*Original Research Article*

**Nutritional Composition and Functional Properties of Cake from blends of Unripe plantain and Sweet potato flour enriched with Pallid emperor moth**

.

ABSTRACT

|  |
| --- |
| **Aims:** This study evaluated the quality attributes in the proximate, mineral and functional properties of cake produced from unripe plantain and sweet potato composite flour enriched with edible insect pallid emperor moth.  **Study design:** The design of the study is experimental.  **Place and Duration of Study:** The study took place at the processing laboratory of the Department of Food Technology, University of Ibadan, Ibadan between January 2024 and March 2024.  **Methodology:** Flour blends from unripe plantain and sweet potato were evaluated and prepared in different proportions. The cakes produced were subjected to proximate and mineral analysis while the flour blends were also subjected to functional analysis using AOAC methods.  **Results:** The proximate composition of the cake produced ranged from 8.44 to 10.41%, 8.90 to 13.10%, 10.02 to 14.19%, 0.90 to 5.04%, 1.34 to 2.02%, 58.88 to 73.03% for moisture, protein, fat, fibre, ash and carbohydrate content, respectively. The mineral content results showed that sample F had the highest values of calcium, potassium, iron and sodium content. The study also indicated that the levels of calcium, iron, potassium and sodium were abundant in the sample blends. The functional properties ranged from 0.68 to 0.73 g/L, 1.20 to 1.90 mL/g, 1.20 to 1.80 mL/g, 70 to 78% and 1.04 to 1.24 g/mL for bulk density, oil absorption capacity (OAC), water absorption capacity (WAC), dispersibility and wettability, respectively.  **Conclusion:** The results obtained indicated that the cake produced from sample D, E, and F had notable increase in protein, fat, ash and fibre contents and the flour blend had great potential as a functional ingredient in partial substitution of wheat flour in the diets, particularly in the developing countries and thus the edible insect flour improves the nutritional quality of the flour blends. |

*Keywords:* Functional properties, cake, composite flour, unripe plantain, sweet potato

1. INTRODUCTION

“Plantain (*Musa paradisiaca*) is one of the most important crops of tropical plants. It belongs to the family Musaceae and the genus Musa. *Musa paradisiaca*, also known as plantain (English), ‘*Ogede agbagba*’ (Yoruba), ‘*Ayaba*’ (Hausa) and ‘*Ogadejioke’* (Igbo), is a tropical plant that is native to India” (Oladiji et al., 2010). “Plantain contains high fibre content, and thus is capable of lowering cholesterol and helps to relieve constipation, hence preventing colon cancer. Besides this, its high potassium content is found to be useful in the prevention of rising blood pressure and muscle cramps” (Ng and Fong, 2000). “Moreover, as the consumption of cereal foods has become very popular globally, there is an increase in the replacement of wheat flour with other food sources. Plantain flour is a good substitute for gluten-intolerant persons, to whom wheat flour irritates the digestive system” (Aziz et al., 2014). “It can therefore be used in the preparation of bread, biscuits, and other bakery products. With the increased production and use of plantain flour, new economic strategies are now being considered, such as its use as a functional ingredient in various food domains. Sweet potato *Ipomoea batatas* (L.) Lam, belonging to the family Convolvulaceae, is an important root vegetable that is large, starchy, and sweet-tasting” (Mohanraj and Sivasankar 2014). “Sweet potato ranks seventh among all food crops worldwide, with an annual production of 115 million metric tons. Sweet potato is rich in carbohydrates, vitamins (A and C), calories, minerals and precursors of vitamin A” (Antonio et al., 2011).

“Edible insect consumption is common among some tribes in Africa, Australia and Asia as part of subsistence diets. Among the edible insects in Nigeria include: pallid emperor moth (*Cirinaforda Westwood*), weevil larva (*Rhynochophorusspp*), snout beetle (*Oryctesmonocerusoliver*), caterpillar (*Anaphevenata*), yam beetle (*Heteroligusmelesbillberger*), Grasshopper (*Zonocerus*) and so on” (Banjo et. al., 2006). The caterpillar of the pallid emperor moth (*Cirina forda*) is of the order, Lepidoptera and family- Saturniidae. It is an insect pest of *Butyrospermun paradoxum*, the shea-butter tree and is widely accepted as afood source and is also an important item of commerce in many Nigeria states such as Oyo, Kwara, Kogi Niger, Kaduna and Benue. The larvae of this insect are processed into the dried form and consumed as a delicacy served as snacks or as essential ingredients on vegetable soups along with carbohydrate food in Southern Nigeria and many homes in Africa. Abiona et al., (2023) reported an increase in fat, protein, crude fibre and ash content of biscuits produced from maize-soybeans composite flour enriched with edible insect “kanni”. Agu and Okoli (2014) also reported that the formulated biscuits made from wheat flour improved with benniseed and unripe plantain are rich in protein, carbohydrate and ash content. Gbadamosi et al., (2011) also produced cookies using wheat and African oil bean flour blends. This study, therefore, was aimed at using edible insect flour as enrichment in unripe plaintain and sweet potato composite flour for the production of cakes and to improve the nutritional quality of the flour blends. Thus, the objective of this study was to examine the proximate and mineral composition of the cake and functional properties of unripe plantain and sweet potato flour blends.

2. materiaLS and methods

**2.1 Materials and Methods**

The unripe plantain and sweet potato tubers used for this work were bought from Oja-Oba market in Ado-Ekiti. Ekiti State, Nigeria.

**2.2 Preparation of samples**

**2.2.1 Processing of unripe plantain into flour**

The unripe plantains were washed with the skin so as to get rid of dirt and stones. The skin was then peeled off and the plantains were sliced. The sliced unripe plantains were then spread on a tray and oven-dried at 600 C for 48 h in Gallenkamp OVL 570 010J drying-oven. The dried plantain was milled into flour using Ndayambaje et al., (2019) method.

**2.2.2 Processing of sweet potato into flour**

Sweet potato tubers were thoroughly selected concerning shape and sizes washed to remove adhering soil, dirt and extraneous materials, and thereafter peeled and sliced to 2 mm thickness. The sliced tubers were blanched in water at a temperature of 60 0C for 2 min to inactivate enzymes that may catalyze browning reaction, and then drained followed by drying at 600 C for 48 h in Gallenkamp OVL 570 010J drying-oven. The sliced tubers were milled, sieved with a mesh of 250 µm into fine flour and packaged for use.

**2.3 Sample formulation**

Unripe plantain, sweet potato and pallid emperor moth flours were blended in the ratio 100:0:0, 90:5:5, 80:10:10, 70:15:15, 60:20:20 and 50:25:25, respectively.

**2.4 Cake Production**

The cake was produced according to the method described by Ceserani and kinton (2008) with slight modification. The ingredients used were: flour (400g), butter (125g), sugar (200g), egg (300g), milk (200g), baking powder (0.5g), vanilla essence (5mL). The fat and sugar were creamed together until fluffy, mechanically in a bowl. The eggs were beaten for 5 minutes with the homogenizer, liquid milk and vanilla essence were added to the homogenized egg and then poured into the fluffy batter and thoroughly mixed. The sieved composite flours and baking powder were added into the mixture, thoroughly mixed to uniform texture and then poured into greased cake pans. The cake mixture was baked in a pre-heated oven at 190°C for 15min. After baking, the cakes were cooled to room temperature, packaged in an aluminium foil and kept on the shelf for further analysis.

**2.5Proximate analysis**

The proximate composition of the cakes produced were analyzed for moisture, ash, protein and crude fibre using the methods of (AOAC 2023) while the total carbohydrate content (%) was calculated by difference method (A.O.A.C.1990).

**2.6Mineral Analysis**

The mineral content of each sample was determined using the method of AOAC (2005). (0.5 g) of each sample was weighed into 250 ml Erlenmeyer flask; 10 ml HNO3 solution (Nitric perchloric acid) was added and was brought to heating. The content was allowed to undergo digestion in a fume cupboard for 30 min until the colour changes to colourless. The digest was allowed to cool and was then measured on buck scientific atomic absorption spectrophotometric model 210/211 VCP for analysis.

**2.7Functional properties of composite flours**

Bulk density (BD) of flour blends was determined using the method described by Mbofung et al., 2006. Water and oil absorption capacity (WAC and OAC) were determined using the method described by Omowaiye-Taiwo et al., (2014). Dispersibility (D) was determined according to the method described by Mora-Escobedo et al., (2009). Wettability was determined according to the technique of Onwuka (2005).

**2.8Statistical Analysis**

The data were subjected to analysis of variance (ANOVA) using Statistical Package for Social Science (SPSS). One-way ANOVA (Analysis of variance at the level of significance p≤0.05) was used, and means were separated using the new Duncan multiple range test.

3. results and discussion

**3.1 Proximate composition of cake samples from unripe plantain and sweet potato enriched with edible insect pallid emperor moth flour**

The result of proximate composition is shown in Table 1 and the cakes produced from unripe plantain-sweet potato composite flour enriched with edible insect pallid emperor moth were significantly different. The results showed that the cake produced indicates that samples E (60% unripe plantain 20% sweet potato 20% pallid emperor moth) and F (50% unripe plantain 25% sweet potato 25% pallid emperor moth) were higher in moisture, ash, fibre, fat and protein content as the ratio of edible insect increased. This phenomenon agrees with the findings of Akubor and Badifu (2004); Gbadamosi et al., (2011) who reported an increase in nutrient composition of supplemented cookies. This is in line with the findings of Jiskani (2001) that flour blends have nutritional attributes which have higher values in ash and protein content and have potential desire by the populace. These also indicate that flour blends incorporated with sweet potato contain enhanced quantities of nutrients and may thus have nutritional advantage to consumers of the flour sample. “However, edible insects have been shown to have higher protein content, on a mass basis, than other animal and plant foods such as beef, chicken, fish, soybeans, and maize” (Teffo et al., 2007). Protein is the basis of all organism activity and constitutes many important materials such as enzymes, hormones, and hemoglobin.

**Table 1: Proximate composition of cake samples from unripe plantain and sweet potato enriched with edible insect pallid emperor moth flour**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Samples** | **Moisture**  **Content (%)** | **Ash (%)** | **Fat (%)** | **Fibre (%)** | **Protein (%)** | **Carbohydrate**  **(%)** |
| A | 8.48±0.08a | 1.67±0.04b | 10.02±0.01a | 0.90±0.01b | 8.90±0.05b | 58.88±0.17a |
| B | 9.89±0.04b | 1.70±0.05a | 14.16±0.02b | 1.42±0.04a | 10.10±0.04a | 59.45±0.11b |
| C | 8.79±0.09c | 1.71±0.04c | 12.24±0.01c | 1.24±0.03b | 10.50±0.03c | 67.15±0.05c |
| D | 10.41±0.04d | 1.79±0.01d | 12.97±0.05d | 5.04±0.01a | 11.40±0.05e | 71.40±0.12e |
| E | 9.01±0.03c | 1.79±0.05d | 13.27±0.05e | 2.89±0.02c | 12.50±0.02d | 63.00±0.04c |
| F | 9.02±0.02cd | 2.07±0.04e | 14.19±0.06e | 2.76±0.04c | 13.10±0.01d | 73.03±0.01e |

Key:

Sample A= 100% unripe plantain (Control);

Sample B= 90% unripe plantain 5% sweet potato 5% pallid emperor moth

Sample C= 80% unripe plantain 10% sweet potato 10% pallid emperor moth

Sample D= 70% unripe plantain 15% sweet potato 15% pallid emperor moth

Sample E= 60% unripe plantain 20% sweet potato 20% pallid emperor moth

Sample F= 50% unripe plantain 25% sweet potato 25% pallid emperor moth

**3.2 Mineral composition of cake samples from unripe plantain and sweet potato enriched with edible insect pallid emperor moth flour**

The mineral compositions of the cake produced are shown in Table 2 below and the samples were significantly different. The cake samples examined had calcium (78.09-132.20mg/100g), iron (0.78-1.42mg/100g), magnesium (6.38-8.22mg/100g) and potassium (152.50-247.30mg/100g). The cake samples contain appreciable amounts of calcium (Ca), magnesium (Mg), Iron (Fe) and potassium (K) respectively. Other mineral elements present in the cakes include sodium (Na), zinc (Zn), and manganese (Mn). The observation from this study showed that the cake samples produced were a source rich in calcium. Calcium plays significant roles in blood clotting and muscle contraction in humans. Ifie and Emeruwa (2011) stated that the larva (*Oryctes monoceros*) contain appreciable amount of iron, sodium, magnessium, potassium and zinc and Elemo et al., (2011) also reported that African palm weevil (*Rhyncophorus phoenicis* F.) is rich in sodium, iron, copper, manganese, potassium and phosphorus. Magnesium is needed for more than 300 biochemical reactions in the body. It helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system and regulates blood sugar levels (Saris et al., 2000). “Magnesium helps in the maintenance of electrical potential in nerves (Okaka et al., 2006).

Sample A (control) has the least value (36.30 mg/100g) of sodium compared to all other samples. Sodium helps in the maintenance of proper acid-balance and in the control of osmotic pressure that exist between blood and cells” (Paiko et al., 2012). Therefore, edible insects can supply essential nutritive elements for human body functions and could be consumed along with other foods and animals rich in other essential minerals to further complement the diet of these insects.

**Table 2: Mineral composition of cake samples from unripe plantain and sweet potato enriched with edible insect pallid emperor moth flour**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Samples** | **Sodium**  **(mg/100g)** | **Calcium**  **(mg/100g)** | **Potassium**  **(mg/100g)** | **Magnesium**  **(mg/100g)** | **Iron**  **(mg/100g)** | **Zinc**  **(mg/100g)** |
| A | 36.30±1.14a | 78.09±0.04a | 152.50±0.03b | 6.38±0.05b | 0.79±0.03a | 0.77±0.16a |
| B | 38.30±0.14b | 83.97±0.01b | 156.97±0.06b | 6.42±0.04a | 0.97±0.00b | 0.86±0.61b |
| C | 45.80±0.95bc | 86.40±0.11c | 167.87±0.14c | 6.94±0.08c | 0.94±0.61c | 0.88±0.58c |
| D | 51.20±0.08cd | 93.80±0.14d | 192.76±0.07d | 7.17±0.01a | 1.12±0.01c | 0.93±0.01d |
| E | 58.90±0.57d | 120.80±0.02e | 210.27±0.08de | 8.08±0.00b | 1.40±0.00d | 0.96±0.07e |
| F | 71.30±0.04e | 132.20±0.02de | 247.30±0.01a | 8.22±0.61e | 1.42±0.01e | 0.72±0.02cd |

Key:

Sample A= 100% unripe plantain (Control);

Sample B= 90% unripe plantain 5% sweet potato 5% pallid emperor moth

Sample C= 80% unripe plantain 10% sweet potato 10% pallid emperor moth

Sample D= 70% unripe plantain 15% sweet potato 15% pallid emperor moth

Sample E= 60% unripe plantain 20% sweet potato 20% pallid emperor moth

Sample F= 50% unripe plantain 25% sweet potato 25% pallid emperor moth

**3.3 Functional properties of flour blends from unripe plantain and sweet potato enriched with edible insect pallid emperor moth**

The results of the functional properties of flour blends are shown in Table 3. The water absorption capacity ranged from 1.2–1.88g/100g. The water absorption capacity (WAC) of the flour blends increased with an increase in sweet potato flour and pallid emperor moth in sample D, E and F. This confirmed the report of Anthony et al., (2014), that carbohydrate can influence WAC to a great extent. The values obtained for water absorption capacity could be useful in bakery products such as bread, cakes and cookies that require hydration to improve dough handling characteristics (Ohizua et al., 2017). The result also implies that the composite flour blends could be useful in new food products formulation where hydration for easy handling is required.

The bulk density of the samples ranged from 0.32 to 0.45g/ml. Bulk density increase as level of sweet potato flour increased. The high bulk density of flour blends suggests their suitability for use in food preparations in terms of machinability and packaging. The values obtained for dispersibility ranged from 71 to 78%. High dispersibility as observed in this finding will aid the reconstitution of batter to a fine consistency during mixing (Adebowale et al., 2008).

Also, oil absorption capacity value increases with increased levels of sweet potato flour in the flour blend. The possible reason for increase in the OAC of composite flours could be variations in the presence of non-polar amino acid side chains of protein which might bind the hydrocarbon side chain of the oil among the flours as reported by Jitngarmkusol et al., (2008). This is an indication that the blends could be useful in structural interaction in food especially in flavor retention, improvement of palatability and extension of shelf life particularly in bakery or meat products where oil absorption property is of prime importance.

**Table 3: Functional properties of flour blends from unripe plantain and sweet potato enriched with edible insect pallid emperor moth**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **Bulk density (g/ml)** | | **Packed density (g/ml)** | | **WAC (g/100g)** | | **OAC**  **(g/ml)** | | **Dispersibility %** | | | **Wettability (g/ml)** |
| **A** | | 0.32±0.63d | | 0.68±0.08d | | 1.20±0.06a | | 1.57±0.14e | | 71±0.61a | 1.04±0.08b | |
| **B** | | 0.38±0.55c | | 0.72±0.06c | | 1.50±0.01b | | 1.60±0.06d | | 71±0.59b | 1.19±0.13a | |
| **C** | | 0.40±0.01b | | 0.73±0.01b | | 1.60±0.06c | | 1.63±0.01c | | 73±0.11c | 1.21±0.06c | |
| **D** | | 0.43±0.02a | | 0.72±0.14d | | 1.60±0.05d | | 1.60±0.61b | | 73±0.14d | 1.24±0.02b | |
| **E** | | 0.40±0.03ab | | 0.74±0.01b | | 1.80±0.04e | | 1.70±0.01a | | 74±0.08e | 1.24±0.14c | |
| **F** | | 0.45±0.13e | | 0.77±0.07a | | 1.88±0.14de | | 1.80±0.00ab | | 78±0.95d | 1.26±0.04d | |

Key:

Sample A= 100% unripe plantain (Control);

Sample B= 90% unripe plantain 5% sweet potato 5% pallid emperor moth

Sample C= 80% unripe plantain 10% sweet potato 10% pallid emperor moth

Sample D= 70% unripe plantain 15% sweet potato 15% pallid emperor moth

Sample E= 60% unripe plantain 20% sweet potato 20% pallid emperor moth

Sample F= 50% unripe plantain 25% sweet potato 25% pallid emperor moth

4. Conclusion

This study has revealed the potential of unripe plantain and sweet potato flour blends enriched with pallid emperor moth. Proximate analysis showed that the cakes had high nutritional content in terms protein, fibre, fat, and carbohydrate. The levels of Mg, Fe, Na, and Zn were abundant in the cake, which shows that the cake samples were rich in mineral composition. Furthermore, the flour blends have high functional characteristics and could be useful in new food product formulation. Therefore, the flour blend has great potential as a functional ingredient in the diets, particularly in developing countries.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

References

Abiona S. O., Ogunlade A. O. & Idowu-Mogaji G. O. (2023). Proximate, mineral and sensory

analysis of maize-soybeans composite flour biscuit enriched with edible insect “kanni”. *Food Science Nutrition Research* 6(2), 1-4.

Adebowale, A. A., Sanni, L. O. & Ladapo, F. O. (2008): Chemical, functional and sensory

properties of instant yam-breadfruit. *Nigerian Food Journal*, 26(1), 2-12.

Akubor, P. I. & Badifu, G. I. O. (2004). Chemical Composition, functional properties and

bakingpotential of african breadfruit kernel and wheat flour blends. *International Journal of Food Science and Technology,* 39, 223-229.

Antonio, G. C., Takeiti, C. Y., Augustus de Oliveira, R., & Park, K. J. (2011). Sweet potato:

Production, Morphological and Physicochemical Characteristics and Technological Process. Fruits, Vegetables, Cereal Science and Biotechnology. *Global Science Books*, 5(2), 1-18.

Anthony, N. M., Sawi, M. K., Aiyelaagbe, O. O., Taiwo, A., Winnebah, T., &Fomba, S. N.

(2014).Proximate characteristics and complementary assessment of five organic sweet potatoes cultivars and cowpea varieties. *The International Journal of Engineering and Science*, 3, 38– 42.

AOAC (2005). Association of Official Analytical Chemists’ Official Methods of Analysis –18th

ed.Washington D.C.

AOAC (2012). Official methods of analysis. Association of Official Analytical Chemists,

WashingtonD.C.

Aqu, H. O. & Okoli, N. A. (2014). Physico chemical, sensory, and microbiological

assessments of wheat-based biscuit improved with beniseed and unripe plantain*. Food Science and Nutrition*, Vol. 2(5), 464 - 469.

Aziz, I., Lewis, N. R., Hadjivassiliou, M., Winfield, S. N., Rugg, N., Kelsall, A. & Sanders, D.

S. (2014). A UK study assessing the population prevalence of self-reported gluten sensitivity and referral characteristics to secondary care. *European Journal Hepatology* 26, 33-39.

Banjo A. D, Lawal, O. A, & Adeyemi A.I. (2006). The microbial fauna associated with larvae

of Oryctesmonocerus. *Jounal Applied Science Research* 2(11), 837-843.

Ceserani, V. and Kinton, R. (2008). Practical cookery, 10th ed, London: Holder and

Stoughter.

Elemo, B. O, Elemo, G. N, Makinde, M. A, & Erukainure, O. L (2011). Chemical evaluation of

African palm weevil, Rhychophorusphoenicis, larvae as a food source. J. Insect Sci. 11:146 available online: insectscience.org/11.146.

Gbadamosi, S. O., Eniujugha, V. N. & Odepidan, F. O. (2011). Chemical composition and

functionalcharacteristics of Wheat/African oil bean flour blends and sensory attributes of their cookies. Proceeding at Faculty of Technology Conference, Obafemi Awolowo University, Ile-Ife, September 25th - 29th.

Ifie I. & Emeruwa, C. H. (2011). Nutritional and anti-nutritional characteristics of the larva of

Oryctesmonoceros. *Agric. Biol. J. N. Am*., 2(1), 42-46

Jiskani, M M. (2001). Energy potential of mushrooms. The Economics and Business Review,

Oct. 15-21, P. IV.

Jitngarmkusol, S., Hongsuwankul, J. & Tananuwong, K. (2008). Chemical composition,

functional properties and microstructure of defatted macademice flours. *Food Chemistry*, 110, 23-30.

Mbofung, C.M.F., Abubakar, Y.N., Njitang, A. & Abduo-Boubak, B.F. (2006). Physico-

chemical and functional properties of six varieties of Taro flour. *Journal of Food Technology*, 4, 135-142.

Mohanraj, R. & Sivasankar, S. (2014). Sweet Potato (Ipomoea batatas [L.] Lam)- A Valuable

Medicinal Food: Journal Of Medicinal Food. 17 (7) 2014, 733–741 #Mary Ann Liebert, Inc., and Korean Society of Food Science and Nutrition DOI: 10.1089/jmf.2013.2818.

Mora-Escobedo, R., Robles-Ramirez, M.C, Ramon-Gallegos, E. & Reza-Aleman, R. (2009).

Effect ofProtein Hydrolysates from Germinated Soybeanon Cancerous Cells of the Human Cervix: An In Vitro Study. *Plant Foods for Human Nutrition*. 64, 271-278.

Ndayambaje, J. P., Dusengemungu, L., & Bahati, P. (2019). Nutritional composition of

plantain flour (Musa paradisiaca): The effect of various drying methods in Rwanda. American Journal of Food Science and Technology, 7(3), 99–103. https://doi.org/10.12691/ ajfst-7-3-5.

Ng James, H. K. & Fong, J. K. (2000). Metabolically engineered lactic acid bacteria and their

use. Patent number U.S. 7,465,575 B2.

Ohizua, E. R., Adeola, A. A., Idowa, M. A., Sobukola, O. P., Afolabi,, T. A., Ishola, R. &

Oyekale, T. O. (2017). Nutrient composition, functional and pasting properties of unripe cooking banana and sweet potato flour blends. *Food Sciences and Nutrition*, 5(3), 750-762.

Okaka, J.C., Akobundu, E.N.T. & Okaka, A.N.C. (2006). Food and Human Nutrition an

Integrated Approach.OCJ Academic Publishers, Enugu, 135-368.

Oladiji, A. T., Fetuga, B. L. Abodunrin, T.P. & Yakubu, M.T. (2010). Studies on the

physicochemical properties and fatty acid composition of the oil from ripe plantain peel (*Musa paradisiaca*). African Scientist, 11(1), 73-78.

Omowaiye-Taiwo, O.A., Fagbemi, T.N., Ogunbusola, E.M., &Badejo, A.A. 2014. Effect of

germination and fermentation on the proximate composition and functional properties of full-fat and defatted *Cucumeropsismannii* seed flours. *Journal of Food Science and Technology*, 52(8), 5257-5263. doi: [10.1007/s13197-014-1569-2]

Onwuka, G. (2005). Food Analysis and Instrumentation: Theory and Practice, Tuber and

Legume Flour, *Journal de Food Science and Technology*. 50, 94-100.

Paiko, Y.B., Dauda, B. E. N, Salau, R. B. & Jacob, J.O. (2012). Preliminary data on the

nutritional potentials of the larvae of edible dung Beetle consumed in Paikoro Local Government Area of Niger State, Nigeria. Continental Journal of Food Science and Technology 6(2), 38-42.

Saris N. E., Mervaala E., Karppanen H., Khawaja J. A. & Lewenstam A. (2000). Magnesium:

an update on physiological, clinical, and analytical aspects. *Clinical Chimica Acta*. 294, 1-26.

Teffo, L. S., Toms, R. B. & Eloff, J. N. (2007). Preliminary data on the nutritional composition

of the edible stink-bug, *Encosternum delegorguei* Spinola, consumed in Limpopo province, South Africa. *South Africa Journal Science* 103, 434 - 436.

Okafor, J. N., Obiegbuna, J. E., & Agu, H. O. (2021). Functional and pasting properties of composite flour from wheat, sweet potato and soybean. International Journal of Environmental and Agriculture Research, 12(12), 1-9.