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DETERMINATION OF THE IDEAL CONCENTRATIONS OF POTASH DERIVED FROM PLANTAIN BANANA PEELS CAPABLE OF PRESERVING THE CHLOROPHYLL OF GUINEA SORREL LEAVES

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ABSTRACT

This study focused on determining the ideal concentrations of potash derived from plantain peel that can preserve the chlorophyll of leafy vegetables after cooking, specifically the leaves of Guinea sorrel locally known as "dâh" leaves (Hibiscus sabdariffa). The results showed that the chlorophyll content of dâh leaves gradually increases proportionally to the concentrations of potash until reaching a maximum at a concentration of 8.5 mg/ml of potash, at all four conservation times (0 hours, 24 hours, 48 hours, and 72 hours). Beyond 8.5 mg/ml of potash, the chlorophyll content decreases. After 72 hours of conservation, the chlorophyll content remains higher than the chlorophyll content obtained in the control sample without potash, which is 0.02 mg/g.

Keywords: potash, plantain peel, chlorophyll, dâh leaves, Hibiscus sabdariffa, conservation time.

INTRODUCTION

The food balance sheet of Côte d'Ivoire in 2024 stands at around 10 million tons, with five (5) major crops accounting for the bulk of annual production: yam (5,500,000 tons/year), cassava (2,300,000 tons/year), maize (over 500,000 tons/year), rice (700,000 tons/year), and plantain banana (1,500,000 tons/year) [1].

This plantain banana production makes Côte d'Ivoire the 3rd largest producer of plantain bananas in West Africa, behind Nigeria and Ghana [1]. In Côte d'Ivoire, plantain bananas rank 4th in terms of consumption after rice, cassava, and yam. The favorable cultivation areas are located from Man to Bondoukou via Bouaké. Since 2000, the flagship production area has been the Central-West region [2]. Despite this self-sufficiency in food crops, the banana sector faces several challenges, including difficult access to large production areas and conservation issues [2], resulting in significant post- harvest losses (30 to 40% of production).

To combat these post-harvest losses, some initiatives have emerged, such as plantain processing and the valorization of by-products. Among these, the peel is often used for livestock feed but also for human consumption with the difference that it is previously transformed into potash. This potash, obtained by incinerating dried banana peel, is used as a preservative to maintain the green color of leafy vegetables. These leafy vegetables contain micronutrients (vitamins, minerals) that contribute to the well-being of the body [3]. They are most often consumed cooked. However, these leafy vegetables lose their green color a few hours after cooking [4]. To address this issue, certain salts such as potash are added to these vegetables during cooking in many Ivorian households. Although it is undeniably useful in human nutrition, its consumption could pose a public health problem due to the lack of control over the necessary dosage to maintain the green color of cooked leafy vegetables [4].

Thus, the objective of the study conducted is to determine the ideal concentrations of potash derived from plantain peel that can preserve the chlorophyll of leafy vegetables after cooking, specifically the leaves of guinea sorrel locally known as "dâh" leaves (Hibiscus sabdariffa).

1. MATERIALS AND METHODS

1.1. Biological materials

The plant material consists of, on the one hand, mature plantain peels collected from "aloco" sellers. Alocos are a local dish in Côte d'Ivoire, made by frying ripe plantains, probably cut into cubes, in palm oil. These peels will be used for the production of potash. On the other hand, fresh leaves of guinea sorrel, locally known as "dâh" leaves, were used for chlorophyll extraction after cooking; these leaves were purchased from vendors at the Gouro market in Adjamé.

1.2. Artisanal extraction of potash

The peels of the plantain banana are used for this extraction. The indicated weight for these peels is 20 kg. Using a precision balance, 20 kg of diced peels were weighed. These peels were then dried in an oven (Thermo Scientific) at 80°C for 24 hours to remove moisture. After drying, the fragments were incinerated in a muffle furnace (Thermolyne Type 48000 furnace) at 550°C for five hours until a gray, light, or whitish color was obtained [5]. The resulting ash from this incineration was collected in an opaque glass flask. An aliquot of 5 g of ash was dissolved in 10 ml of distilled water and hand-shaken. After homogenization, the supernatant collected was filtered through fabric. The filtrate constituted the mother solution of potash with a concentration of 0.5 g/ml. Another aliquot of 5 g of ash was used for the determination of mineral

elements using the ISO 6869:2000 method at LANADA. The levels of mineral elements were calculated and expressed in milligrams per 100 g of ashes.

1.3. Determination of chlorophyll content in guinea sorrel leaves

To determine the required concentration of potash for preserving chlorophyll in cooked guinea sorrel leaves, a series of dilutions starting from the mother solution of potash at 0.5 g/ml were prepared [4]. Potash concentrations of 1.5 g/ml, 2.5 mg/ml, 3.5 mg/ml, 4.5 mg/ml, 6.5 mg/ml, 8.5 mg/ml, 10.0 mg/ml, and 12.5 mg/ml were prepared, as well as a control with a concentration of 0 g/ml where the potash solution was replaced with distilled water. These potash concentrations and the control were used for cooking the green guinea sorrel leaves. For cooking, 10 g of guinea sorrel leaves were used and brought to a boil for 10 minutes, the average time needed for cooking most green vegetables. After cooking, the chlorophyll content was immediately determined in the cooled guinea sorrel leaves, as well as in leaves left in darkness for 24 hours, 48 hours, and 72 hours to determine the necessary preservation time for chlorophyll content in the leaves. To determine the chlorophyll content, 0.1 g of dâh leaves were crushed in a porcelain mortar with 10 ml of 90% alcohol as described by [6] and [7]. The pigment extract obtained was filtered using a funnel and filter paper. The extract was repeatedly washed with small amounts of alcohol (approximately 3 ml each time) until all the pigments were completely dissolved. The pigment extract was transferred to a 25 ml volumetric flask and topped up to 25 ml with 90% alcohol. This extract was mechanically stirred to homogenize it. Then, the optical densities were read on a spectrophotometer (GenesysTM Holland, Amsterdam) at 663 nm, 644 nm, and 645 nm respectively for chlorophyll a and chlorophyll b. The chlorophyll contents of the dâh leaves in each of the 8 potassium concentrations as well as the control were determined after cooking as well as in leaves stored for 24h, 48h, and 72h using the Arnon equation (1949) as follows:

Chl a (mg.g-1) = [(12.7 × A663) - (2.6 × A644)] × ml acetone / mg leaf
Chl b (mg.g-1) = [(22.9 × A645) - (4.68 × A663)] × ml acetone / mg leaf
Total Chl = Chl a + Chl b.

Three independent extractions were performed for each sample.

1.4. Statistical Test

For data analysis, a statistical study was conducted using the XLSTAT software. For the preservation of chlorophylls based on potassium concentrations and the storage time after cooking, analysis of variance (ANOVA) was performed on the average value of chlorophyll contents associated with each optical density read on the spectrophotometer. After checking for residual normality and homoscedasticity, the comparison between means was done using the Duncan test with a probability of 5%.

2. RESULTS

2.1. Minerals in banana peels

For our sample, starting with listing the minerals it contains in descending order of content, we have

potassium with 3225 mg/100g, followed by magnesium, calcium, manganese, and iron with values of 353.71 mg/100g, 86.35 mg/100g, 13.26 mg/100g, and 7.16 mg/100g respectively. Finally, we have zinc which has a value lower than 0.001 mg/100g (Table I).

Table I: Mineral composition of banana peels (mg/100g of ash)

Mineral elements	Average values (mg/100g)
Magnesium	353,71
Potassium	3225
Manganese	13,26
Iron	7,1
Calcium	86,35
Zinc	< 0,001

2.2. Chlorophyll content in Guinea sorrel leaves

The histogram (Figure 1) allows us to evaluate the effect of nine (9) concentrations of potash on the preservation of chlorophyll in sorrel leaves at 4 distinct time intervals. It allows us to observe that the chlorophyll content in Guinea sorrel leaves (dâh leaves) varies differently according to potash concentrations ranging from 0 mg/ml to 12.5 mg/ml for a given time.

In all four cases, the results show that the analysis of variance reveals a significant effect of potash concentration at a 5% significance level according to the Duncan test, and highlights the existence of 8 and 6 groups of potash concentrations respectively for the first and last preservation periods after cooking. The most remarkable effect was recorded by the potash concentration C6: 8.5 mg/ml (groups f, h). Indeed, the chlorophyll content in dâh leaves increases gradually with potash concentrations up to the concentration C6: 8.5 mg/ml; but from 8.5 mg/ml of potash, significantly lower chlorophyll contents are observed; and this is true for all 4 preservation times (T0, T24, T48, T72). However, after 72 hours of preservation, the chlorophyll contents remain higher than 0.02 mg/g, which is the chlorophyll content obtained in the control.

Furthermore, the highest chlorophyll contents (values around 0.07 mg/g) are observed in potash concentrations C6 to C8, with a slight predominance for C6. Statistical analysis reveals a significant difference at a 5% significance level between cooked dâh leaves with potash and the control without potash.

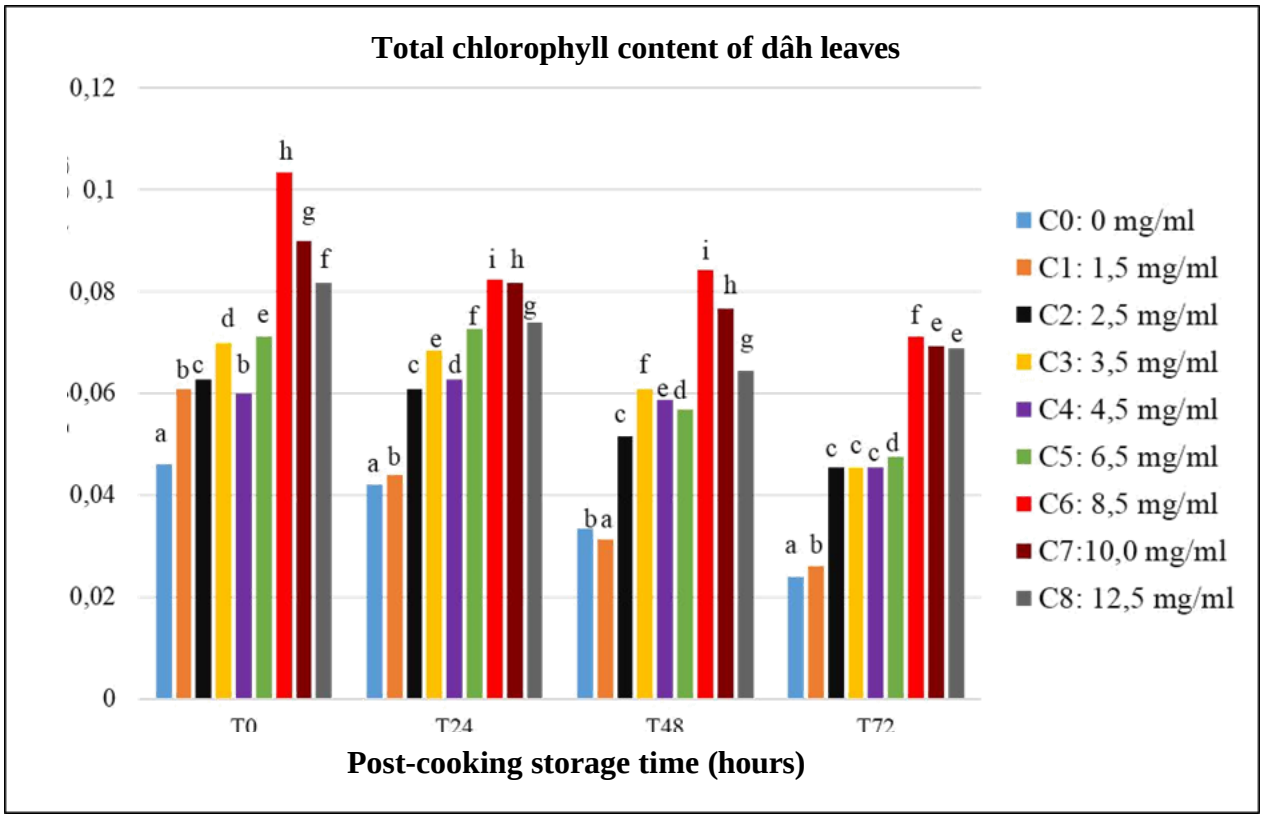

Figure 1: Total chlorophyll content of dâh leaves during conservation after 10 minutes of cooking.

3. DISCUSSION

Plantain banana peel ash is composed of minerals with variable concentrations. Potassium, magnesium, and calcium are the elements with the highest concentration, with potassium being predominant (3225 mg/100g of ash), unlike manganese and iron. Zinc is almost non-existent with a concentration below 0.001 mg/100g.

Mineral elements are known for their role as co-factors in metabolism and energy balance in the body [8]; [9]; [10]. Studies on chlorophyll, such as those conducted by [11] have shown that chlorophyll content decreases with increasing intensity of salt stress. However, the study conducted by [12] showed that severe salt stress (6 g NaCl/l) negatively affects physiological and metabolic parameters studied (chlorophyll content, foliar water potential, and proline content).

These results contradict ours because the highest chlorophyll content is recorded at higher intensities of salt stress (in this case, potash from banana peels) ranging from 8.5 mg/ml to 12.5 mg/ml.

This could be explained by the difference in composition of the mineral salts constituting each salt. Only concentrations of C6 to C8, ranging from 8.5 mg/ml to 12.5 mg/ml, correspond to concentrations capable

of maintaining chlorophyll in Guinea sorrel leaves with 10 minutes of cooking for 4 days. The highest chlorophyll content after these 4 days is 0.07 mg/g, a value significantly higher than 0.02 mg/g (Figure 1), which represents the chlorophyll content of Guinea sorrel leaves cooked without potash. Our results are consistent with the study conducted by [4] on banana stem ash. These results can be explained by the effect of minerals contained in potash, specifically calcium. Calcium is believed to play an important role in maintaining chlorophyll in vegetables after cooking. Chlorophyll contains a pyrrolic core with unstable magnesium at its center. When these vegetables are cooked in the presence of potash containing calcium, the calcium ion would replace magnesium in these combinations during cooking, thus creating better stability of the pyrrolic core of chlorophylls, thereby maintaining the green pigments of plants.

Thermal treatment in an acidic environment would remove magnesium from the pyrrolic core of chlorophylls. This magnesium, associated with organic acids released during cooking, is responsible for the degradation of chlorophylls into pheophytin (olive-brown) [4].

However, in order to satisfy consumer taste with the ideal concentration for chlorophyll preservation and without presenting any health risks, and considering that sodium intake should be between 1500 mg and 2300 mg (3.8 g to 5.8 g per day) in adults according to [13], the concentrations chosen by our study, which are 8.5 mg/ml to 12.5 mg/ml, equivalent to 85 mg to 125 mg of potash in terms of quantity for chlorophyll preservation, are in compliance. In fact, they are well below the recommended amount of salt, which is 3.8 g to 5.8 g of salt per day.

CONCLUSION

The objective of this study was to determine the ideal non-lethal concentration of potash made from plantain peel that can preserve the green color of leafy vegetables, particularly Guinea sorrel leaves known as "feuilles de dâh" in Côte d'Ivoire.

To achieve this, different pre-made concentrations of potash were added one by one to a known quantity of "feuilles de dâh" and boiled for 10 minutes. The chlorophyll content was then determined for each of these concentrations. These data allowed us to establish a histogram from which we can conclude that only concentrations ranging from 8.5 mg/ml to 12.5 mg/ml have the ability to maintain the green color of "feuilles de dâh" for 4 days.

This study therefore provides a means of valorizing plantain processing residues. Beyond these results, there are some research perspectives to consider, namely:

- Identifying the nutritional value of chlorophyll in leafy vegetables.
- Determining the exact concentration at which potash would potentially be toxic to consumers.

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