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Evaluation of physico-chemical properties of unripe plantain peels as affected by different drying temperature regimes

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Abstract

This study is aimed at evaluating the physico-chemical properties of unripe plantain peel, as affected by different drying temperature regimes. The plantain peels were subjected to different drying temperatures of 60, 75, 90 and 105 oC for 12 hours, using a laboratory Oven to produce flour samples. Standard analytical methods were used in evaluating the flour sample parameters. Results of the physico-chemical analysis of the flour samples showed that samples dried at 60, 75, 90 and 105 oC had moisture contents of 2.67, 2.00, 1.38 and 0.66%, respectively; ash contents of 15.83, 15.35, 15.08 and 14.97%, respectively; fibre contents of 12.84, 13.34, 13.68 and 14.10%, respectively; protein contents of 9.80, 8.40, 7.35 and 7.00%, respectively; lipid contents of 77.43, 7.55, 7.80 and 7.94%, respectively; carbohydrate contents of 54.09, 55.02, 56.32 and 56.43%, respectively; caloric values of 321.47, 322.63, 324.32 and 325.74 kcal, respectively. There was a significant difference ($p < 0.05$) in moisture, ash, fibre, protein, lipid and carbohydrate contents, as well as the caloric value of the unripe plantain peel flour samples. The different drying temperature regimes had significant effect on the physico-chemical properties of the unripe plantain peel. Moisture, ash, fibre and protein contents decreased with corresponding increase in drying temperature, while lipid content, carbohydrate content and caloric value increased with increase in drying temperature.

Keywords: Evaluation, Physico-chemical properties, Plantain peel, Temperature regimes, Unripe plantain, Flour.

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Contents

Contribution of this paper to the literature
This research paper contributes to the literature in the area of food processing technology, food value addition, and converting agricultural waste materials to useful food product, which ultimately contributes in food security.

1. Introduction

Plantain (*Musa paradisiaca*) with a world production index of 20.5 million tons per year is a very important food of the tropics and subtropics, where both ripe and unripe foods are consumed [1].

Plantain is a versatile and very nutritious food staple that is widely consumed, either ripe or unripe. They are a great source of carbohydrates, having a nutritional value that is similar to that of yam or potato. In Nigeria, they are eaten as snacks in the form of chips, as plantain *amala*, or *dodo ikire* [2]. Unripe and mature plantain could be ground into flour. Typically, in Nigeria, flour is turned into *amala*, a low-glycemic gruel that is frequently advised for diabetics. Plantain is rich in healthy components such as phenols, carotenoids and dietary fiber [3-5].

The peel of foods contains a higher proportion of bioactive compounds compared to the pulp [6]. Moreover, the antioxidant activity of the peel is greater than that of the food itself [7].

Research on some nutritional properties of thirteen plantain cultivars after proximate analysis revealed that moisture content in cultivars (peels) ranged from 78.74% to 87.33%; Ash content varied between 0.87% and 2.38%; Protein content ranged from 1.67% to 4.2%; Lipid content varied from 0.84% to 2.24%; Fibre values oscillated between 2.38% and 3.72%; Dry matter content fluctuated between 12.67% and 21.26%; and Carbohydrate content ranged from 88.84% to 92.91% [8]. The chemical makeup of banana and plantain peels, which is influenced by the ripeness of the fruit, determines their ultimate purpose. On a dry basis, unripe fruit peel contains 33–43% total dietary fiber, 6–10% protein, 6–12% ash, 2–6% lipids, and 11–39% starch [9].

Additionally, dopamine, a potent antioxidant, is abundant in plantain peels. The antioxidant in plantains is thought to be mostly responsible for catecholamine [6]. Plantain peel has been used for generations as a traditional treatment in various countries, according to Imam and Akter [10]. Plantain peel extract has the potential to be utilized as a functional component in the food sector, according to Pereira and Maraschin [11]. To enhance the functionality of bioactive substances, like phenolic compounds found in plantain peel, they must be extracted from the peel and then encapsulated to prevent deterioration and increase storage effectiveness. For the production of functional plantain peel powder, optimal extraction and effective encapsulation are consequently crucial.

Plantain peels are important raw materials for several products yet termed useless and unproductive which makes the cost of the raw material reliant on the food excluding the peels in the market because consumers do not recognize the value of its peels, thus they are thrown away. An environmental issue is the careless way in which this peel trash is being disposed of. Peels from a wide range of fruits and meals are now being promoted as a natural source of nutritional fiber and antioxidants. For these reasons, plantain peel has gained popularity as new studies indicate that it is a highly beneficial source of antioxidants and dietary fiber. The aim of this study is to evaluate the physico-chemical properties of unripe plantain peels, as affected by different drying temperature regimes.

2. Materials and Methods

2.1. Sample Collection and Preparation

Fresh unripe plantain was bought from the local market in Ikot Akpaden, MkpatEnin L.G.A., Akwa Ibom State, Nigeria. The unripe plantain was cleaned, peeled and the peels made into chips, of uniform sizes. The fresh chips oven-dried for 12 hours at 60, 75, 90 and 105 °C, respectively, andthen milled using Food Grade model SK-30-SS disc attrition mill, manufactured by Munson Machinery Co. Inc., New York, sieved with laboratory sieve of 600 µm aperture size, and the sample stored for laboratory analyses [2].

2.2. Determination of Physico-Chemical Properties

2.2.1. Moisture Content Determination

Moisture content was determined according to the standard method of analysis of the AOAC [12] as highlighted by Umoh and Iwe [13]. A beaker that had been cleaned and dried in the oven was weighed after it had cooled in a desiccator (a). The beaker was weighed after adding two grams (2 g) of the flour mix sample, and the weight of the beaker plus sample was recorded (b). After being dried for four hours at 105 °C in the oven, the beaker and its contents were swiftly placed into a desiccator to cool before being weighed again. This process was carried out repeatedly until a consistent weight, (c) was achieved. Equation 1 was used to compute the moisture content.

Calculation:

$$\text{Moisture Content (\%)} = \frac{\text{loss in weight due to drying}}{\text{weight of sample taken}} = \frac{b-c}{b-a} \times 100 \quad (1)$$

Where: a = weight of empty beaker (g) b = weight of beaker + sample (g) c = weight of beaker + sample after drying (g)

2.2.2. Ash Content Determination

A muffle furnace (Model SKL-1200) was used to ignite a crucible with a lid at 105 °C for one hour. After that, it was weighed and placed in a desiccator to cool (a). The pre-weighed crucible was filled with two grams (2g) of the flour sample, and the weight of the crucible and its content taken (b). In a fume cupboard, bunsen flame was used to burn the crucible and its contents until the smoking stopped. The crucible and content were moved into a muffle furnace and heated to 550 °C for two hours, or until a white ash formed. The crucible was then cooled, covered, and put in a desiccator, before it was weighed (c). Equation 2 was used to determine the amount of ash content in the sample [12].

$$\text{Ash (\%)} = \frac{b-C}{b-a} \times 100 \quad (2)$$

Where: a = weight of crucible (g), b = weight of crucible + sample (g), c = weight of crucible + ash (g).

2.2.3. Crude Fibre Determination

Petroleum ether was used to defatten two grams (2 g) of the sample for two hours. 200 milliliters of sulfuric acid (H_2SO_4) solution were used to boil it for 30 minutes. It was then filtered through linen on a fluted funnel and rinsed with hot water until the washings were no longer acidic. After being moved to a beaker, the residue was heated for a further thirty minutes with 200 milliliters of NaOH solution. It was then filtered, and boiling water was used to wash the residue multiple times until it was clear of base sodium hydroxide (NaOH). Ultimately, the residue underwent two methanol washes, was quantitatively moved into a crucible that had been weighed beforehand, and was oven dried at 105 °C (Io). It was weighed (Ia), chilled in a desiccator, and burned at 550 °C. After burning, the weight loss was also recorded. Using Equation 3, the crude fiber content was determined [12].

$$\text{Crude fibre (\%)} = \frac{I_{a-I_o}}{\text{weight of original sample taken}} \text{ X } 100 \quad (3)$$

2.2.4. Crude Protein Determination

Crude protein was determined using the Kjeldahl method, as explained by Umoh and Iwe [13]. A standard 250 ml Kjeldahl flask was filled with precisely one gram (1g) of the wheat sample, 1.5 g of catalyst (CuSO4), 1.5 g of Na2SO4, and 5 ml of concentrated H2SO4. To prevent foaming, the digesting (Kjeldahl) flask was placed on a heating mantle and heated gradually over a number of hours to create a clear, blue solution. The digested solution was quantitatively moved to a 100 ml standard flask and filled with distilled water to the proper level after being allowed to cool. An equivalent volume of 40% NaOH solution was added to a 20 milliliter (20 ml) portion of the digest after being pipette into a semi-micro Kjeldahl distillation unit. A 100 ml conical flask containing a 10 ml saturated boric acid solution and two drops of Tashirus indicator (double indicator) were added to the ammonia after it had undergone a steam distillation procedure. The distillation process was continued until around two thirds of the original volume was recovered after the condenser tip was immersed in the boric acid-double indicator solution. After titrating the distillate with 0.1M Hydrochloric acid (HCl) solution until a purple-pink end-point was observed, a few milliliters of distilled water were used to cleanse the condenser's tip. With the exception of excluding the sample, a blank determination was also carried out in the same manner as described above. Equation 4 was used to determine the crude protein content [12].

$$\frac{(\text{Sample titre} - \text{blank titre}) 0.1 \times 0.014}{\text{weight of sample}} \times \frac{100}{20} \times \frac{100}{1} \times 6.25 \quad (4)$$

2.2.5. Crude Fat Determination

The extraction thimble was filled with two grams (2 g) of the flour samples after it had been cleaned, dried in the oven, and slightly blocked with cotton wool. A round bottom flask with a capacity of 500 ml was filled with 150 ml of petroleum ether, which has a boiling point ranging from 35 to 60 ℃. The round-bottom flask was placed on a heating mantle and the soxhlet extractor was inserted. After being put together, the soxhlet device was left to reflux for almost four hours. A dried, pre-weighed beaker (W_1) was filled with the extract, and the thimble was then cleaned with some ether before being returned to the beaker. After being heated in a steam bath to remove extra solvent, the beaker was cooled in a desiccator and weighed (W_2). The crude fat content was calculated using Equation 5 [12].

$$\text{Crude fat (\%)} = \frac{\text{weight gain in flask}}{\text{weight of sample}} \times \frac{100}{1} = \frac{W_2 - W_1}{\text{weight of sample}} \times \frac{100}{1} \quad (5)$$

2.2.6. Carbohydrate Content Determination

Determination of carbohydrate content of the sample was carried out by subtracting the total estimations (in %) made of nitrogen (protein), fat, ash and crude fibre contents from 100%. The resultant value gave the percentage carbohydrate content by difference, using Equation 6 [12].

$$\text{Carbohydrate (\%)} = 100 - (a + b + c + d) \quad (6)$$

Where,

a = Percentage protein content.
b = Percentage lipid content.
c = Percentage ash content.
d = Percentage fibre content.

2.2.7. Caloric Value Determination

This was obtained using the Atwater factor method. The values of the crude protein, fat, and carbohydrate obtained were multiplied by 4, 9, 4 respectively, and the sum of the products was taken as the caloric or energy value, (in kcal) of the sample, using Equation 7 [12].

$$\text{Energy value (kcal)} = (x \times 4) + (y \times 9) + (z \times 4) \quad (7)$$

Where, x = Protein content.
y = Lipid content.
z = Carbohydrate content.

2.3. Statistical Analysis

The triple-checked data were analyzed using the Statistical Analysis of Variance (ANOVA), with a 5% threshold of significance applied to the mean separation using the Duncan's Multiple Range Test.

3. Results and Discussions

The results of the physico-chemical properties of unripe plantain peel flour are presented in Table 1.

Table 1. Physico-chemical properties of unripe plantain peels flour.

Sample	Temp (°C)	Moisture content (%)	Ash (%)	Fibre (%)	Protein (%)	Lipid (%)	Carbohydrate (%)	Caloric value (kcal)
A	60	2.67 ± 0.003^{a}	15.83 ± 0.010^{a}	12.84 ± 0.022^{d}	9.80 ± 0.003^{a}	7.43 ± 0.004^{d}	54.09 ± 0.011^{d}	321.47 ± 0.002^{c}
B	75	2.00 ± 0.011^{b}	15.35 ± 0.022^{b}	13.34 ± 0.001^{b}	8.40 ± 0.022^{b}	7.55 ± 0.006^{c}	55.02 ± 0.002^{c}	322.63 ± 0.026^{d}
C	90	1.38 ± 0.001^{c}	15.08 ± 0.002^{c}	13.68 ± 0.006^{c}	7.35 ± 0.020^{c}	7.80 ± 0.032^{b}	56.32 ± 0.022^{a}	324.32 ± 0.041^{a}
D	105	0.66 ± 0.100^{d}	14.97 ± 0.004^{d}	14.10 ± 0.021^{a}	7.00 ± 0.201^{d}	7.94 ± 0.024^{a}	56.43 ± 0.006^{b}	325.74 ± 0.021^{b}

Note: Values are mean ± standard deviation of triple determination. Mean values with different superscripts, a, b, c, d, are significantly different ($p< 0.05$) from each other.

3.1. Moisture Content

Results of the physico-chemical analysis of the unripe plantain peel flour samples indicated that sample dried at 60, 75, 90 and 105 °C had moisture contents of 2.67, 2.00, 1.38 and 0.66%, respectively. Sample dried at the lowest temperature (sample A) recorded the highest moisture content, while the highest drying temperature produced the sample with the lowest moisture content (Table 1). There was a significant difference ($p < 0.05$) in the moisture contents of the samples. The moisture content of the unripe plantain peel decreased with increase in the drying temperature. Therefore, drying temperature significantly affected the moisture content of the unripe plantain peel. Moisture content of samples is presumed as one of the most important determination of shelf stability. The moisture content values for the flour samples ensure adequate storage in packages [14].

3.2. Ash Content

The unripe plantain peel recorded ash contents of 15.83, 15.35, 15.08 and 14.97% for samples dried at 60, 75, 90 and 105 °C, respectively (Table 1). These recorded values are higher than 3.94 to 4.28%, earlier reported for green plantain flour [2]. The high ash content is an indication that unripe plantain peel is a rich potential source of mineral elements. Similarly, there was a significant difference ($p < 0.05$) in the ash contents of the unripe plantain flour samples. Increase in drying temperature resulted in decrease in ash content of the sample. Thus, drying temperature had a significant effect on the ash content of the unripe plantain peel.

3.3. Fiber Content

Fibre contents of the unripe plantain peel were 12.84, 13.34, 13.68 and 14.10% for samples dried at 60, 75, 90 and 105°C, respectively (Table 1). These values are higher than the range of values, 1.00 to 2.76%, earlier reported for aerial yam-soybean flour [14]. There was a significant difference ($p < 0.05$) in the fibre contents of the samples. Fibre content of the sample increased with a corresponding increase in drying temperature. The drying temperature significantly affected the fibre content of the unripe plantain peel.

3.4. Protein Content

The unripe plantain peel flour samples recorded protein contents of 9.80, 8.40, 7.35 and 7.00% for samples dried at 60, 75, 90 and 105 °C, respectively (Table 1). These recorded values are higher than 3.85 to 4.68%, earlier reported for green plantain flour [2]. There was a significant difference ($p < 0.05$) in the protein contents of the unripe plantain peel. However, the protein content decreased with increase in drying temperature. This may be attributed to the process of protein denaturation. Therefore, the drying temperature significantly affected the protein content of the unripe plantain peel.

3.5. Lipid Content

Results of the physico-chemical evaluation of the unripe plantain peel flour samples showed that lipid contents were 7.43, 7.55, 7.80 and 7.94% for samples dried at 60, 75, 90 and 105 °C, respectively (Table 1). There was a significant difference ($p < 0.05$) in the lipid contents of the unripe plantain peel. Increase in drying temperature resulted in increased lipid content of the sample. The drying temperature had a significant effect on the lipid content of the unripe plantain peel.

3.6. Carbohydrate Content

The unripe plantain peel recorded carbohydrate contents of 54.09, 55.02, 56.32 and 56.43% for samples dried at 60, 75, 90 and 105 °C, respectively (Table 1). These recorded values are lower than 85.66 to 86.81%, earlier reported for green plantain flour [2]. The low carbohydrates contents imply that unripe plantain peel flour could be recommended as a diet for the diabetics. There was a significant difference ($p < 0.05$) in the carbohydrate content of the samples. The carbohydrate content increased with increase in the drying temperature. The drying temperature significantly affected the carbohydrate content of the unripe plantain peel.

3.7. Caloric Value

The caloric value of the unripe plantain peel ranged from 321.47 to 325.74 kcal. This range of values is a bit lower than 421.75 to 429.34 kcal for aerial yam-soybean flour, earlier reported by Umoh [14] and 380.29 to 385.23 kcal for green plantain flour [2]. Samples dried at 60, 75, 90 and 105 °C had caloric values of 321.47, 322.63, 324.32 and 325.74 kcal, respectively (Table 1). There was a significant difference ($p < 0.05$) in the caloric values of the unripe plantain peel flour samples. The caloric value increased with a corresponding increase in the drying temperature. Consequently, the drying temperature had a significant effect on the caloric value of the unripe plantain peel.

4. Conclusions

This study has shown that different drying temperature regimes has significant effect on the physico-chemical properties (moisture, ash, fibre, protein, lipid, carbohydrate and caloric value) of unripe plantain peel. Moisture, ash, fibre and protein contents decrease with corresponding increase in drying temperature, while lipid content, carbohydrate content and caloric value increase with increase in drying temperature.

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