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Research Article

ANALYSIS OF THE GOOD TASTE OF FRENCH PLANTAINS COMPARED TO FALSE HORN BANANAS BASED ONTHEIR CONTENT OF CONSTITUENTS OF NUTRITIONAL INTEREST

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Abstract

In terms of world production, bananas and plantains are the fourth largest agricultural product after wheat, rice and corn. They are rich in energy, mineral salts (potassium, calcium, phosphorus) and vitamins (A, B and C). Finally, they play a major role in the food security of populations, particularly in the Democratic Republic of the Congo. Plantain cultivars give several types of diets in which the fingers are in competition. The False Horn plantain has larger fingers than the French plantain. Studies have shown that French plantain has a good taste compared to False Horn plantain. This study was conducted to justify this difference in taste. For this, certain constituents of nutritional interest were dosed. The contents of the constituents that relate to the taste of which the raw proteins and carbohydrates were analyzed. The crude protein content is higher in French plantain green than in False Horn plantain, while the carbohydrate content is lower. The study also showed that the specific surface area exposed to moist heat during cooking of green FalseHorn plantain is smaller than that of French plantain, since the volume of the former is larger. In order to eliminate the gelatinization resistant fraction of the starch during cooking in False Horn plantain, it will be necessary to either extend the cooking time or increase the specific surface area exposed to moist heat by cutting it off before cooking.

Keywords: D.R. Congo, False Horn/ French plantain, energetic constituents, Cooking, The specific surface exposed to moist heat, Taste, Resistant starch, Starch gelatinization.

INTRODUCTION

In terms of world production, bananas and plantains are the fourth largest agricultural product after wheat, rice and maize. Compared to other food crops, their production is second only to cassava. Bananas and plantains are the world's leading fruit crops. They have a high market value and play an important role in improving the income of the population. Indeed, they are rich in energy, mineral salts (potassium, calcium, phosphorus) and vitamins (A, B and C). The Democratic Republic of the Congo is the tenth world producer of bananas and plantains, which play an important role in the food security. (Benoit Dhe'a *et al.,* 2019). In Sub-Saharan Africa, they contribute significantly to the security food as they are one of the main staple foods for more than one hundred million people (Sharrock etFrison, 1998; Emma Assemand, 2012; USDA, 2004). The study on the importance (nutritional, dietary, economic, social...) of bananas and plantains conducted by Picq *et al.* (1998) reports that the plantain banana is the only fruit classified as a starchy consumer product worldwide. The plantain banana or simply plantain, also called cooking banana, of scientific name, Musa paradisiaca L. is the fruit of the plantain banana tree, a plant of the musaceae family. It is a cross between the two species: Musa acuminata and Musa balbisiana. Their cultivars give several types of diets within which the fingers (fruits) are in competition. The apical fingers being larger than those born at the base. Indeed, based on the number of fruits in a bunch, the presence/absence of the male bud, the number of flower layers bearing female flowers (number of hands) as well as the number of differentiated female flowers per hand (number of fingers), a typology of bunches has been established.

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Due to the absence of the male bud and the reduced competition of the fingers within a bunch, True Horn Plantain (bpVC) will have larger fingers than False Horn Plantain (bpFC). Also the latter will have larger fingers than the French type (bpF) (Mbarga, 2013; Dhed'ADjailo *et al.,* 2011). The study carried out is on the choice of plantain plants to be cultivated by farmers by Joseph Adheka Giria (2010) showed that the main criteria justifying their choices are: taste (44.4%), availability of planting material (17.4%), market demand (15.2%) and the size of the bunch (14.4%). For the common man, a food is tasty if it is delicious and sweet. Loïc Briand (2017) reports that when we eat a food, sapid (taste) molecules solubilize in the saliva and activate the taste detectors located in the papillae of the tongue. His work also reports that human beings, like most animals, distinguish four fundamental tastes that are perceived and distinguished: sweet, bitter, acid and salty. The role of sweetness, for example, is to detect energy-rich foods that can be directly assimilated. Apart from these four fundamental flavors, Loïc Briand also reported that there is a fifth fundamental flavor: the umami flavor. Umami derives from Japanese and means delicious. The umami flavor is generated by some amino acids, including glutamic acid or its salt, L-glutamate. Indeed, glutamic acid is the most abundant amino acid in proteins and it helps the tongue to detect protein-rich foods. The same work indicates that humans are also able to detect starch (starchy foods) but that its receptors on the tongue have not yet been identified. Another study by Andrés Giraldo Toro (2015) established that the cooking process increases the in vitro digestibility of plantain starch. Indeed, plantain has starch granules of crystalline type B or C (Zhang *et al.,* 2012). These configurations are known and present a particular resistance to enzymatic attack during digestion (Bordoloi *et al.,* 2012). This resistant starch is not digested in the small intestine by enzymes but ferments in the colon with production of volatile short-chain fatty acids mainly: acetate, propionate and butyrate which protect against certain diseases such as colon cancer (Topping and Clifton, 2001). Cooking is intended to destroy totally and irreversibly (gelatinization) the structure of the starch in rapidly assimilable proportions. Cooking can also destroy this starch in two proportions: one rapidly assimilable and the other resistant to enzymatic attack. Finally, the gelatinization of plantain starch by cooking allows the development of specific organoleptic properties such as texture, taste, color, aromas (Njintang and Mbofung, 2013; Gilbert *et al.,* 2010). This study is conducted in order to justify the qualitative food choice (taste) of French banana compared to False Horn banana. For this purpose, the contents of their constituents of nutritional interest are determined, and then the contents of the constituents providing good taste are compared.

MATERIALS AND METHODS

Material

Plant material: The plant material for the current study consists of four hands of green/ripe plantains including two hands of French plantains and two hands of False Horn bananas. This plant material was purchased in Kinshasa in the Matadi Kibala market.

Equipment: The equipment used in this study of certain constituents of nutritional interest in samples of French and False Horn plantains in the green/ripe state includes: kitchen knife: 1; kitchen basin: 2; Kern emb 500-1 analytical balance, accuracy 0. 1 g: 1; precision analytical balance (Mettler AE100, accuracy 0.001g; tissue packet: 1; Soxhlet apparatus: 1; concentrated H_2SO_4; aluminum capsule: 1; desiccant containing silicagel : 1; Oven (Heraeus):1; Spatula:1; Hot plate brand Luxell:1; Porcelain crucible:1; Fat extractor brand: Velp Scientific:1; Beaker:1; Rotavapor (IKA Janke & KUnkel): 1; 100 mL volumetric flask:1; Nitrogen distiller:1; Pipettes; Magnetic rod:1; Magnetic stirrer:1; Mineralizer (brand: Buchhi, Velp Scientific):1; Reflux assembly (according to Soxhlet): 1; Filter paper (Whatman n01); 250 mL ground-necked flask: 1; pH meter (brand: Hanna Instruments and Mettler Toledo): 1; UV/VIS spectrophotometer VWR UV-6300PC: 1; Wadding; HCl (0.1 N); Tape measure : 1.

Methods

Samples to be analyzed: In this work the samples retained for analysis are the pulp of French and False Horn plantains in green/ripe uncooked state, boiled and cooked in steam.

Preparation of samples for analysis: The samples for analysis in this study are: French and False Horn plantains in the green/ripe state, uncooked, boiled and cooled and finally steam-cooked and cooled. They were prepared according to the method described by (Likengelo *et al.,* 2020). In order to determine each component of nutritional interest in the study, a few g of product was taken from three pulps of the uncooked, boiled and boiled in water French/False Horn/ripened plantains and analyzed using the methods described below. The result obtained is an average with the standard deviation as the error.

Determination of constituents of nutritional interest in the samples: In this work, the constituents of nutritional interest targeted are the energy constituents (contents of water, total ash, crude protein, lipids, total carbohydrates and energy); mineral elements (Ca, Mg, Fe) and vitamins (C, B_6). They will be dosed by the classical methods below.

The water content, H (%) of the recipe samples was determined using the method of dehydration of the samples to constant weight described by Vervack (1982) and then calculated by the relation:

$$H (\%)=(P_2-P_3)/P_e \times 100. \quad (1)$$

With :
H (%): water content of the sample
P_1 (g): weight of empty capsule ;
P_2 (g): weight of capsule with fresh sample ;
P_3 (g): weight of the capsule with sample after steaming;
P_e (g): test sample.

The total ash content was determined by charring followed by incineration Vervack (1982). The total ash content was calculated with the relation :

$$CT (\%)=(C_3-C_2)/ 〚C_2-C_1〛 \times 100 \quad (2)$$

With :
CT (%): total ash content of the sample
C_1 (g): weight of empty crucible ;
C_2 (g): crucible weight with fresh sample ;
C_3 (g): weight of crucible with sample after incineration ;

The fat content of the samples was determined by the Soxhlet method as described by Vervack (1982). The following expression is used to determine the fat content:

$$MG (\%)=(P_f-P_v)/P_e \times 100 \quad (3)$$

MG (%): fat content of the sample
P_f (g): weight of the capsule with fat after evaporation of the solvent;
P_v (g): weight of the empty capsule;
P_e (g): test sample.

Crude protein content was deduced from the determination of total crude nitrogen using the Kjedahl method described by Vervack (1982). It was then calculated using the expression:

$$PB (\%)=((V_a-V_b)x1.4f_c)/P_e \times 100 \quad (4)$$

With :
PB (%): crude protein content of the sample
V_a (mL): Titration volume of acid ;
V_b (mL): Volume of base used (10 mL) ;
F_c: Conversion factor used (6.25) based on the fact that most pure proteins contain approximately 16% nitrogen.
P_e (g): test sample.

The crude fiber content was determined by Kurschner's method based on the attack of organic matter by a mixture of nitric acid and acetic acid described by Vervack (1982). It was then calculated by the relation:

$$FB (\%) = ((P_2-P_1)-(C_2-C_1))/P_e \times 100 \quad (5)$$

With:
FB (%): crude fibre content of the sample
C1 (g): weight of empty crucible;
C2 (g): weight of the crucible after incineration;
P1 (g): weight of filter paper;
P2(g): weight of filter paper with dried and cooled filtrate;

Pe (g): test sample.

For the mineral elements, mineralized solutions were first prepared for each sample recipe. Their total ashes were solubilized in 100 mL Erlenmeyer flasks containing a boiling solution of 10% HNO_3. After cooling, each solution was filtered into a 50 mL volumetric flask using filter paper (Whatman n°1) placed under a funnel. The resulting filtrate was adjusted to the 50 mL volume with distilled water and each solution obtained was used for the determination of the different mineral elements (Vervack 1982).

Ca^{2+}, Mg^{2+} and Fe^{2+} ions were titrated by complexometry with EDTA as chelating agent by adjusting the pH in the presence of a specific indicator. The table below shows the pH range and the indicator used. Iron titration was performed by complexometry at 70°C.

Table 1. pH range and indicator used for mineral titration

Ion	pH	Indicator
Ca^{2+}	12-13	Patton reeder
Mg^{2+}	10	Erriochrome
Fe^{2+}	2-3	Sulfosalicilicacid

The contents of these various trace elements were calculated with the relation below:

% element = (V_t.meq gr [EDTA].100.F_d)/P_e (6)

F_d=V_b/V_p

With :

V_t (mL): titration volume of EDTA used
meq gr : milliequivalent gram of element to be dosed.
F_d : dilution factor
V_b (mL): Volume of the balloon used
V_p (mL): Volume sampled
P_e (g): test sample

As for the dosage of vitamins,

The vitamin Content was determined by iodometry by titrating according to pH conditions, either with a sodium thiosulphate solution or with a solution of di arsenic trioxide of iodine released by the chemical reaction. The vitamin C content is calculated by the following relationship:

Vit C (%) = (V_t.meq gr.[I]).100/P_e (7)

V_t (mL): Volume of 0.1N iodine used
[I] : Iodine concentration (0.1 N)
m eq gr: 88.1 10^{-3} g
P_e (g): test sample

The content of vitamin B_6 was made by the determination of absorbance using a UV/Visible spectrophotometer. The vitamin B_6 content is obtained by the relation:
Vit B_6 (%) = A.10^{-6} /εC (8)

A: Absorbance or optical density.
C (microg/L): Concentration of the absorbent substance
ε(m^3/mol. cm): molar extinction coefficient of the absorbent substance in solution,

Calculation of the volume of plantain pulp for flavor analysis: It has been noted above that the proportion of starch resistant after cooking of plantain banana has an impact on taste. The study by Mahmoud Soltani *et al.* (2011) allows the volume of plantain pulp to be calculated. This volume influences the cooking quality. Indeed, if it is small, its specific surface area exposed to the moist heat produced by cooking is larger and the final product cooks faster than one that has a large real volume but whose specific surface area exposed to moist heat under the same conditions is small. According to Andrés Giraldo Toro, (2015), humid heat propagates in the product according to two mechanisms: capillary diffusion at the beginning of the firing at about 50°C followed by molecular diffusion above 75°C. Thus, with the same cooking time, the greater the volume of the endocarp (pulp), the less the starch gelatinization will be total. We have modelled plantain bananas in ellipsoids whose parameters are: the major axis (length of the pulp), rib and minor axis (diameter of the circumference of the fruit in the middle). These parameters were measured using the tape measure.

The volumes of the endocarps were then calculated by the relation (9) below:

$$V_{ep}=\frac{\pi}{15}.\ C^2\ L. \quad (9)$$

V_{ep} (cm^3): Estimated pulp volume
C (cm): Circumference of the pulp
L (cm): Length of the pulp

RESULTS

These are the contents of the constituents of nutritional interest studied. These values are each an average of three samples each on a pulp with as error the standard deviation. They are grouped in Tables 1, for energy constituents and 2 for vitamins and minerals. Table 3 shows the estimated volumes.

Table 2. Contents of energy constituents in samples of French and False Horn Plantain

	H (%)	C.T (%)	M.G (%)	P.B (%)	F.B (%)	H.C (%)	ENERGY (in Cal.)
Wet samples (uncooked)							
<bpFv>	60,4±0,7	0,55±0,06	2,33±0,15	2,91±0,09	2,91±0,09	32,02±0,22	734,01±9,10
<bpFm>	63,2±0,9	1,07±0,13	0,97±0,01	2,91±0,17	2,91±0,17	31,35±0,25	650,36±16,37
<bpFCv>	0,84±0,02	0,84±0,02	0,35±0,24	2,33±0,15	2,91±0,09	33,83±0,24	683,22±15,80
bpFCm>	1,07±0,13	1,06±0,04	0,38±0,02	0,97±0,01	2,91±0,17	31,92±0,17	685,79±11,15
Boiled samples							
<bpFv>	62,4±0,9	0,65±0,25	1,26±0,80	2,10±0,77	2,78±0,05	28,74±0,37	645,90±16,88
<bpFm>	67,2±0,5	0,81±0,12	0,47±0,23	1,76±0,26	3,91±0,17	34,36±1,33	590,35±21,31
<bpFCv>	63,9±0,8	0,56±0,22	1,01±0,17	1,71±0,07	2,78±0,05	32,79±0,75	645,90±16,88
<bpFCm>	63,8±0,2	0,55±0,29	0,98±0,76	1,88±0,48	3,25±0,15	32,84±0,22	547,63±17,45
Steam-cooked samples							
<bpFv>	63,7±0,5	0,51±0,40	0,89±0,34	1,39±0,60	0,91±0,01	33,47±0,62	532,94±15,87
<bpFm>	61,3±2,2	0,44±0,26	0,68±0,42	1,51±0,37	1±0,04	36,11±2,39	578,21±18,34
<bpFCv>	61,7±1,7	0,44±0,42	0,56±0,03	1,11±0,73	0,63±0,01	36,21±1,37	667,91±24,52
<bpFCm>	61,9±0,7	0,74±0,08	0,96±0,05	1,72±0,74	1,21±0,11	35,09±0,59	646,23±3,85

Table 3. Vitamin and mineral contents of samples of French and False Horn Plantains

	VIT C	VIT B6	Fe^{++}	Mg^{++}	Ca^{++}
		Wets amples (uncooked)			
<bpFv>	39,72±7,90	1,15±0,04	121,05±5,28	436,43±15,59	70,91±9,79
<bpFm>	17,37±0,11	2,32±0,21	66,09±9,42	365,55±15,43	88,83±15,50
<bpFCv>	47,67±7,27	1,19±0,05	225,72±5,73	380,27±17,50	87,19±0,89
<bpFCm>	22,80±4,74	2,28±0,04	68,43±1,79	339,46±18,36	64,06±5,25
			Boiled samples		
<bpFv>	5,870±4,386	11,729±16,318		83,81±27,22	35,545±4,050
<bpFm>	6,734±2,851	2,961±0,675		63,647±24,455	19,42±14,05
<bpFCv>	6,248±1,348	2,336±0,426		68,551±38,448	25,20±9,99
<bpFCm>	9,449±2,411	2,122±0,282		66,203±19,356	30,02±11,45
			Steam-cooked samples		
<bpFv>	8,14±5,53	2,99±1,751		109,81±51,92	41,98±62,73
<bpFm>	9,85 ±2,42	3,30 ±0,375		67,48±19,10	34,41±11,21
<bpFCv>	7,62±0,16	4,20±0,918		81,54±11,57	23,05±11,85
<bpFCm>	19,49±21,07	3,00±0,66		71,12±18,88	30,50±8,76

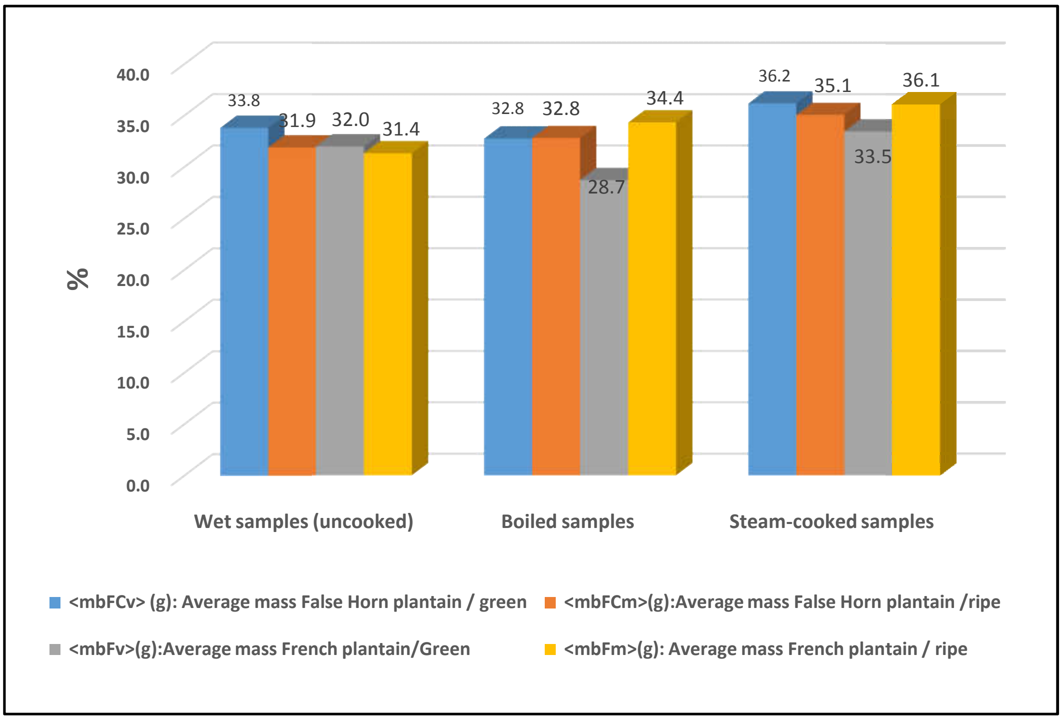

Figure 1. Histogram of carbohydrate content (%) of two types of plantains (French and False Horn)

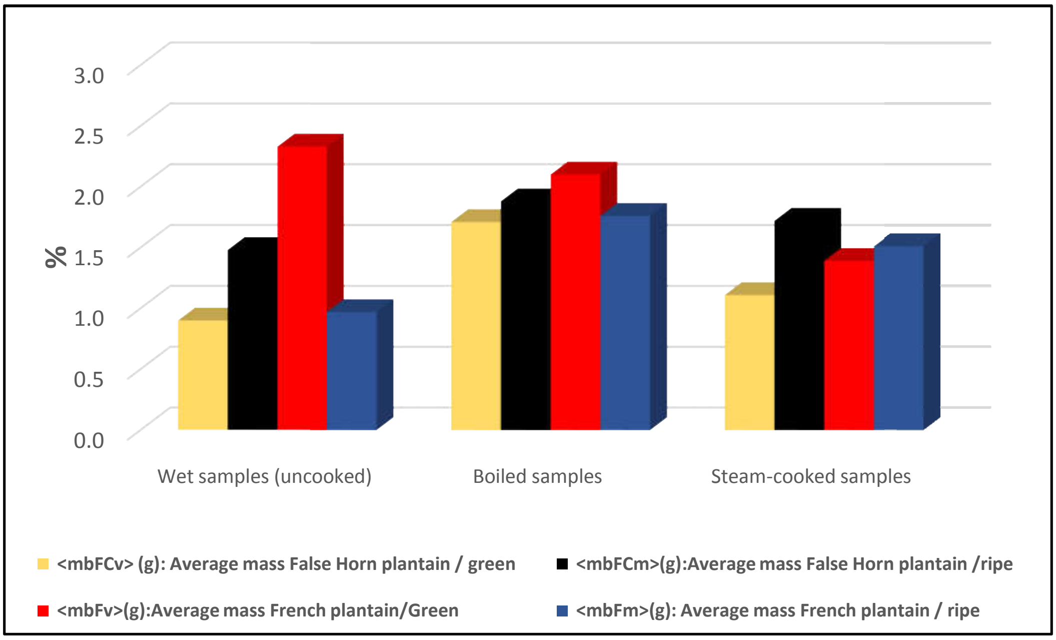

Figure 2. Histogram of protein content (%) of two types of plantains (French and False Horn)

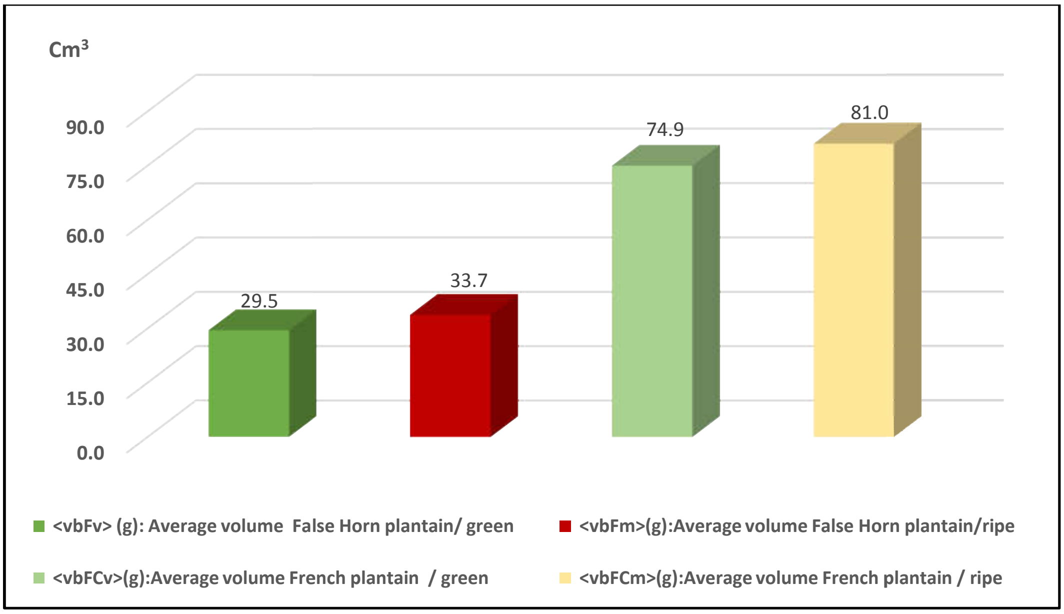

Figure 3. Histogram of volumes (Cm^3) of two types of plantains (French and False Horn)

DISCUSSION

This study conducted in order to justify the qualitative food choice (good taste of French plantain compared to False Horn plantain) shows that :

- The constituents of nutritional interest targeted in the study and grouped in tables 1 and 2 are found in both types of plantains.
- Iron present in the uncooked samples is no longer present in the prepared samples whose results are listed in Table 2. This means that the moist heat of cooking destroys the iron binding sites and the element is percolated into the residual water after preparation.
- The histograms in Figures 1 and 2 show the crude protein and carbohydrate contents of our samples.

They show that:

- The crude protein content in uncooked, boiled and steamed French green stage plantain is higher than that of False Horn plantain. Therefore prepared French plantains are more delicious than False Horn plantains.
- The carbohydrate content of uncooked, boiled and steamed False Horn green stage plantains is higher than that of French plantain. These plantains are therefore less sweet than French plantains. This less sweet taste comes from the fraction of ungelatinized starch when they are cooked under the same temperature and time conditions. Indeed, as shown in the histogram in Figure 3, False Horn plantains have large volumes, therefore small specific surfaces exposed to humid heat which do not allow this heat to diffuse rapidly through the product and gelatinize the starch as in the French plantain. To improve the sweet taste, the starch in False Horn plantains must be completely gelatinized either by prolonging the cooking time or by cutting them into pieces before cooking.

Conclusion

In Joseph Adheka Giria's work cited above, the author showed that farmers prefer to plant plantain cultivars in their fields according to 4 main criteria including: taste (44.4%), availability of planting material (17.4%), market demand (15.2%) and size of the diet (14.4%). In order to explain this preponderant choice related to taste, we measured certain constituents of nutritional interest of French and False Horn plantains in their uncooked, boiled and steamed samples. We then analyzed the contents of the constituents of nutritional interest that contribute to taste: carbohydrates and crude protein. These analyses show that in the uncooked, boiled and steam-cooked green stage samples, the carbohydrate (starch) content is higher in the False Horn plantain than in the French plantain. Assuming that the carbohydrate content represents that of the ungelatinized starch after cooking the fruit in the green state, the fruits of False Horn plantain have less gelatinized starch, therefore are less sweet than the pulp of French plantain. This can be explained by the fact that the volume of the fruits of False Horn plantains is large, their specific surface exposed to humid heat is smaller, therefore a large proportion of ungelatinized starch remains after cooking. In order to improve the taste when cooking, it will be necessary either to cook them longer or to cut them into pieces before cooking to increase their specific surface exposed to the humid heat.

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