*Original Research Article*

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

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ABSTRACT

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| **Aims:** This study evaluated the quality attributes in the proximate, mineral, and functional properties of flour blends of 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 flour, 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. 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*), belonging to the family *convolvulaceae*, is an important root vegetable that is large, starchy, and sweet-tasting. 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 (*Cirina forda* *Westwood*), weevil larva (*Rhynochophorus spp*), snout beetle (*Oryctes monocerus oliver*), caterpillar (*Anaphe venata*), yam beetle (*Heteroligus meles billberger*), 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 on biscuits made from maize-soybeans composite flour enriched with edible insect “kanni”. Aqu and Okoli (2014) also reported on biscuits made from wheat flour improved with benniseed and unripe plantain. 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 toto improve the nutritional quality of the flour blends. Thus, the objective of this study is to examine the proximate, mineral, 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 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 plantains were then spread on a tray and oven-dried at 102 °C for 72 h. The dried plantain was then milled into flour.

**2.2.2 Processing of sweet potato into flour**

Sweet potato tubers were thoroughly sorted to remove bad ones, 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. Following drying, the sliced tubers were milled, sieved with a mesh of 250 µm into fine flour and packaged for use.

**2.3 Sample formulation**

Plantain and sweet potato flours were blended in the ratio 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50, respectively.

**2.4 Cake Production**

The cake was produced the method described by Ceserani and kinton (2008) with slightly modification.

**2.5 Proximate analysis**

The proximate composition of the cakes produced were analyzed for moisture, ash, protein and crude fibre using the methods of AOAC (2012) while the total carbohydrate content (%) was calculated by difference method.

**2.6 Mineral Analysis**

The mineral content of each sample was determined using the method of AOAC (2005). Five grams (5 g) of each sample was weighed into 250 ml Erlenmeyer flask; 25 ml HCL solution was added and was brought to heating. It was cooled and transferred to a 50 ml volumetric flask and made to volume with deionized water and mixed thoroughly. The solution was filtered through No. 1 Whatman filter paper, while the filtrate was used for mineral determination using corresponding standards and blanks. The filtrate of each sample was used for Atomic Absorption Spectrophotometric analysis. The minerals (sodium, potassium, iron, zinc and magnesium) content in the flour blends was determined using BUCK Scientific

**2.7 Functional properties of composite flours**

**2.7.1 Determination of bulk density**

The bulk density (BD) of flour blends was determined using the method described by Mbofung et al., 2006.

**2.7.2 Determination of water and oil absorption capacity**

Water and oil absorption capacity (WAC and OAC) were determined using the method of Sathe et al. (1982) described by Omowaiye-Taiwo et al., (2014).

**2.7.3 Determination of dispersibility**

The dispersibility (D) of the flours was determined according to the method described by Mora-Escobedo et al., (2009).

**2.7.4 Determination of wettability**

The wettability of the flours was determined according to the technique of Onwuka (2005).

**2.8 Statistical 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 nutritional composition of supplemented cookies. This is in line with the findings of Jiskani (2001) that flour blends have nutritional attributes 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 | 1.67 | 10.02 | 0.90 | 8.90 | 58.88 |
| B | 9.89 | 1.70 | 14.16 | 1.42 | 10.10 | 59.45 |
| C | 8.79 | 1.71 | 12.24 | 1.24 | 10.50 | 67.15 |
| D | 10.41 | 1.79 | 12.97 | 5.04 | 11.40 | 71.40 |
| E | 9.01 | 1.79 | 13.27 | 2.89 | 12.50 | 63.00 |
| F | 9.02 | 2.07 | 14.19 | 2.76 | 13.10 | 73.03 |

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 cakes produced are shown in Table 2 below, and the samples were significantly different. The cake samples examined had calcium (78.09-132.20 mg/100g), iron (0.78-1.42 mg/100g), magnesium (6.38-8.22 mg/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). This observation showed that the cake samples were a rich source of calcium. Calcium plays significant roles in blood clotting and muscle contraction in humans. Ifie and Emeruwa (2011)) and Elemo et al. (2011) reported potassium (K), sodium (Na), zinc (Zn), manganese (Mn), and copper (Cu) in *O. monoceros, M. nigeriensis, and R. phoenicis*. 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 compared to all other samples. Sodium is an essential electrolyte that helps to maintain the body’s homeostatic and acid-base balances and assists in the transmission of nerve impulses (Enwere, 2008). 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 cakes 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 | 78.09 | 152.50 | 6.38 | 0.79 | 0.77 |
| B | 38.30 | 83.97 | 156.97 | 6.42 | 0.97 | 0.86 |
| C | 45.80 | 86.40 | 167.87 | 6.94 | 0.94 | 0.88 |
| D | 51.20 | 93.80 | 192.76 | 7.17 | 1.12 | 0.93 |
| E | 58.90 | 120.80 | 210.27 | 8.08 | 1.40 | 0.96 |
| F | 71.30 | 132.20 | 247.30 | 8.22 | 1.42 | 0.72 |

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 values increased with increased level 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 | | 0.68 | | 1.20 | | 1.57 | | 71 | 1.04 | |
| **B** | | 0.38 | | 0.72 | | 1.50 | | 1.60 | | 71 | 1.19 | |
| **C** | | 0.40 | | 0.73 | | 1.60 | | 1.63 | | 73 | 1.21 | |
| **D** | | 0.43 | | 0.72 | | 1.60 | | 1.60 | | 73 | 1.24 | |
| **E** | | 0.40 | | 0.74 | | 1.80 | | 1.70 | | 74 | 1.24 | |
| **F** | | 0.45 | | 0.77 | | 1.88 | | 1.80 | | 78 | 1.26 | |

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 cakes, 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 partial substitution of wheat flour in the diets, particularly in developing countries.

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