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Research Article

The Impact of Processing Procedures on the Proximate and Phytochemical Composition of Unripe *Musa Paradisiaca* (Plantain)

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ABSTRACT

The study assessed the impacts of processing methods (sun drying and oven drying) on the proximate and phytochemical composition of unripe *Musa paradisiaca* (plantain) flour. Proximate and phytochemical analyses of the samples were performed using the standard methods. The unripe plantain flours were dried using sun drying and oven drying process and compared against fresh plantain for their nutritional and antinutritional content. The proximate content (%) of the unripe *Musa paradisiaca* include crude protein (3.58±0.43), carbohydrate (68.74±1.10), crude fat (2.02±0.19), and moisture content (9.06±1.88) after oven drying while crude protein (3.24±0.09), carbohydrate (64.84±1.24), crude fat (1.29±0.26), and moisture (15.86±1.61) were obtained after sun drying of unripe *Musa paradisiaca.* The phytochemical analysis (%) showed that the unripe *Musa paradisiaca* samples contain alkaloid (0.30±0.10), flavonoid (0.40±0.06), saponins (0.36±0.10), and tannin (0.30±0.10) for oven dried whereas some amount of alkaloid (1.18±0.20), flavonoid (0.79±0.16), saponins (1.59±0.23), and tannin (1.70±0.26) were observed for sun dried feedstock. The analysis of the nutritional composition implies that drying style has the potential to lower the moisture levels of plantain flour ($p<0.005$), whereas oven dried had the least moisture levels compared to sun dried and freshly prepared samples (59.74±1.88). The crude protein and phytochemical contents of the processed samples also reduced significantly, while carbohydrate, ash and crude fiber contents increased significantly ($p<0.005$) in relation to freshly prepared (27.84±1.27; 1.87±0.42; 1.62±0.51). The drying procedure of the unripe *Musa paradisiaca* produced flour with comparable nutritional contents, as oven dried gave least moisture content which is indicative of high potential to prevent spoilage and microbial development thereby increasing and prolonging the lifespan to usability.

Keywords: *Musa paradisiaca*, sun drying, oven drying, phytochemicals, proximate analysis

INTRODUCTION

The benefits of plant foods to the human body are enormous in terms of its nutritive, therapeutic, and pharmaceutical utilization (Okechukwu et al., 2021; Omokpariola et al., 2021a, 2021b). There are a lot of health benefits that can be obtained through the consumption of these plant foods, these health benefits are mostly connected to their physiological properties with regards to the nutritional and phytochemical values on the body system (Orole et al., 2020).

Musa paradisiaca (Plantain) is a major and beneficial starchy staple food which belongs to the *musaceae* family, also known as Ogadejioke (Igbo), Ogede Agbagba, (Yoruba), and Ayaba (Hausa) across diverse languages in Nigeria, which is cultivated mainly in the tropical (hot) and sub-tropical regions of the world. Plantain is a seasonal and highly perishable crop that is available during the period of September to February, which is dependent on available water and soil contents like excess fruiting has led to immerse food wastage as it does not survive for long period of time without processing for other food sources or utilization (Lamptey et al., 2019; Oko et al., 2015).

In Nigeria and other countries, processing of plantain is done either by roasting, boiling, frying, drying, and pulverize to flour, which is used as different food sources all year round due to its high nutritive content such as iron, zinc, sodium,

calcium, and potassium for prevention of high blood pressure and muscle cramp, in relation to its high fiber content, which can mitigate cholesterol increase, relieve constipation and prevent colon cancer exposure to human health (Borges et al., 2019,2020). As a result of food security, seasonal unavailability and limitation of the food crop utilization by populace; drying is mostly utilized for increasing the shelf life of plantain so as to maintain sustainability and food availability all year round (Baiyeri et al., 2011; Okareh et al., 2015).

Drying process is widely utilized for processing of *Musa paradisiaca* via various drying methods which include sunlight, oven, microwave and solar aeration devices aimed at removing moisture content in food through evaporation (Habou et al., 2003; Mukhtar, 2009).

The most utilized drying style practiced in Nigeria is sun drying due to inexpensive and ease to operate but there are a number of complications connected which include weather unpredictability, gradual drying process and possible damage of plantain flour by bacteria and insects (Olorode and Ewuoso, 2017). Nevertheless, the need for an effective and clean drying process should be adopted and improved. Hence, the study aims to ascertain the impact of two processing methods on the proximate and phytochemical constituents of unripe *Musa paradisiaca* (plantain) flour with a view of identifying a better drying procedure that can preserve the nutritional and phytochemical contents.

METHODOLOGY

Sample Preparation

The plantain samples (unripe) were sourced from Eke Awka market, Anambra State, Nigeria. Botanical identification and verification were carried out at Botanist, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. The samples were washed, peeled, and pulverized to flour thereafter was three portions of constant weight were weighed out correspondingly.

The first portion was put on a stainless-steel tray and placed under direct sunlight from 10:00 to 16:50 (GMT +1) until constant weight was obtained after various moisture loss measurement. The second portion was put on a sheet of aluminum foil and inserted into electric oven to dry at 105°C for about six hours as described by AOAC (2016) while the third portion was used as a control without drying.

Proximate Analysis

The moisture content, ash content, fat content of both sun and oven dried plantain samples was analyzed according to the method described by AOAC (2010). Crude fiber content was analyzed as described by Sadasivam and Manickam (1992). Crude protein content was analyzed by the Kjeldahl method. Carbohydrate was calculated using the percentage weight method. This was achieved by difference of the percentage (%) sum of plantain composition: % protein, % crude lipids, % crude fiber and % ash from 100%, as shown in the following:

$\%C_x(H_2O)_y$=100%-(%Crude protein + %Crude lipid + %Crude fiber + %ash + %moisture)

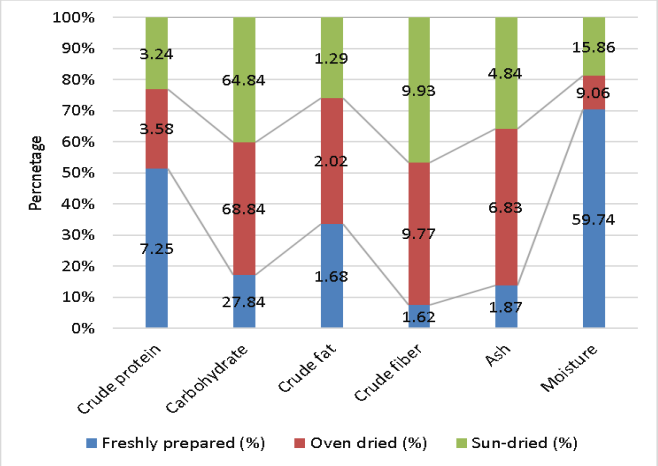

Figure 1. Percentage stark column of proximate constituent in unripe *Musa paradisiaca*

Phytochemical Analysis

Tannin, flavonoid, alkaloid, and saponin were quantified according to the method described by Trease and Evans (1996).

Statistical Analysis

All analysis was carried out in triplicates and results were expressed as mean±standard deviation. All the results obtained were explain using statistical package for social sciences (SPSS version 17.0) and micro soft excel.

RESULTS AND DISCUSSION

Proximate Content

Proximate constituents of freshly prepared, oven and sun dried method of *Musa paradisiaca* are presented in **Figure 1** and **Table 1**. From the result, crude protein (%) was highest in freshly prepared, followed by oven dried and sun dried with 7.25±0.91, 3.58±0.43, and 3.24±0.09, respectively. There were statistical differences at ($p>0.05$) between freshly prepared from oven dried and sun dried in the carbohydrate content. In the same result, crude fat and crude fiber were not greater than 2.02±0.19 and 9.93±1.10 in all the processing methods. In the same 95% level of confidence, significant difference in the three processing styles exist and moisture content was found to follow in order of (freshly prepared >sundried >oven dried). As seen in **Figure 1**, crude protein accounted for 51% in freshly prepared unripe *Musa paradisiaca* than others (oven dried and sun dried), as carbohydrates levels in freshly prepared was 18%, while oven and sun dried was 42% and 40%, respectively. So therefore, oven dried produced stark percentage of 9%-49%, as freshly prepared unripe *Musa paradisiaca* of protein and moisture was highest than others.

Moisture and the protein content of plantain of both dried processes were lower than the freshly prepared samples (control). Application of heat may be responsible to the decrease in these micro nutrients. This corresponds with the results by Mepba et al. (2007) and Yarkwan and Uvir (2015). Crude fiber, carbohydrate and ash constituents were observed to be high in the drying styles used in the present study. The increase in carbohydrate, ash and fiber contents observed in

Table 1. Proximate constituent of unripe freshly prepared, oven dried, and sun dried *Musa paradisiaca*

Parameters	Freshly prepared (%)	Oven dried (%)	Sun dried (%)
Crude protein	7.25±0.91[b]	3.58±0.43[a]	3.24±0.09[a]
Carbohydrate	27.84±1.27[a]	68.74±1.10[b]	64.84±1.24[b]
Crude fat	1.68±0.15[b]	2.02±0.19[c]	1.29±0.26[a]
Crude fiber	1.62±0.51[a]	9.77±1.12[b]	9.93±1.10[b]
Ash	1.87±0.42[a]	6.83±0.76[c]	4.84±1.54[b]
Moisture	59.74±1.88[c]	9.06±1.88[a]	15.86±1.61[b]

Note. Values represent mean±SD of triplicate analysis. Values in same row bearing the same alphabets are not statistically significant at ($p<0.05$)

the present study across the drying methods could be as a result of elimination of moisture which tends to increase the concentration of plantain nutrients (Fadimu et al., 2018; Yarkwan and Uvir, 2015).

Treatment of food with heat can be mutually valuable and harmful to the food constituents. Hence, application of heat to food results in nutrients' losses which hastens biochemical and nutritional differences in food constituents. It also improves food shelf life, making them safe to consume. Carbohydrate contents of freshly prepared unripe plantain significantly increase in the processed samples as revealed in **Table 1**. Processing methods has been reported to increase carbohydrates availability in a more digestible form (Fadimu et al., 2018; Yarkwan and Uvir, 2015). The moisture content for the freshly prepared *Musa paradisiaca* flour was analyzed to be 59.74% which is similar with 60.00% and 59.77% reported by Agoyero et al. (2011) and Yarkwan and Uvir (2015), respectively. The moisture content of flour was analyzed to be 9.06±1.88% (oven dried) 15.86±1.61% (sun dried) as compared to 9.09±0.01% (oven dried) and 15.00±0.01% (sun dried) reported by Yarkwan and Uyir (2015). The data were observing to have significant difference ($p<0.05$) from each other.

Moisture content of a particular food reveals its shelf life. Low moisture content is a condition for long storage life. During storage, fungal growth is bound to be observed on moist food samples. Fungal food contamination could be a predisposing factor to food poisoning. Since a well dried food sample withstands fungal and other microbial infestation better during storage, oven dried flour samples yield lower moisture content, Thus, oven dried samples are recommended. Total lipid of the plantain flour was 1.68% (fresh), 2.02% (oven dried), and 1.29% (sun dried) as revealed in **Table 1**. This was similar with the study of Yarkwan and Uvir (2015) on unripe plantain flour with values of 1.51% (fresh), 1.55% (oven dried), and 1.37% (sun dried) and Agoyero et al. (2011) with values of 2.75% (fresh), 1.38% (sun dried), and 1.57% (oven dried) on plantain flour. No significant difference ($p>0.05$) exist between the fresh and sun dried samples, but these are significantly different ($p<0.05$) from the oven dried samples.

The variations observed between sundried and oven dried samples is trace to be as a result of solar emissions mediated oxidation of the composite lipids, mostly the unsaturated fatty acids thereby decreasing the overall crude lipids content and quality. Loss of nutrients has been reported to be as a result of chemical changes specifically oxidation. Heat, sun light and radiations are factors known to increase oxidation of fats (Savage et al., 2002; Wiriya et al., 2009). The crude protein content of freshly prepared unripe plantain was assessed to be 7.25% while 3.58% and 3.24% for the oven dried and sun dried unripe plantain respectively. The values are in line with the 7.6%, 3.35%, and 3.61% protein in fresh, sun dried, and oven dried plantain flour respectively reported by Yarkwan and Uvir (2015). Low protein content observed in the present study is indication of Millard reaction, which results between carbohydrates and protein (Ibukum et al., 2012; Wiriya et al., 2009). It could also be due to drying under elevated temperatures. In the presence of atmospheric oxygen, proteins contained in exposed tissues tend to react, forming several intermediates which make the amino group of the amino acids non bio-available (Udo et al., 2021).

Conversely, application of heat results in nutritional losses by inducing biochemical and nutritional variations in food constituents, mostly sun drying. Subsequently, plantain is consumed majorly for its energy content, this significant decrease in crude protein due to processing does not invalidate the need for food security by processing nor the acceptance of this food sample in its processed form. Moreover, the gain from energy seems to increase significantly ($p<0.05$).

Crude fiber denotes the content of the non-digestible components of food, such as lignin, cellulose, and hemicelluloses. These are essential in animal nutrition, since they enhance the transit time through the bowels, facilitates bowels movement thus reducing the risk of colon cancer (Omokpariola et al., 2021a). Crude fiber was significantly different ($p<0.05$) between the freshly prepared sample and the processed samples as revealed in **Table 1**. Crude fiber assessed to be 1.62% which is similar with 1.40% by Adepoju et al. (2012). The values for sundried and oven dried were 9.93% and 9.77%, which were similar with the values reported for sundried and oven dried plantain flour by Agoyero et al. (2011), Fadimu et al. (2018), Yarkwan and Uvir (2015).

Ash content of food is defined as the inorganic residue after the water and organic matter have been removed by heating a food sample. Significant difference ($p<0.05$) was observed in the ash content between the freshly prepared sample and the processed samples as revealed in **Table 1**. It was analyzed to be 1.87% from the fresh sample, which is significantly different from 1.40% reported by Adepoju et al. (2012).

Phytochemical Contents

The results of the phytochemical contents show a significant difference ($p<0.05$) between freshly prepared, oven dried, and sun dried in their alkaloid, flavonoid, saponin, and tannin contents as revealed in **Table 2** and **Figure 2**. A close review of stark column (%) of phytochemicals in unripe *Musa paradisiaca* (**Figure 2**) showed that freshly prepared and sundried accounted for over 81% across all phytochemicals (alkaloids, flavonoid, saponin, and tannin).

The phytochemical composition as shown in **Table 2** revealed that unripe freshly prepared, oven dried and sun dried

Table 2. Phytochemical contents of unripe freshly prepared, oven dried, and sun dried *Musa paradisiaca*

Parameters (mg/100g)	Freshly prepared (%)	Oven dried (%)	Sun dried (%)
Alkaloid	1.33±0.10[b]	0.30±0.10[a]	1.18±0.20[b]
Flavonoid	0.90±0.10[b]	0.40±0.06[a]	0.79±0.16[b]
Saponin	1.81±0.20[b]	0.36±0.10[a]	1.59±0.23[b]
Tannin	1.57±0.25[b]	0.30±0.10[a]	1.70±0.26[b]

Note. Values represent mean±SD of triplicate analysis. Values in same row bearing the same alphabets are not statistically significant at ($p<0.05$)

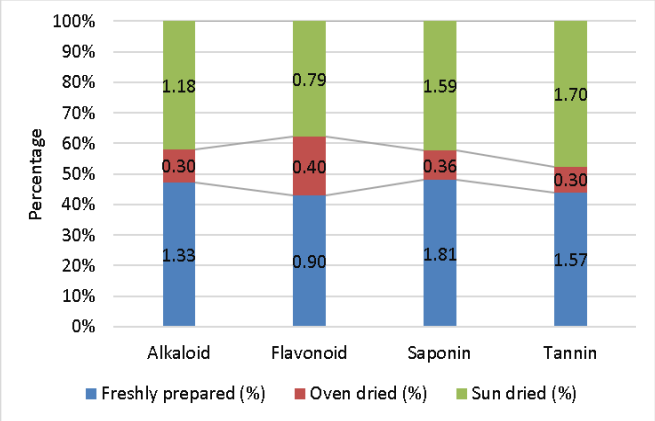

Figure 2. Percentage stark column of phytochemicals in unripe *Musa paradisiaca*

plantain contains varying amount of alkaloids, tannin, flavonoid and saponin, however, the values were significantly different from each other. Phytochemical analysis of the unripe plantain contains 1.33±0.10% alkaloid for freshly prepared, 0.30±0.10% for oven dried, and 1.81±0.20% for sun dried. It was observed that tannin content of sun dried increased significantly while the oven dried decreased. The tannin content range from 1.57±0.25% for freshly prepared 0.30±0.10% for oven dried, and 1.70±0.26% for sun dried. Oven dried had the lowest saponin content of 0.36, followed by freshly prepared 1.81 and sun dried 1.59. Saponins contents help in reduction of cholesterol, cytotoxic permeabilization of the intestine and can cause paralysis of the sensory system thereby having both beneficial and deleterious effects (Price et al., 1987). The low phytochemical values (**Table 2**) observed in the present study are consistent with the results of Eleazu et al. (2011). Flavonoids, alkaloids, and tannins are polyphenolic compounds with antioxidant properties. Additionally, phenolic compounds found in plants are also responsible for their contribution to color, sensory, and antioxidant properties of food (Robbins, 2003). The result also shows a significant difference ($p<0.05$) between freshly prepared, oven dried and sun dried in their alkaloid, flavonoid, saponin, and tannin contents and the results of the analyzed phytochemicals are low to cause any deleterious effects.

CONCLUSION

The research produced a useful empirical report both on proximate and phytochemical composition of unripe plantain (*Musa paradisiaca*) before and after the drying procedures and significant variations. There was high carbohydrate content in relation to protein and crude content, as moisture content was influenced by processing methods. There was no effect from the phytochemical constituents observed on the nutritional availability and retention of the unripe *Musa paradisiaca*. The oven and sun drying methods are reliable as they produced good nutritional constituents with insignificant variances from the freshly prepared samples. To achieve a fast drying and conserve nutritional constituents, the oven drying method is recommended even though expensive the sun drying method is mostly practice, cheap, and dry gradually, which is susceptible to contamination by dirt dust and wind-blown debris if proper hygiene process is not done. Future research should focus on pharmacological synthesis of plantain for therapeutic and nutritional needs.

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Ethics approval and consent to participate: Not applicable.

Availability of data and materials: All data generated or analyzed during this study are available for sharing when appropriate request is directed to corresponding author.

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