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Functional Properties of Full-Fat and Defatted African Elemi *(Canarium Schweinfurthii)* Flour

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Abstract

Flours derived from African elemi (*Canarium schweinfurthii)* fruit pulp could be another source of fruit flours. However, assessing the functional properties of these flours is a prerequisite for determining their potential use in the food industry. Thus, this study aimed to analyze the functional properties of the full fat and defatted flours of African elemi fruit. The fresh pulp of African elemi fruit (*Canarium schweinfurthii)* were processed into flour. The flours processed from the fruit were evaluated for their water absorption capacity, bulk density, emulsion capacity and least gelation concentration using standard methods. One-way analysis of variance (ANOVA) was performed on the data gathered using the Minitab 21 statistical software. Results showed that the defatted flour had significantly lower bulk density (0.34g/ml) than the full-fat flour ($p < 0.05$). Defatting, improved the water absorption capacity for the full-fat flour from 387.13% to 588.6%. Emulsion capacity (4.17%) and least gelation concentration (5.42%) of the full-fat flours also improved to (45.84%) upon defatting. The results obtained in this study indicate that the fruit flours (full fat and defatted) have potential applications in food formulations.

Keywords: *Canarium Schweinfurthii*, African Elemi, Full-Fat, Defatted Flours, Functional Properties.

Introduction

Achieving food security and a pollution-free environment has increased the attention fruits from tree crops receive (Ehiem et al., 2019). Though, quite a number of them are yet to be fully utilized. One of such tree crop is the African elemi fruit. The African elemi fruit (*Canarium schweinfurthii*) is a species of large tree native to tropical Africa. It is commonly found in the Eastern and Northern parts of Nigeria and is locally known as 'ugbe mgba' in Igbo, 'atili' in Hausa, and 'Origbo' in Yoruba (Aniemeka & Ndubuisi, 2017).

The Eastern parts of Nigeria, mostly consume the fruit after it has been blanched in lukewarm water and eaten with salt sprinkled on it. Research studies show that the fruit pulp contains significant amounts of proteins, carbohydrate, and vitamins (Onimawo & Adukwu, 2003). The pulp of the fruit is also very rich in oil (Kiin-Kabari *et al*., 2020). Traditionally, whole seeds and pulp of African elemi and the resin of the tree have been used as medicinal remedies and wood fuel (Maduelosi & Angaye, 2015). Although, one major problem this rich fruit encounters is rapid spoilage. According to Ehiem et al (2019) about 40% of this fruit is wasted annually due to hardening and rotting. The problem of post-harvest losses of certain fruits whose mesocarp contains a significant quantity of liquid that facilitates its deterioration may be alleviated if they are processed into flours. Processing these fruits into flours would provide a stable storage form and a more diversified use, limiting post-harvest loss that may have been occurring due to limited usage (Folorunso et al., 2019).

Processing the fruit into flour would also encourage its application in several food formulations. It is important to note that the utilization of any plant sources in new food product development or as a food supplement is based on the knowledge of their functional properties and nutrient composition (Omowaye-Taiwo, 2015). Awuchi et al (2019) described the functional properties of food as the essential physicochemical properties that reflect the complex interactions between the chemical composition of the food components with the nature of the environment and the conditions in which these are measured and associated. Therefore, understanding the functional properties of a food ingredient helps in the determination of its application during food preparations.

Previous studies of the African elemi fruit were on its proximate, mineral, and vitamin composition (Maduelosi & Angaye, 2015; Mathew et al., 2020; Nyam et al., 2014), assessment of the nutritional values of its oil (Ejike, 2021) and water absorption capacity of the fruits (Ehiem et al., 2019). These studies on African elemi *(Canarium schweinfurthii)* were limited to the full-fat pulp and its oil extraction. There is limited scientific documentation on what happens to the by-product after it has been defatted. Therefore, the dearth of information on the functional properties of the full-fat and defatted flour of African elemi fruit prompted the need for this study. This study will also be adding to the existing body of knowledge on the functional properties of indigenous fruit flours. The study findings will be valuable to food industries, researchers, food chemists, flour industries, and nutritionists.

Objectives of this study

This study specifically aimed to;

1. Process full-fat and defatted flour from African elemi (*Canarium schweinfurthii*) fruit;
2. Analyze the functional properties (water absorption capacity, emulsion capacity and stability, least gelation concentration, and bulk density) of the flours processed.

Materials and method

Study design: This study adopted an experimental research design for the processing of the fruits and analysis of their functional properties.

Material procurement: Fresh African elemi fruits (*Canarium schweinfurthii*) were purchased from Obollo Afor market in Nsukka, Enugu state Nigeria.

Production of African elemi flour

African elemi (*Canarium schweinfurthii*) fruits were cleaned and the pulp was sliced thinly from the kernel using a kitchen knife. The sliced pulps were then oven-dried using a hot air circulatory oven (model QUB 305010G, Gallenkamp, UK). The dried pulp was milled using a grinding mill (Gx160-5.5hp). The dried pulp was divided into two portions. One part was defatted with a Soxhlet extractor apparatus (Soxhlet extractor Bomex 500ml Quick fit glass),a heating mantle (500ml, 250W, 110V, Electric Temperature Regulation Heating Mantle, Sleeve, US Plug), and analytical grade ethanol. For each batch of extraction, 50g of the ground pulp was loaded in a folded 24cm Whatman filter paper and the Soxhlet apparatus was assembled. Analytical grade ethanol (250ml) was poured into a 100ml round bottom flask of the apparatus and heated to 50 °C using a heating mantle. The extraction process lasted for 4 hours. After the oil extraction, the remaining pulp left was removed from the Soxhlet apparatus and dried in an air circulatory oven (model QUB 305010G, Gallenkamp, UK) at 40 °C for 18hours. This was done to remove the solvent from the pulp flour. The solvent free pulp flour was then re-milled using a grinding mill (Gx160-5.5hp) to achieve finer flour texture and packed in low density polyethylene bag and stored at room temperature until needed.

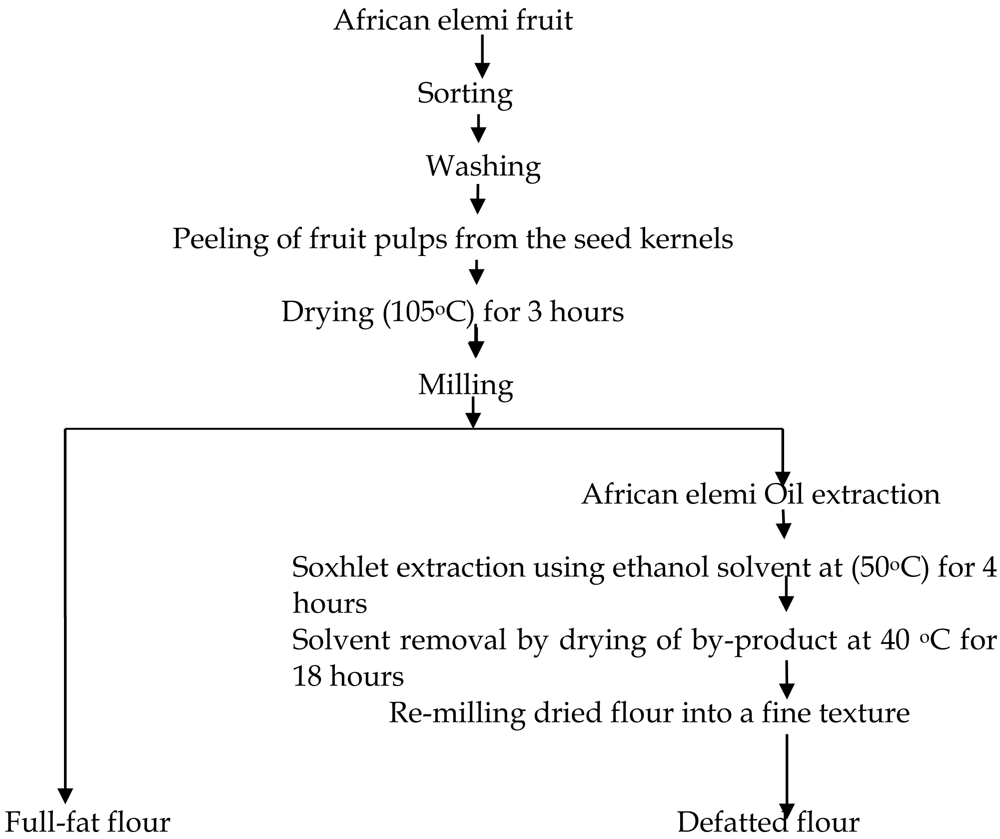

Fig. 1: Production of full fat and defatted African elemi flour

Functional properties determination

The determinations of the functional properties of the flours were carried out at the Home Science and Management analytical laboratory, University of Nigeria, Nsukka.

Bulk density

The bulk density of the flour was determined by the method described by Kaushal et al (2012). In this method, the flour samples were gently filled into 10 ml graduated cylinders, previously tared. The bottom of each cylinder was gently tapped on a laboratory bench several times until there was no further diminution of the sample level after filling to the 10 ml mark. Bulk density was calculated as the weight of sample per unit volume of sample (g/ml).

Water absorption capacity

The flour samples (1g) each were mixed with 10 ml of water in a centrifuge tube and allowed to stand at room temperature (30 ± 2°C) for 1 hour. It was then centrifuged at 2000 rpm for 30 minutes. The volume of water on the sediment-water was measured. Water absorption capacities were calculated as ml of water absorbed per gram of flour (Oke et al., 2020)

Least gelation concentration

The least gelation concentration was determined by the method of Eke-Ejiofor (2021) with slight modifications. Sample suspensions (10%, 20%w/v) were prepared in a test tube and heated in a boiling water bath for 1 h followed by rapid cooling under running cold tap water. The test tube was further cooled for 2hours at 4°C. The least gelation concentration was determined as the concentration when the sample from the inverted test tube did not fall down or slip.

Emulsion capacity and stability

The flour samples (2g) each and distilled water (100ml) was blended for 30 minutes in a Moulinex blender (model dep 3, France) at high speed (Ca. 100rpm). After complete dispersion, oil was added from a burette in streams of about 5ml. Blending continues until there was separation into two layers. Emulsification determinations were carried out at 30°C and expressed as grams of oil emulsified by 1g of flour. Briefly, the sample of 4g was dispensed in distilled water (100ml). 100ml of oil was added at the rate of 12.5 per second while blending. Each sample was blended in a Moulinex blender at high speed for additional 60 seconds and transferred into a 250ml graduated cylinder. Volumetric changes in foam, oil, and aqueous layers were recorded after three hours (Ukpong et al., 2021).

Statistical analysis

All analyses were performed in duplicates and results were expressed as mean values ± standard deviation (SD). One-way analysis of variance (ANOVA) was used in analyzing the means. The Tukey Pairwise comparison was used to determine the difference between means of the tested parameters using Minitab 21 Statistical software. Statistical significance was accepted at $p < 0.05$.

Results

Functional properties of full fat and defatted African elemi pulp flour.

Table 1 presents some of the functional properties of full fat and defatted flour African elemi flour. The water absorption capacity of the full-fat flour

(387.13%) significantly increased (588.6%) upon defatting (p< 0.05). The emulsion capacity (4.17%) and emulsion stability (5.42%) of the full-fat flour also increased (45.84%) significantly when defatted (p< 0.05).

Table 1: Functional properties of full fat and defatted African elemi pulp flour

	African Elemi flour	
Functional properties	**Full-fat**	**Defatted**
Water absorption capacity (%)	387.13±5.59[b]	588.6±59.5[a]
Emulsion capacity (%)	4.17±21.2[b]	45.85±.3.22[a]
Emulsion stability (%)	5.42±1.77 [b]	45.85±5.87 [a]

*Values are means ± standard deviation of duplicate determination.
*Means that do not share a letter are significantly different (p< 0.05)

Figure 2 shows the least gelation capacity of the flours. Defatting significantly increased the gelation concentration of African elemi flour. The full fat flours had the highest gelation concentration (20%) while the defatted flour had the least gelation concentration (10%) (p< 0.05) density (0.34g/ml). Defatting significantly decreased the bulk density of African elemi flour (p< 0.05).

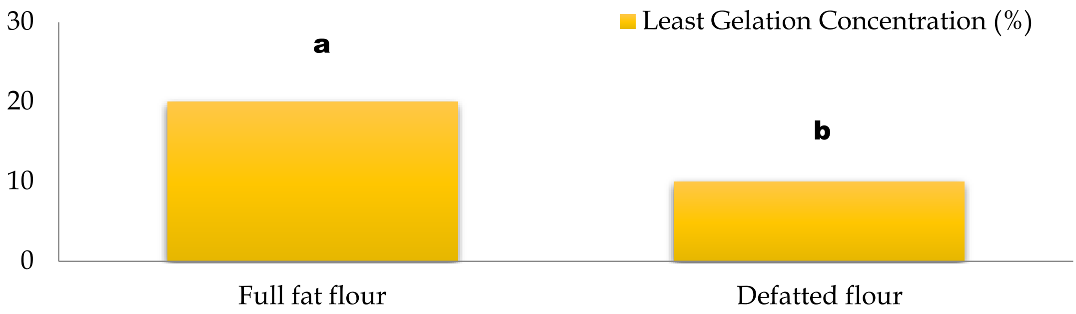

Fig 2: Least gelation concentration of full fat and defatted African elemi flour

*Values are means of duplicate determination.
*Means that do not share a letter are significantly different (p< 0.05)

Figure 3 shows the bulk density of the flours. The full fat flours had the highest bulk density (0.56g/ml) while the defatted flour had the lowest bulk.

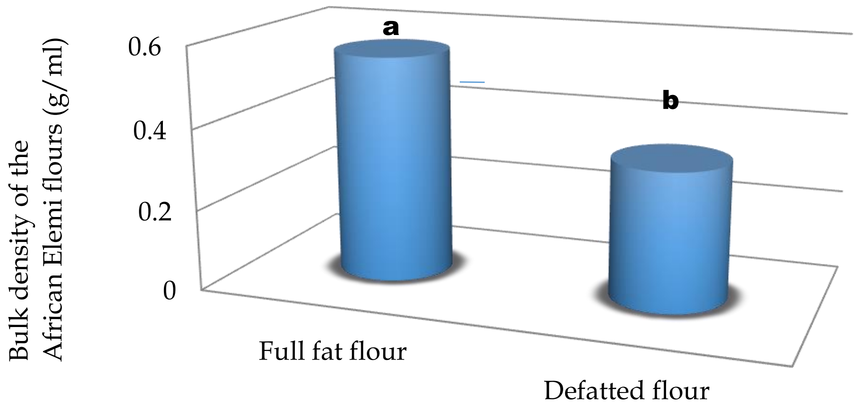

Fig. 3: Bulk Density of full fat and defatted African elemi flour

*Values are means of duplicate determination.
*Means that do not share a letter are significantly different ($p < 0.05$)

Discussion

Water absorption capacity (WAC)

The water absorption capacity of the full fatted flour was seen to increase upon defatting. This finding corroborates with other similar studies on the water absorption capacity of the full fat and defatted flours of moringa oleifera kernel, and cashew kernel (Ogunsina et al., 2010; Alobo et al., 2009). The values obtained for the defatted African elemi flour are similar to the water absorption values of defatted cassia fistula flour (Akinyede & Amoo, 2009). Generally, the values recorded in this study are comparatively higher than the values obtained from a study on melon seed flours (Omowaye-Taiwo et al., 2015). According to Hasmadi et al (2020) water absorption capacity measures the ability of flour or starch to hold water against gravity that can comprise of bound water, hydrodynamic water, capillary water, and physically entrapped water. The increase in the water absorption capacity of the African elemi flour may be due to defatting. The process of defatting exposes the water binding sites present on side chain groups of proteins that were previously blocked in a lipophilic environment (Akinyede & Amoo, 2009). This allows the proteins to interact well with the solvent thereby causing an increase in the water absorption capacity of the flour. According to Omowaye-Taiwo et al (2015) defatted flours with higher water absorption capacity may suggest that they can be better thickeners in some food formulations than full-fat flours.

Emulsion capacity and stability

Emulsion capacity and stability of flours reflect their ability to emulsify in oil and be able to resist the changes in its physicochemical properties over a period of time (Singh, 2005; Awuchi et al., 2019). The emulsion capacity and stability of the African elemi full-fat flour significantly increased when defatted. The increase in the emulsion capacity and stability of defatted African Elemi flour observed in this study compares favorably to a previous report on defatted maize germ flour (Siddiq et al., 2009). This observed increase may be attributed to the process of defatting which had a positive effect on the proteins in the flour (Akinyede & Amoo, 2009). During food processing, proteins are responsible for the increase in the emulsion capacity and emulsion stability of foods such as mayonnaise, frozen desserts, salad dressings, and comminuted meat products (Kaushal et al., 2012). Therefore, the increase in the emulsion capacity and stability of the defatted African elemi flour is an indication that they could serve as additives for the stability of fat emulsion in the production of soups, bakery and meat products.

Least gelation concentration (LGC)
Defatting significantly increased the gelation concentration of African elemi flour. The full-fat flours had the highest gelation concentration while the defatted flour had the least gelation concentration. According to Ohizua et al (2017) the least gelation concentration (LGC) of flour describes the ability of the flour to be able to form a gel in a measured volume of water. The higher the LGC, the higher the quantity of flour needed to form a gel, and the lower the LGC the better the gelling ability of the flour (Ohizua et al., 2017). The defatted African elemi flour formed a gel a significantly lower concentration compared to the full-fat flour. This indicates that the defatted African elemi flour may be used in the formulation of curd or as an additive in other gel-forming materials in food products. The LGC values obtained in this study are higher than the values reported by Eke-Ejiofor et al (2021) orange-flesh sweet potato starch, soya bean, and groundnut flour. This variation may be attributed to the difference between the chemical components of the flours. The LGC measures the least protein concentration that forms a gel when inverted in a tube (Chandra et al., 2015). It is important to note that existing literature has shown that groundnut and soya bean is among the richest sources of plant protein. This explains why their flours may have a lower gelation concentration than some flours from other sources like African Elemi. However, the LGC values recorded in this study compare favorably to that of rice and taro flours reported by Kaushal et al (2012).

Bulk density
The full-fat flours had the highest bulk density while the defatted flour had the lowest bulk density. Raigar and Mishra (2015) described bulk density as a functional property of flours that measures the mass of the many particles of flour material divided by the total volume they occupy. The bulk density is an important factor considered in the determination of packaging requirements, material handling, and application in wet processing in the food industry (Ocloo et al., 2010). According to David (2015), food materials with low bulk density may be lighter and easier to transport however, they occupy a greater space and require more packaging material per unit weight and thus incur high packaging costs. This implies that African elemi full-fat flours may require less packaging material as a result of their bulk density compared to defatted African elemi flour which has a lower bulk density. Apart from the packaging material advantage flours with high bulk density have, Ocloo et al. (2010) reported their suitability as

thickeners in food preparations. Comparatively, flours with low bulk density indicate they can be used as potential ingredients in the formulation of complementary foods where low bulk density is required (Suresh &Samsher, 2013). This indicates that African elemi full fat and defatted flours can be used for the food formulation suitable for adults and young children. The bulk density of roasted Bengal gram flour and tiger nut flour (Raigar & Mishra, 2015; Oladele & Aina, 2007) compares favorably with the bulk density of African elemi full-fat flour.

Conclusion

Results from this study revealed that the functional properties of African elemi pulp were improved after defatting. However, the full-fat and defatted flours both have potential in the food industry as a thickener, binding agent, and complementary food formulation.

Recommendation

Based on the research findings of this study, it was recommended that further research studies be carried out on different processing methods on the on the functional properties of African elemi flour. Also, studies on the various applications of the flours in several food formulations should be carried out.

References

Akinyede, A. I., & Amoo, I. A. (2009). Chemical and functional properties of full fat and defatted *Cassia fistula* seed flours. *Pakistan Journal of Nutrition*, *8*(6), 765-769.

Alobo, A. P., Agbo, B. N., & Ilesanmi, S. A. (2009). Physicochemical and functional properties of full fat and defatted cashew kernel flours. *International Journal of Food Science & Technology*, 44(3), 581-585.

Aniemeka, A. E. A., & Ndubuisi, E. T. I. (2017). Effect of processing on anti-nutrients contents of African elemi (*Canarium Schweinfurthii*) and African walnut (*Plukenetia Conophora*) consumed as traditional Snacks in Nigeria. *International Journal of Scientific & Technology Research*, 6(7), 383-391.

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

Chandra, S., Singh, S., & Kumari, D. (2015). Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Journal of Food Science and Technology*, *52*(6), 3681-3688.

David, O., Arthur, E., Kwadwo, S. O., Badu, E., & Sakyi, P. (2015). Proximate composition and some functional properties of soft wheat flour. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*(2), 753-758.

Ehiem, J. C., Ndirika, V. I. O., Onwuka, U. N., Gariepy, Y., & Raghavan, V. (2019). Water absorption characteristics of *Canarium Schweinfurthii* fruits. *Information Processing in Agriculture*, *6*(3), 386-395.

Ejike, I. (2021). Assessment of nutritional values and oil characteristics of the fruit of Canarium Schweinfurthii Linn. (Undergrdauate Dissertation). Michael Okpara University of Agriclture Online Repository.

Eke-Ejiofor, J., PC, O. E., Wordu, G. O., & Vito, M. B. (2021). Physicochemical, functional and pasting properties of orange-flesh sweet potato starch, soya bean and groundnut flour complementary food. *American Journal of Food Science and Technology*, *9*(3), 96-104.

Emmanuel-Ikpeme, C., Eneji, C., & Igile, G. (2012). Nutritional and organoleptic properties of wheat (*Triticum aestivum*) and beniseed (*Sesame indicum*) composite

flour baked foods. *Journal of Food Research*, *1*(3), 84.
Folorunso, A.A., Habeeb, A.S., & Ajayi, O.T. (2019). Sensory evaluation of snacks produced from wheat-breadfruit flour and nutritional composition of the flour blends. *Agriculture and Food Sciences Research.* 6(1):89-97.
Hasmadi, M., Noorfarahzilah, M., Noraidah, H., Zainol, M. K., & Jahurul, M. H. A. (2020). Functional properties of composite flour: a review. *Food Research*, *4*(6), 1820-1831.
Kaushal, P., Kumar, V., & Sharma, H. K. (2012). Comparative study of physicochemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*Oryza sativa*) flour, pigeon-pea (*Cajanus cajan*) flour and their blends. *LWT-Food Science and Technology*, *48*(1), 59-68.
Kiin-Kabari, D. B., Umunna, P. S., & Giami, S. Y. (2020). Physicochemical properties and fatty acid profile of african elemi fruit pulp oil compared with palm kernel oil. European *Journal of Agriculture and Food Sciences*, 2(6). https://www.ejfood.org/index.php/ejfood/article/view/149.
Maduelosi, N. J., & Angaye, S. S. (2015). Characterization of african elemi (*Canarium schweinfurthii*). *International Journal of Advanced Research in Chemical Science*, *2*(11), 34-36.
Mathew, J. T., Ndamitso, M. M., Etsuyankpa, M. B., Shaba, E. Y., Otori, A. A., & Tanko, E. (2020). Evaluation of chemical nutritional composition of African elemi pulp and seeds. *AU eJournal of Interdisciplinary Research*. *5*(1). http://www.assumptionjournal.au.edu/index.php/eJIR/article/view/4407.
Nyam, M.A., Makut, M.D., Itelima, J.U.,& Daniel, A.M. (2014). Nutritional potential of the fruits of black olive (*Canarium schweinfurthii linn*) from Plateau State, Nigeria. *Parkistan Journal of Nutrition*. 13(6). https://dx.doi.org/10.3923/pjn.2014.335.339.
Ocloo, F. C. K., Bansa, D., Boatin, R., Adom, T., & Agbemavor, W. S. (2010). Physico-chemical, functional and pasting characteristics of flour produced from jackfruits (*Artocarpus heterophyllus*) seeds. *Agriculture and Biology Journal of North America*, *1*(5), 903-908.
Ogunsina, B. S., Radha, C., & Govardhan Singh, R. S. (2010). Physicochemical and functional properties of full-fat and defatted *Moringa oleifera* kernel flour. *International Journal of Food Science & Technology*, *45*(11), 2433-2439.
Ohizua, E. R., Adeola, A. A., Idowu, M. A., Sobukola, O. P., Afolabi, T. A., Ishola, R. O., ... & Falomo, A. (2017). Nutrient composition, functional, and pasting properties of unripe cooking banana, pigeon pea, and sweet potato flour blends. *Food Science & Nutrition*, *5*(3), 750-762.
Oke, E. K., Idowu, M. A., Sobukola, O. P., & Bakare, H. A. (2020). Nutrient composition, functional, physical and pasting properties of yellow yam (*Dioscorea Cayenensis*) And Jack Bean (*Canavalia ensiformis*) Flour Blends. *Carpathian Journal of Food Science &Technology*, 12(5).https://chimiebiologie.ubm.ro/carpathian_journal/Papers_12(5)/CJFST12 (5)2020_4.pdf.
Oladele, A. K., & Aina, J. O. (2007). Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). *African Journal of Biotechnology*, 6(21). https://www.ajol.info/index.php/ajb/article/view/58100.
Omowaye-Taiwo, O. A., Fagbemi, T. N., Ogunbusola, E. M., & Badejo, A. A. (2015). Effect of germination and fermentation on the proximate composition and functional properties of full-fat and defatted *cucumeropsis mannii* seed flours. *Journal of Food Science and Technology*, 52(8), 5257-5263.

Onimawo, I. A., & Adukwu, B. I. (2003). Proximate composition and selected physicochemical properties of the fruits of *Canarium schweifurthii Linn*. *African Journal of Science and Technology*, 4(1). https://www.ajol.info/index.php/ajst/article/view/15247.

Raigar, R. K., & Mishra, H. N. (2015). Effect of moisture content and particle sizes on physical and thermal properties of roasted Bengalgram flour. *Journal of Food Processing and Preservation*, *39*(6), 1839-1844.

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

Ukpong, S. E., Njoku, H. O., & Ire, F. S. (2021). Quality evaluation of flour and biscuits produced from wheat and African Yam Bean Tempeh Flours. *GSC Biological and Pharmaceutical Sciences*, *17*(1), 124-132.

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