisture	Protein	Total ash	Crude fibre	Crude fat	Carbohydrate
LLRF	8.30±0.00^{d}	7.76±0.01^{c}	1.09±0.01^{c}	1.24±0.01^{ab}	2.23±0.06^{b}	79.38±0.06^{a}
UPRF	8.97±0.01^{a}	7.45±0.00^{d}	1.27±0.01^{b}	1.21±0.00^{b}	2.06±0.03^{b}	79.04±0.03^{b}
NLLRF	8.53±0.02^{c}	9.92±0.01^{a}	1.50±0.01^{a}	0.93±0.00^{c}	2.79±0.05^{a}	76.33±0.05^{d}
NUPRF	8.75±0.01^{b}	9.55±0.00^{b}	1.27±0.00^{b}	1.28±0.06^{a}	2.18±0.24^{b}	76.97±0.22^{c}

Values are presented as mean±standard deviation. Values with the same superscript within the column are not significantly different ($p \leq 0.05$). LLRF: Lowland rice flour, UPRF: Upland rice flour, NLLRF: Nixtamalised Lowland rice flour, NUPRF: Nixtamalised upland rice flour.

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Table 1. Proximate composition of rice cakes (%)

Sample	Moisture	Protein	Total ash	Crude fibre	Crude fat	Carbohydrate
LLRC	14.63±0.04^{d}	15.35±0.03^{c}	1.82±0.06^{c}	1.00±0.04^{c}	23.70±0.03^{a}	43.50±0.02^{a}
NLLRC	17.79±0.06^{a}	14.54±0.05^{d}	2.19±0.01^{a}	1.09±0.01^{b}	22.37±0.05^{d}	42.02±0.04^{b}
UPRC	16.62±0.03^{b}	17.19±0.47^{a}	1.75±0.02^{c}	1.06±0.03^{bc}	23.54±0.01^{b}	39.84±0.46^{d}
NUPRC	16.00±0.05^{c}	16.78±0.08^{b}	2.07±0.04^{b}	1.46±0.02^{a}	22.58±0.01^{c}	41.11±0.15^{c}

Values are presented as mean±standard deviation. Values with the same superscript within the column are not significantly different (p≤0.05). LLRF: Lowland rice flour, UPRF: Upland rice flour, NLLRF: Nixtamalised Lowland rice flour, NUPRF: Nixtamalised upland rice flour.

ingredient in the food industry. Sefa-Dedeh *et al.* (2004) reported a WAC of 170 g/100 g in maize flour nixtamalised by cooking in 1% lime solution. They affirmed that lime concentration and cooking have a significant effect on the WAC of the maize flours. Among the rice varieties, low land rice flours (Nerica 8) is significantly higher in OAC than upland rice flour (Faro 52), while their WAC was not significant. The WAC and OAC obtained in the rice samples used for this study are higher than the values of 95.35% and 72.55% (WAC) and 58.05% and 60.47% (OAC) reported for Nerica 7 and Faro 44 rice flours (Ogunbusola *et al.*, 2020). The values are also higher than the values of WAC and OAC reported for Faro 44 rice flour (Iwe *et al.*, 2016). Variation in the WAC and OAC of different varieties of rice used may be an indication of differences in their amylose/amylopectin ratio (Lawal *et al.*, 2004). The swelling capacity of the rice flours ranged from 222.34% to 313%. The swelling capacity of nixtamalised Nerica 8 rice flour (NLLRF) is significantly higher than that of its non-nixtamalised sample (LLRF), while it decreased in NUPRF. The Bulk density (BD) of the rice flours are 0.79 g/mL, 0.73 g/mL, 0.80 g/mL and 0.75 g/mL respectively in LLRF, UPRF, NLLRF and NUPRF respectively. Although there was an increase in the bulk density due to nixtamalisation, there was no significant difference (p≤0.05) in the BD.

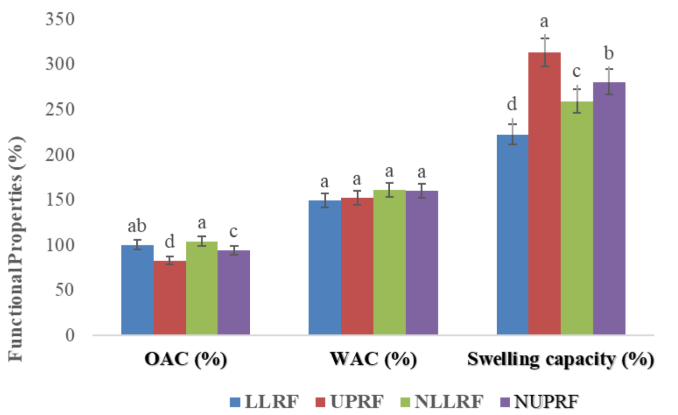

Figure 1. Functional properties of nixtamalised and non-nixtamalised rice flours. Bars with different alphabets are significantly (p≤0.05) different. LLRF: Lowland rice flour, UPRF: Upland rice flour, NLLRF: Nixtamalised Lowland rice flour, NUPRF: Nixtamalised upland rice flour.

3.3 Pasting properties of rice flours

The pasting viscosities of the rice flours varied significantly with lime treatment (Table 3). The peak viscosities of the nixtamalised samples are significantly lower than the non-nixtamalised samples. Peak viscosity gives an indication of the extent of swelling or the water-binding ability of starch during thermal processing. The lower peak viscosity of the Nixtamalised rice flour may be attributed to Ca^{2+} and $Ca(OH)^{+}$- starch interaction, causing saturation of the starch's hydroxyl site and subsequent reduction in water absorbed during heating (Sefa-Dedeh *et al.*, 2004). The final and setback viscosities of the flour samples were reduced in the nixtamalised samples. High setback viscosity has been attributed to the tendency of the flour paste to retrograde or undergoes staling during cooling. In this study, non-nixtamalised rice flours have higher final and setback viscosities, indicating that they may have a greater

Table 3. Pasting properties of rice flour samples.

Pasting Characteristic	LLRF	UPRF	NLLRF	NUPRF
Peak viscosity (RVU)	2340±57.9^{ab}	2398±14.1^{a}	2190±0.0^{c}	2291±26.8^{b}
Trough (RVU)	2252.5±41.7^{a}	2261±5.6^{a}	2130±0.0^{b}	2161.5±16.2^{b}
Breakdown viscosity (RVU)	87.5±16.2^{b}	137.0±8.4^{a}	60.0±0.0^{b}	129.5±10.6^{a}
Final viscosity (RVU)	4538.5±169.0^{a}	3990.0±16.9^{b}	3945.5±38.8^{b}	3870.0±35.3^{b}
Set back (RVU)	2286.0±127.2^{a}	1729.0±22.6^{b}	1815.5±38.8^{b}	1708.5±19.0^{b}
Peak time (min.)	6.2±0.1^{b}	6.1±0.1^{b}	6.4±0.0^{a}	6.2±0.0^{b}
Pasting temperature (°C)	86.4±0.1^{c}	85.9±0.5^{d}	87.2±0.0^{a}	86.6±0.0^{b}

Values are presented as mean±standard deviation. Values with the same superscript within the row are not significantly different (p≤0.05). LLRF: Lowland rice flour, UPRF: Upland rice flour, NLLRF: Nixtamalised Lowland rice flour, NUPRF: Nixtamalised upland rice flour.

tendency to retrograde. The pasting temperature signifies the minimum temperature required for cooking the flour. The pasting temperature of the rice flours ranged from 85.90°C to 87.25°C with UPRF having the lowest and NLLRF having the highest. This shows that Nixtamalisation increased the pasting temperature of the flour samples, thus requiring more thermal energy and time in cooking. Sefa-dedeh *et al*. (2004) also observed increased pasting temperature in maize flour subjected to cooking in lime at various concentrations. The pasting temperature of the non-nixtamalised rice samples LLRF (Nerica 8) and UPRF (Faro 52) is higher than 79.95°C for Faro 44 rice flour (Iwe *et al*., 2016) and the range of 62.1 - 78.3°C reported for some rice varieties and (Thomas *et al*., 2004).

3.4 Sensory evaluation of rice cakes

The sensory evaluation of cakes produced from nixtamalised and non-nixtamalised rice flours is shown in Table 4. Lime treatment does not show any significant effect on the colour, texture, flavour and overall acceptability of the cake samples. The taste and mouthfeel of the cakes are however significantly different. The taste and mouthfeel of nixtamalised upland rice cakes (NUPRC) were rated inferior to other samples. Non-nixtamalised cake samples were generally rated higher in all the sensory attributes evaluated compared to their nixtamal counterpart. Lime treatment may be responsible for this observation. The present study shows that the use of nixtamalised or non-nixtamalised rice flour does not affect the overall acceptability of the cakes produced. Rodríguez-Miranda *et al*. (2011) reported no significant difference in the overall acceptability of extruded snacks produced from the blends of taro and either nixtamalised or non-nixtamalised maize flour blends. However, consumer sensory evaluation of Masa produced from nixtamalised fermented millet was significantly superior to those from non-nixtamalised fermented millet (Owusu-Kwarteng and Akanbada, 2013). Among the rice varieties, there was no significant difference in the cakes from upland or lowland rice, UPRC is however rated higher in taste, flavour, mouthfeel and overall acceptability. Both rice varieties and their nixtamal may be suitable substitutes for wheat flour in confectionary industries especially in the production of acceptable and nutritious cakes.

4. Conclusion

Nixtamalisation of rice significantly affected the proximate composition, functional properties and pasting characteristics of upland (Faro 52) and lowland (Nerica 8) rice flours. Protein content and water absorption capacity were enhanced due to lime treatment, pasting viscosities of nixtamalised rice flours were generally reduced while pasting temperature increased. Cakes prepared with nixtamalised flours were not significantly inferior to those from non-nixtamalised flours in all sensory attributes evaluated. Nixtamalisation may find use in rice processing for the production of high protein flour applicable in the baking industry to reduce over-dependence on wheat flour.

Conflict of interest

The authors declare no conflict of interest.

References

AOAC. (2012). Official method of analysis of AOAC International. 19th ed. Gaithersburg, USA: AOAC International.

Asimah, V.K., Kpodo, F.M., Adzinyo, O.A. and Dzah, C. S. (2016). Utilisation of Brown Rice Flour and Peanut Paste in Cake Production. *American Journal of Food Science and Technology*, 4(5), 129-134. http://dx.doi.org/10.12691/ajfst-4-5-2.

Cayetano, A.C., Atienza, L.M. and Juanico, C.B. (2019). Proximate Properties, Functional Components, and Vitamin and Mineral Content of Nixtamalised Lagkitan Corn (*Zea mays* L.). *Ecronicon Nutrition*, 14(4), 360-372.

Chandra, S., Singh, S. and Kumari, D. (2015). Evaluation of functional properties of composite flours and sensorial attributes of composite flour

Table 4. Sensory evaluation of nixtamalised and non-nixtamalised rice cakes

Parameters	LLRC	UPRC	NLLRC	NUPRC
Colour	7.90±0.99^{a}	7.90±0.57^{a}	7.80±0.63^{a}	7.90±0.57^{a}
Taste	7.90±0.57^{ab}	8.30±0.68^{a}	7.90±0.74^{a}	7.40±0.70^{b}
Texture	7.80±1.23^{a}	7.60±0.94^{a}	7.20±0.99^{a}	7.40±0.79^{a}
Flavour	7.40±0.97^{a}	7.70±1.16^{a}	7.40±1.08^{a}	7.20±0.63^{a}
Mouth feel	7.90±0.88^{a}	8.00±0.94^{a}	7.90±0.88^{a}	7.10±0.74^{b}
Overall acceptability	7.90±0.70^{a}	8.00±0.47^{a}	7.80±0.88^{a}	7.50±0.97^{a}

Values are presented as mean±standard deviation. Values with the same superscript within the row are not significantly different ($p \leq 0.05$). LLRF: Lowland rice flour, UPRF: Upland rice flour, NLLRF: Nixtamalised Lowland rice flour, NUPRF: Nixtamalised upland rice flour.

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biscuits. *Journal of Food Science and Technology*, 52(6), 3681–3688. https://doi.org/10.1007/s13197-014-1427-2

Chen, Y., Ye, R., Yin, L. and Zhang, N. (2014). Novel blasting extrusion processing improved the physiochemical properties of soluble dietary fiber from soybean residue and *in vivo* evaluation. *Journal of Food Engineering*, 120, 1–8. https://doi.org/10.1016/j.jfoodeng.2013.07.011

Das, A., Ray, S., Raychaudhuri, U. and Chakraborty, R. (2013). Innovative formulation of rice cake for celiac people and its characterisation, *Natural Products: An Indian Journal*, 9(8), 331-338

Devika, J. and Sherry, A.T. (2016). Effects of different processing methods on the micronutrient and phytochemical contents of maize: From A to Z. *Comprehensive Reviews in Food Science and Food Safety*, 15(15), 912–926. https://doi.org/10.1111/1541-4337.12216

Eshun, G., Amankwah, E.A. and Barimah, J. (2019). Proximate composition, mineral nutrients and functional properties of Digang, NERICA-1 and NERICA-2 rice varieties from Ghana. *Global Advanced Research Journal of Agricultural Science*, 8(6), 207-213.

Gutiérrez-Cortez, E. Rojas-Molina, J.I., Zambrano-Zaragoza, M.L., Quintanar-Guerrero, D., González-Reza, R.M., Rojas-Molina, A. and Espinosa-Arbeláez, D.G. (2013). Effect of processing conditions on the production of nixtamalised corn flours by the traditional method. *CyTA - Journal of Food*, 11(1), 46-53. https://doi.org/10.1080/19476337.2013.778904

Hussein, A.M.S., Hegazy, N.A. and Ibrahim, T.A.A. (2012). Production and Evaluation of Gluten-Free Cakes. *Australian Journal of Basic and Applied Sciences*, 6(12), 482-491

IITA. (2001). Operation manual for the series 3 rapid visco analyser using thermocline for windows. USA: Newport Scientific.

Iwe, M.O., Onyeukwu, U. and Agiriga, A.N. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food and Agriculture*, 2(1), 1142409. https://doi.org/10.1080/23311932.2016.1142409

Jamal, S., Qazi, I.M. and Ahmed, I. (2016). Comparative Studies on Flour Proximate Compositions and Functional Properties of Selected Pakistani Rice Varieties. *Proceedings of the Pakistan Academy of Sciences: Life and Environmental Sciences*, 53(1), 47–56

Lawal, O.S., Adebowale, K.O. and Oderinde, R.A. (2004). Functional properties of amylopectin and amylose fractions isolated from bambarra groundnut (*Voandzeia Subterranean*) starch. *African Journal of Biotechnology,* 3, 399-404. https://doi.org/10.5897/AJB2004.000-2082

Man, S. Paucean, A. and Muste, S. (2014). Preparation and Quality Evaluation of Gluten-Free Biscuits. *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca Food Science and Technology,* 71(1), 38-44. https://doi.org/10.15835/buasvmcn-fst:10080

Mendez-Montealvo, G., Francisco, J., Garcia-Suarez, Paredes-Lopez, O. and Bello-Perez, A. (2007). Effect of Nixtamalisation on Morphological and Rheological Characteristics of Maize Starch. *Journal of Cereal Science*, 48, 420-425. https://doi.org/10.1016/j.jcs.2007.10.007

Milán-Carrillo, J., Gutiérrez-Dorado, R., Cuevas-Rodriguez, E.O., Garzon-Tiznado, J.A. and Reyes-Moreno, C. (2004). Nixtamalised Flour from Quality Protein Maize (*Zea mays* L). Optimization of Alkaline Processing. *Plant Foods for Human Nutrition*, 59, 35–44. https://doi.org/10.1007/s11130-004-4306-6

Mishra, N. and Chandra, R. (2012). Development of functional biscuit from soy flour and rice bran. *International Journal of Agricultural and Food Science*, 2(1), 14-20

Musita, N., Nurdjanah, S. and Oktiani, D. (2018). Nixtamalisation Application as A Quality Improvement of Corn Flour. *The 11th Regional Conference on Chemical Engineering: AIP Conference Proceeding*, 2085, 020037. https://doi.org/10.1063/1.5095015

Ocheme, O.B., Oloyede, O.O. and Mikailu, E.G. (2010). Effect of Lime Soaking and Cooking (Nixtamalisation) on the Proximate, Functional and Some Anti-nutritional Properties of Millet Flour. *Abscess University Journal of Technology*, 14(2), 131-138

Ogunbusola, E.M., Alabi, O.O., Sanni, T.A., Seidu, K.T., Oke, H.O. and Akinwale, O.R. (2020). Assessment of gluten-free cookies made from rice and soy protein isolate blends. *Journal of Microbiology Biotechnology and Food Sciences*, 9(5), 907-912. https://doi.org/10.15414/jmbfs.2020.9.5.907-912

Owusu-Kwarteng, J. and Akabanda, F. (2013). Applicability of Nixtamalisation in the Processing of Millet-based Maasa, a Fermented Food in Ghana. *Journal of Food Research*, 2(1), 59-65, https://doi.org/10.5539/jfr.v2n1p59

Rodríguez-Miranda, J., Ruiz-López, I.I., Herman-Lara, E., Martínez-Sánchez, C.E., Delgado-Licon, E. and Vivar-Vera, M.A. (2011). Development of extruded snacks using taro (*Colocasia esculenta*) and nixtamalised maize (*Zea mays*) flour blends. *LWT - Food Science and Technology*, 44(3), 673-680. https://doi.org/10.1016/j.lwt.2010.06.036

Salinas-Moreno, Y., Garcia-Salinas, C., Ramrez-Diaz, J.L. and Aleman-de la Torre, I. (2017). Phenolic compounds in maize grains and its nixtamalised products. In Phenolic compounds- Natural sources, importance and applications. https://doi.org/10.5772/66893

Sefa-Dedeh, S., Cornelius, B., Sakyi-Dawson, E. and Afoakwa, E.O. (2004). Effect of Nixtamalisation on the chemical and functional properties of maize. *Food Chemistry*, 86(3), 317-324. https://doi.org/10.1016/j.foodchem.2003.08.033

Sobhan, M.A. (2014). Loss of rice nutrients in milling, washing and cooking. Retrieved August 6, 2020 from http://ubinig.org/index.php/blog/showAerticle/114

Thomas, R., Bhat, R., Kuang, Y.T. and Abdullah, W.W. (2014). Functional and Pasting Properties of Locally Grown and Imported Exotic Rice Varieties of Malaysia. *Food Science and Technology Research*, 20(2), 469-477. https://doi.org/10.3136/fstr.20.469

Yimaki, G., Hawrysh, Z.J., Hardin, R.T. and Thomson, B.R. (1991). Application of response surface methodology to the development of rice flour yeast breads: sensory evaluation. *Journal of Food Science,* 53(3), 751-759. https://doi.org/10.1111/j.1365-2621.1991.tb05374.x

Zubair, M., Anwar, F., Ali, S. and Iqbal, T. (2012). Proximate Composition and Minerals Profile of Selected Rice (*Oryza sativa L.*) Varieties of Pakistan. *Asian Journal of Chemistry*, 24(1), 417-421.

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