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Effect of domestic cooking on the total phenolic, flavonoid and condensed tannin content from plantain of Côte d'Ivoire

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Abstract

Background: For decades, many studies have been conducted to investigate the effect of cooking methods onto the stability in food nutrients. **Objectives:** To assess the effect of cooking on total phenolic, flavonoid and condensed tannin content from plantain. **Methodology:** To quantify total phenolic, flavonoid and condensed tannin content in plantain pulps, before and after cooking by boiling and by grilling. **Result:** The condensed tannin content decreased around 11.5-fold and 9.9-fold for boiled plantain and grilled plantain respectively, compared to raw plantain (7,5±1µgEC/mg). Otherwise, a significant increase (i.e., 25.7-fold) of flavonoid content was observed during cooking by boiling, while 9-fold for cooking by grilling, compared to raw pulp (7 ± 1 µgEAG/mg). For phenolic compounds, their content increased around 2.4-fold in both cooking processes. **Conclusion and perspectives:** It noteworthy that the boiling of the plantain is better than the grilling process. Besides, it would be more advantageous to cook the pulp with peel due to its strong presence of phenolic compounds.

1. Introduction

Antioxidants are the defence system of the body against the damage of reactive oxygen species, which is normally produced during the various physiological processes in the body. There are various sources of these antioxidants like endogenous antioxidant present in the body and exogenous food source [1].
Banana belongs to the tropical fruits as it grows more profusely in tropical rain forest areas. Interestingly, banana fruit has flesh not only rich in starch which changes into sugars on ripening but is also a good source of resistant starch. Banana is known to be rich in carbohydrates, dietary fibres, certain vitamins, and minerals [2].
With 30,137,993 hg/ha, Banana (Musa spp.) was the tenth most important crop in terms of yield in 2017 (FOA Stat). It is produced in >130 (sub)tropical countries across the globe. The diversity of banana is huge and many banana varieties have higher starch content. Depending on the variety, these starchy bananas have to be cooked (called cooking banana), fried or roasted. Plantain is a specific high starch containing banana variety that is cooked. Approximately 50% of the plantain production comes from the humid forest agro-ecological zone of West and Central Africa making it a very important crop for local farmers. Plantains provide more than a quarter of the carbohydrate requirements for >70 million people making them one of the most important sources of food energy in West and Central Africa [3].

Several studies have suggested that consumption of unripe bananas exerts a beneficial effect on human health, most especially the indigestible components. Unripe bananas are a good source of carbohydrates and nutritionally interesting bioactive compounds [4]. It also contains important bioactive compounds such as phenolics, flavonoids, carotenoids, biogenic amines, sterols, and antimicrobial compounds which make bananas a perfect functional food for health improvement [5]. Physicochemical and biochemical characteristics are influenced by many factors, such as the genotype and ripening stage, which contribute to the differentiation and variation of these characteristics. Furthermore, these parameters help to identify the best application for each genotype (e.g., banana for in natural consumption, banana candy, banana chips, banana pulp, among others). Studies have indicated that banana and plantain fruit contain appreciable quantities of antioxidant compounds, such as carotenoids and phenolic compounds (e.g. flavonoids) [6].

Polyphenols, organic compounds found abundantly in plants, have become an emerging field of interest in nutrition in recent decades. A growing body of research indicates that polyphenol consumption may play a vital role in health through the regulation of metabolism, weight, chronic disease, and cell proliferation. Animal, human and epidemiologic studies show that various polyphenols have antioxidant and anti-inflammatory properties that could have preventive and/or therapeutic effects for cardiovascular disease, neurodegenerative disorders, cancer, and obesity [7].

In Côte d'Ivoire, most of the vegetables are processed before consumption and are cooked by boiling in water or roasting or deep frying or microwaving. These cooking processes would bring about a number of changes in physical characteristics and chemical composition of vegetables. Many studies have showed that the nutritional value of fresh fruits and vegetables are higher than those of processed one [8]. Thus, the aim of this work was to evaluate the effect of two cooking methods (boiling, grilling) on the total phenolic, flavonoid and the condensed tannin content of plantain pulps from Côte d'Ivoire.

2. Material and Methods

2.1. Plant material

Unripe plantains were purchased from a local market named "marché Gouro" in Abidjan district (Côte d'Ivoire). The fruits were brought to our laboratory and the pulps were separated from the peels.

The unripe pulps were divided into three groups. The first group was the raw pulps; the second was boiled pulps and the third group was grilled pulps. The raw peels were constituted a fourth group. Each group was treated separately.

2.2. Chemicals

All chemicals used for analysis were purchased from Carlo-Erba or Sigma Aldrich and were analytical grade.

2.3. Cooking processes

The cooking methods were conducted in conditions close to those commonly applied in African households.

Boiling: 250 g of pulps was boiled in 500 mL distilled water in a clean pot with a lid on an electric hot plate during 30 minutes.

Grilling: 250 g of pulps was grilled at high/medium heat in a grill over hot embers for 30 minutes.

The raw pulps, the boiled pulps, the grilled pulp and the raw peels were pounded into the mortar, separately.

2.4. Extract preparation

Pulp and peel extracts were prepared by applying the maceration with hydroethanolic solution. 100 g of the pulps or peels powder was suspended in 500 mL of hydroethanolic solution 80% (v/v) for 24 hours at room temperature. The mixture was filtered using a Buchner funnel containing Whatman filter paper into 1000 mL filtering flask. The filtrate was placed in an oven to dry at 40ºC. The residue obtained was used for the study. The extracts were kept at -4 °C until it was used in the experiment [9].

2.5. Phenolic compound content assay

The Folin–Ciocalteu method with a modification was used to determine the phenolic compound content of the samples. One milliliter of each extract was diluted with 20 mL distilled water and 0.5 mL of Folin–Ciocalteu reagent (Sigma Co.). After 3 minutes, 1.5 mL of 17 % Na_2CO_3 solution was added to the mixture and the mixture was allowed to stand for 30 minutes at room temperature in a dark room. The absorbance was measured at 720 nm with a UV-visible spectrophotometer (Kontron Instruments, UVIKON 922A, UK). A standard gallic acid solution (500-31 µg/mL) was used for the construction of a calibration curve. Results were expressed as microgram gallic acid equivalent per milligram of extract (µgEAG/mg). The tests were run in triplicate and averaged, against a blank without plant extract taken as reference [10].

2.6. Flavonoid content assay

The determination of total flavonoids was done by the method of Hariri, with some modifications. 1 mL of filtrate diluted in a ratio of 1/8 were mixed with 100 µl of Neu reagent. The absorption was determined at 404 nm and compared to the one of standard quercetin (0.05 mg/mL) treated with the same reagent. The percentage of total flavonoids was expressed in microgram equivalent quercetin per milligram of extract (µgEQ/mg) according to the formula:

$$F = \frac{0.05 * A_{ext} * \mathrm{d}}{A_q * C_{ext}} * 100$$

A_{ext}: Absorbance with extract

A_q: Absorbance with quercetin

d: Dilution factor

C_{ext}: Concentration of extract (mg/mL) [11]

2.7. Condensed tannin content assay

The determination of condensed tannin content was performed according to the method described by Palici, with some modifications. 2 mL of extract (0.4 mg/mL) were mixed with 1 mL of tungstophosphoric acid and 17 mL of $NaCO_3$ (50%, w/v). After 3 minutes, the absorbance at 750 nm was read using a UV-Visible spectrophotometer (Kontron Instruments, UVIKON 922A, UK). A calibration curve was drawn in parallel in the same operating conditions using catechin (0-100 µg/mL). The condensed tannin content was expressed in microgram of catechin equivalent per milligram of extract (µgEC/mg) [12].

2.8. Statistical analysis

All experiments were performed in triplicate, and the results were expressed as mean ± standard deviation (SD) values. The statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS). Values of $p < 0.05$ were considered to be statistically significant

3. Results and discussion

Crude extracts

The yields of extraction after different cooking processes are given in **Table 1**. The extracts of pulps and peels were used to determine the amount of total phenolics, flavonoids and condensed tannins.

Phenolic compound

Polyphenols are the major group of biologically active non-nutrients present in food. They display physiological effects that help prevent several lifestyles and chronic diseases [13].

Table 1: Yield of crude extracts of unripe plantain

Extracts	Yields (%)
Raw pulps	1.9
Boiled pulps	1.6
Grilled pulps	1.7
Raw peels	1.8

Figure 1 shows the effects of cooking processes on the total phenol content of the pulp, as well as the total phenolic content of the peel. Raw pulp had the lowest total phenol content compared to cooked pulp, being on average 2.4-fold smaller than boiled and grilled pulp. Thus, both cooking modes increased the polyphenol content in pulp extracts in similar ways (28.33 ± 1 µgEAG / mg for boiled pulp and 66.8 ± 2 µgEAG / mg for grilled pulp). The higher content of total phenol was found in the fresh peel with an average content of 335.14 ± 6 µgEAG / mg; 12-fold higher than those of the raw pulp and 4.9-fold higher than those boiled and grilled pulp. According to an earlier paper, pistachio, cashew and chestnut flours which maintain, or even increase, their phenolic content and their antioxidant activity can be obtained by combining heat and pressure treatment [14]. Cooking treatments soften the cell walls and facilitate the extraction of bioactives such as polyphenols and carotenoids. There are also published investigations on the influence of cooking methods on the antioxidant activity of some European vegetables, African leafy vegetables and brassica vegetables, and the different effects reported are dependent on the vegetable types [15].

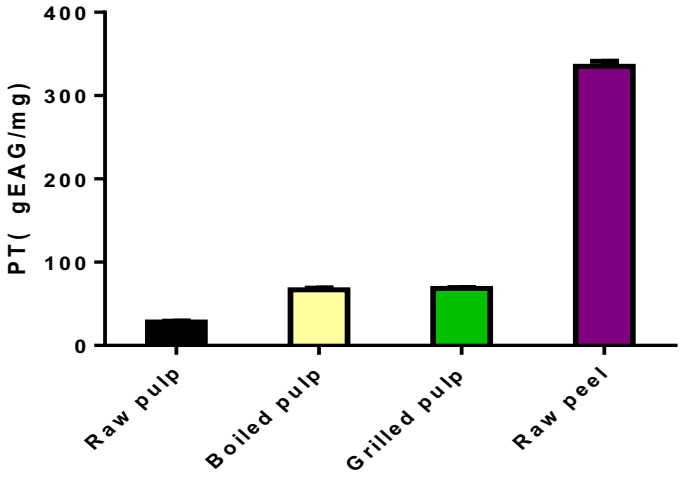
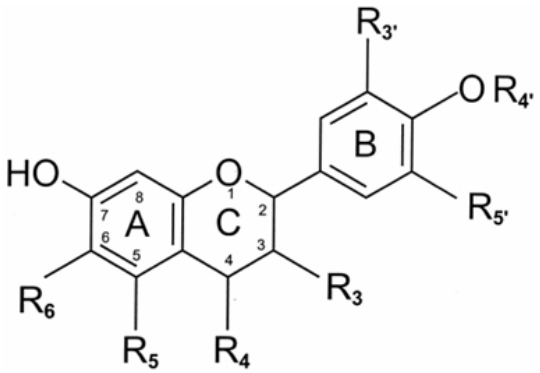


Figure 1 : Total phenol content (TP) of plantain pulp resulting from different cooking methods and peel

Flavonoid content

Flavonoids are a large group of polyphenolic compounds found in fruits and vegetables (Scheme 1). They have been shown to be strong antioxidant and anti-inflammatory agents in human diet, and consumption of foods high in flavonoids has been associated with reduced risk of several chronic diseases. Estimating flavonoid contents in foods is a first critical step toward understanding their health benefits [16]. The effect of different modes of cooking the pulp of plantain on the total flavonoid content showed a strong increase in flavonoids compared to the raw pulp (**Figure 2**). The boiling resulted in a

very significant gain in flavonoid concentration, 25.7-fold higher than in the raw pulp (7 ± 1 µgEQ/mg) while cooking on the embers increased it by 9-fold.



Scheme 1: Molecular Structure of Flavonoid

Thermal processing including domestic cooking have long been known to influence the flavonoid contents of the vegetables. The effects of cooking are affected by many factors, including food matrix, cooking method/condition and the chemical nature of the flavonoids. This may be due to the formation of many newly formed phenolic compounds resulting from the deterioration (degradation) of very high molecular weight flavonoids (catechin tannins) [16,17]. Furthermore, the content of the raw peel was 8.9-fold and 1.4-fold higher than the raw and grilled pulp contents, and 2.9-fold lower than the boiled pulp content.

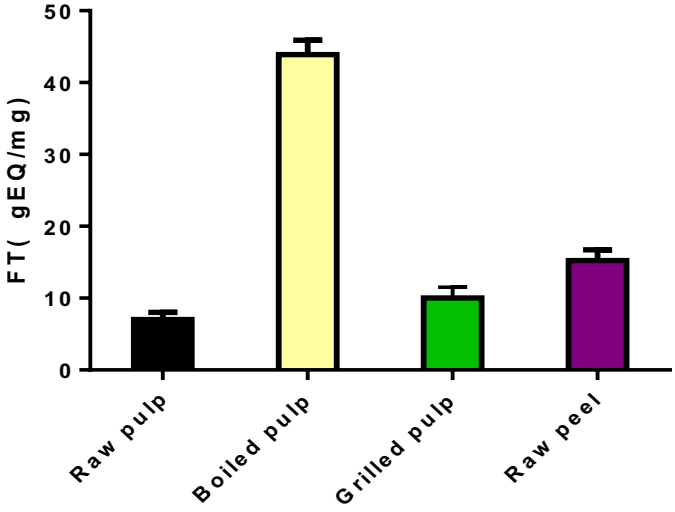


Figure 2: Total flavonoid content (TF) of plantain pulp resulting from different cooking methods and peel

Condensed tannin content

Plant tannins are a major group of antioxidant polyphenols found in food and beverages that attracts research interest with its multifunctional properties to human health. Tannins exhibit antinutritional properties by impairing the digestion of various nutrients and preventing the body from absorbing beneficial bioavailable substances. Antinutrients are valuable active ingredients in food and drinks when used at low levels. Another group of anti-nutrient compounds, like tannins, were found to possess possible antiviral, antibacterial and antiparasitic effects [18].

The information in **Figure 3** shows that cooking by boiling and cooking by grilling have depressed in substantially equal proportions, the condensed tannin content of the raw pulp (7.05 ± 1 µgEC/mg).

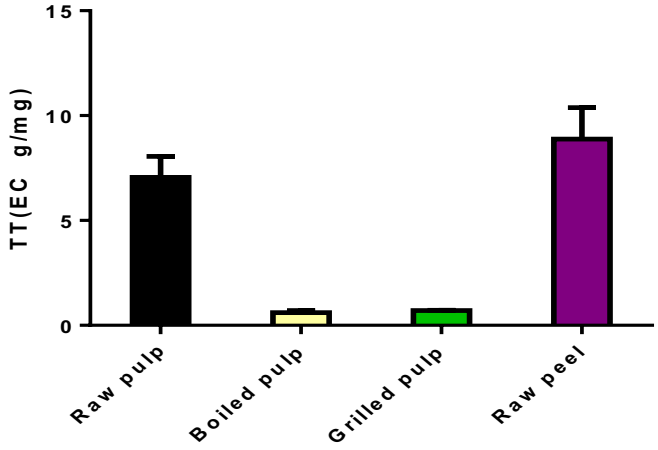


Figure 3: Total tannin (TT) content of plantain pulp resulting from different cooking methods and peel

These decreases in content averaged 11.5-fold for boiling and 9.9-fold for cooking with embers. This reduction in the contents could be made on the one hand, the presence of hydrolysable tannins such as esters of gallic acid (gallic tannins), the hexahydroxydiphenic acid (ellagitannins). These give after hydrolysis, either gallic acid or ellagic acid, thus increasing the content of the total phenols [19]. On the other hand, condensed tannins which are polymers of flavonoid units, may degrade under the effect of heat to give flavonoids thereby increasing their content [17,19]. It should be noted that the raw peel had the highest content of total tannins with a content 1.3-fold higher than the raw pulp, 14.5-fold for the boiled pulp and 12.5-fold for the grilled pulp. Removing undesirable food components is essential to their quality improvement. Different techniques i.e. soaking, cooking, fermentation, radiation, germination and chemical treatment can come in as handy instruments for antinutritional disabling [18]. It therefore appears that the levels of total phenols, total flavonoids and condensed tannins are affected a variable manner depending on the cooking process. Indeed, each method of cooking leads to the formation of different types of bonds between the phytochemicals and the cell structure, which subsequently leads to higher or lower cleavage of the phenolic bonds depending on the type of heat applied, which leads to different responses observed in this study [20].

Existing data on the effect of processing on phenolic compounds shows that food processing plays a significant role when it comes to bioaccessibility and bioavailability of polyphenols. High temperature processing which ensures food safety has both positive and detrimental effects on phenolic compounds. The reviewed literature also suggests that if food processing is judiciously applied, it can serve as a means of improving bioavailability of polyphenols through structural modification or breakdown of the parent compound [21].

The boiled plantain pulp has a very high content of phenolic compounds, especially flavonoids, compared to the grilled pulp. This may be an additional stimulus to encourage consumption of plantain in this form because of their antioxidant properties. In addition, significant levels of polyphenols in the peel suggest that boiling or grilling plantains with peel may be more beneficial.

Conclusion

This work aimed to evaluate the content of phenolic compounds in plantain during the cooking process, by quantifying total phenols, total flavonoids and condensed tannins. These analyses were carried out

on raw pulp, boiled pulp, grilled pulp and on peels. The levels of total phenols and total flavonoids increased significantly with cooking, while condensed tannins decreased significantly. The most important effect observed was the sharp increase in total flavonoid content by boiling. In conclusion, it would be better to boil the plantain rather than grilling. As the raw peel showed a strong presence of phenolic compounds, it would be more advantageous to cook the pulp with the peel because of the possible transfer of compounds from the peel to the pulp. However, the effect of the cooking processes used in this work could be directly investigated on plantain with peel and without peel to determine which of these processes optimizes polyphenol compounds.

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