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Assessment of Biochemical Composition of Boiled Pulps and Fruits Physical Characteristics of Nine Local Plantain Cultivars (*Musa spp.*)

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Abstract Several local cultivars of plantain cultivated in Côte d'Ivoire resist despite environmental constraints, by their permanent presence in plantations and markets. Fruits of several of these cultivars have not yet been the subject of post-harvest scientific studies. The objective of this work was to determine the post-harvest physical characteristics of the fruits and to follow the effect of cooking for 0, 10, 15, and 20 min on biochemical compositions of nine local plantain cultivars pulps. Physical characteristics of fruits and biochemical compositions of raw and boiled samples were determined using INIBAB Technical Guide methods and standard methods of analyses of AOAC respectively. The results showed that *Banakpa* cultivar regime was the heaviest, with an average of 11.2 kg versus 7.8 kg for the *Banaboi* cultivar, which is the lightest. Cultivars *N'glétia* (85 fingers) and *Olègna* (83 fingers) had more fingers per regime. *Ataplègnon* cultivar had longer, heavier, and bulkier fingers. There were reductions in levels of protein (4.71 to 1.77 g/100 g DM), ash (2.63 to 1.33 g/100 g DM), and lipids (0.75 to 0.47 g/100 g DM) during cooking on the one hand. On the other hand, the carbohydrate (90.96 to 94.04 g/100 g DM), fiber (1.44 to 2.23 g/100 g DM), and energy values (385.42 to 389.40 kcal/100 g DM) increased during cooking. Ultimately, 15 min of cooking would be the right medium for boiling the pulps, to limit the loss of certain nutrients.

Keywords: *plantain, physical, local cultivars, biochemical composition, boiling*

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1. Introduction

Plantains are an important staple crop in West Africa with a high nutritional content, variety of preparation methods, and a production cycle that is less labor-intensive than many other crops [1,2]. They are used as food, beverages, flavorings and cooked foods [3,4]. In African cultures, plantain cultivars are consumed in many forms and are best appreciated by variety. They are foutou, foufou, toh, aloco, claclo, ships, etc. [5]. In Côte d'Ivoire, its production is 1.6 million tons for a local consumption estimated at about 64 kg / per / year [6].

However, environmental constraints such as soil depletion, deficiencies of traditional cropping systems and especially diseases, lead to a decline in plantain production [7,8]. One of the real causes of the spread of diseases is the difficulty of getting healthy young plantain plants [9], resulting the decline in production and even the disappearance of certain cultivars. Solutions are developed such as tissue culture, macro-propagation technology [10,11], which would undoubtedly enhance the cultivation of local plantain cultivars highly appreciated by consumers.

Unfortunately, fruits of many of these cultivars, yet well anchored in the dietary habits of populations have not yet been the subject of genuine scientific study. The objective of this work was to evaluate the physical and biochemical post-harvest characteristics of the fruits of nine local cultivars of plantain in Côte d'Ivoire.

2. Materials and Methods

2.1. Collection of Samples and Preparation

The samples were taken from the experimental plot of the National Center for Agronomic Research (CNRA) in

Azaguié (located 50 km north of Abidjan) in Côte d'Ivoire. The plantains were harvested at the traditional cut, that is, when one of the fingers of the bunch begins to turn yellow or when a crack appears on one of the fingers of the bunch. The vernacular name of each cultivar is *Afoto, Attiébana, Banakpa, Ataplègnon, Banaboi, Banadié, N'gletia, Olègna*, and *Banablé* (Photo 1 to photo 9). The fruits were peeled using a stainless steel knife and the pulps were divided into three batches. The pulps of ten fruits were used by cultivar and cooking time (10, 15, and 20 min). These pulps were cut into 5 cm pieces, then slightly immersed in water about 0.5 cm above the level of the pulp pieces and boiled (100°C) in stainless steel pots on a hot plate (Mia-Germany, Kp 8508, 1500 Watts). The boiled pieces were cut into small pieces 2.5 cm thick and dried in an oven (Memmert, 854 Scwachbach, Germany) at 45°C for 72 hours. A batch of raw pulp was used for each cultivar and then dried under the same conditions as the boiled pulp. The dried samples were ground into a powder, sieved with a 250 µm mesh sieve, then stored at room temperature (25 ± 2°C) in airtight containers for analysis.

Photo 1. Cultivar *Afoto*

Photo 2. Cultivar *Attiébana*

Photo 3. Cultivar *Banakpa*

Photo 4. Cultivar *Ataplègnon*

Photo 5. Cultivar *N'glétia*

Photo 6. Cultivar *Olègna*

Photo 7. Cultivar *Banaboi*

Photo 8. Cultivar *Banadié*

Photo 9. Cultivar *Attiébana*

2.2. Physical Characteristics Analysis

2.2.1. Mass of the Bunch

The mass of each bunch was determined by weighing on a balance (Berkel: maximum range 150 kg, France).

2.2.2. Number of Hands

The number of hands on each bunch was counted and noted.

2.2.3. Number of Fingers

The number of fingers was determined by manually counting the fingers of each hand on the bunch.

2.2.4. Mass of Fruit

The mass (kg) of the finger of each plantain bunch was determined by weighing on a scale (Mettler Toledo, type ME403E, Columbus, Ohio, USA).

2.2.5. Length of Fruit

The length of the fruit generally determined by measuring the outer arc of each fruit with a tape from the distal end to the proximal end, where it is judged that the pulp ends. However, some researchers determine the length of the fingers by measuring the arc of bananas from the junction of the pulp and stem to the apex [12].

2.2.6. Circumference of Fruit

The circumference was determined by measuring each fruit with a tape in its central part, that is to say, there is the thickest.

2.2.7. Volume of Fruit

The volume of each fruit was determined by direct displacement of the volume of water. This method consists to determine in advancethe volume of water in a graduated cylinder. Then the fruit is completely immersed in the water of the test tube. The volume of displaced water is equal to the volume of the fruit in cm^3 [12].

2.2.8. Density (Specific Gravity) of the Fruit

Density or specific gravity of the fruit is determined by dividing the weight of the fruit (measured in the atmosphere) by the volume of fruit [13].

2.2.9. Mass of the Pulp and Skin

The mass of the pulp and skin of each fruit were determined separately using a scale (Mettler Toledo, type ME403E, Columbus, Ohio, USA), after peeling each finger manually.

2.2.10. Ratio Pulp/Skin

The pulp/skin ratio was determined by the quotient of the mass of the fruit pulp by that of its skin.

2.2.11. Thickness of the Skin

The thickness of the skin was measured using calipers. Each fruit was cut transversely in its middle part, manually peeled, and then the thickness of the skin was measured [12].

2.3. Biochemical Parameters Analysis

Dry matter content, protein, crude fat, crude fiber and ash contents of the flours were determined by the standard official methods [14]. Carbohydrate was determined by difference [15]. Total sugars contents were determined according to the method described by Dubois et al. [16] using phenol-sulfuric acid. Reducing sugars contents were determined according to the Bernfeld [17] method using 3,5-dinitro-salicylic acids. Energy value was determined according to the Atwater and Rosa [18] coefficients.

2.4. Statistical Analyses

Analysis of data collected from biochemical and physical characteristics was performed using Statistica 7.1 software. Tukey's test at the 5% threshold was used to classify the means of the experimental factors of the fruits.

All parameters physical were used to perform principal component analysis (PCA). PCA makes it possible, from the correlation of the matrices of the original variables, to extract a small number of linear combinations not correlated between them. The principal components are constructed to account for the largest fraction of the total variance. For the analysis, we retain the first principal components which take into account most of the observed variance. The determination, for each principal component, of the variables which are strongly correlated to it, reveals the original variables which contribute the most to the value of each principal component. The projection of all the individuals along the main axes of the main components makes it possible to appreciate the individuals' dispersion and better compare the variability between the fields.

3. Results

3.1. Physical Characteristics of the Fruits

Physical characteristics of plantain bunches are presented in Table 1. The masses of *Banakpa* (11.2 ± 0.9 kg), *Banablé* (11.0 ± 0.5 kg), *Banadié* (10.3 ± 0.8 kg), *Ataplegnon* (10.5 ± 0.5 kg) and *Attiébana* (11.0 ± 0.3 kg) were not significantly different (p ≥ 0.05). *Banaboi* cultivar bunch mass was the lowest (p<0.05), with 7.8 ± 0.9 kg. The number of hands per bunch of plantain cultivars ranged from 2 (*Ataplègnon*) to 8 (*Banadié*). The *Afoto*, *Banaboi* and *Banablé* cultivars had 6 ± 1 hands, and the *Banakpa*, *Olègna*, *Attiébana* and *N'gletia* cultivars had 7 ± 1 hands. In terms of number of fingers per bunch of these plantain cultivars, statistical analysis revealed that this variation was significant (p<0.05). The *Ataplègnon* cultivar had the lowest number of toes (20) and the *N'gletia* cultivar had the highest number of toes (85).

Table 1. Physical characteristics of plantain bunches

Cultivars	Mass of bunches (kg)	Number of hands	Number of fingers
Banaboi	7.8 ± 0.9^{c}	6 ± 0	23 ± 1^{f}
Banakpa	11.2 ± 0.3^{a}	7 ± 0	36 ± 1^{c}
Banablé	11.0 ± 0.5^{a}	6 ± 1	32 ± 1^{d}
Banadié	10.3 ± 0.8^{a}	8 ± 1	36 ± 1^{c}
Olègna	8.8 ± 0.3^{b}	7 ± 0	83 ± 1^{b}
Ataplègnon	10.5 ± 0.5^{a}	2 ± 0	20 ± 1^{g}
Afoto	10.2 ± 0.8^{ab}	6 ± 1	30 ± 1^{e}
Attiébana	11.0 ± 0.3^{a}	7 ± 0	29 ± 1^{e}
N'glétia	10.3 ± 0.6^{a}	7 ± 1	85 ± 1^{a}

In a column the means followed by the same letter are not significantly different from the Tukey averages comparison test at p ≥0.05.

Physical characteristics of the fruits of the plantain cultivars are shown in Table 2 and Table 3. The finger lengths of these cultivars ranged from 17.4 ± 1.7 cm (*N'glétia*) to 36.2 ± 1 cm (*Ataplègnon*). In addition, cultivars such as *Ataplègnon*, *Banaboi*, *Banablé*, *Banakpa*, *Afoto*, *Attiébana*, and *Banadié* had longer fingers (between 26.8 cm and 36.2 cm). Circumference measurements of the central part of the fingers were between 11.9 ± 0.4 cm (*Olègna*) and 16.6 ± 0.2 cm (*Ataplègnon*). Furthermore, there was no significant difference (p ≥ 0.05) between the finger circumferences of the *Olègna* (11.9 ± 0.4 cm) and *N'glétia* (12.73 ± 0.5 cm) cultivars on the one hand, between *Banakpa* (14.5 ± 0.4 cm), *Banablé* (13.9 ± 0.4 cm), *Banadié* (14.5 ± 0.4 cm) and *Afoto* (13.9 ± 0.4 cm) on the other hand, then that of *Banaboi* cultivars (15.7 ± 0.4 cm) and *Atiébana* (15.27 ± 0.3 cm). The fingers of *Ataplègnon* cultivar were the most voluminous (471.98 ± 1.89 *cm3*). The finger volumes of the different plantain cultivars studied were significantly different (p ≤ 0.05). Concerning density of fruit, it ranged between 0.96 ± 0.01 (*Olègna*) and 1.04 ± 0.01 (*Afoto*). Finger/skin ratios of all cultivars were between 1.21 ± 0.02 (*Olègna*) and 2.11 ± 0.01 (*Banadié*). Masses of *Ataplègnon* cultivar fingers (476.70 ± 0.72 g) were the highest. In addition, the masses of the skin and pulp of the cultivar *Ataplègnon* were the highest (pulp: 277.80 ± 0, 80.42 ± 1.22 g, skin: 197.95 ± 0.25 g) while those of the cultivar *Olègna* were the lowest (pulp: 80.42 ± 1.22 g, skin: 66.33 ± 0.54 g). In terms of yield (Table 4), the *Banadié* cultivar had the highest pulp yield (67.73 ± 0.03%) and the lowest skin one (32.11 ± 0.07%) at the threshold of 5%. On the other hand, the cultivar *Olègna* had the lowest yield of pulp (54.58 ± 0.33%) and the highest yield of skin (45.03 ± 0.22%).

Table 2. Length, circumference, volume and dentsity of the fingers

Cultivars	Finger length (cm)	Finger circumference (cm)	Finger volume (cm^{3})	Finger dentsity
Banaboi	29.8 ± 1.4^{b}	15.7 ± 0.4^{ab}	396.68 ± 1.81^{b}	0.98 ± 0.01^{c}
Banakpa	29.1 ± 1.5^{b}	14.5 ± 0.4^{c}	336.37 ± 0.87^{d}	1.01 ± 0.02^{b}
Banablé	29.3 ± 1.2^{b}	13.9 ± 0.4^{c}	322.59 ± 1.39^{e}	1.03 ± 0.02^{ab}
Banadié	27.7 ± 1.3^{b}	14.5 ± 0.4^{c}	273.95 ± 1.98^{f}	1.02 ± 0.01^{ab}
Olègna	22.6 ± 1.0^{c}	11.9 ± 0.4^{d}	153.47 ± 1.36^{h}	0.96 ± 0.01^{c}
Ataplègnon	36.2 ± 1.0^{a}	16.6 ± 0.2^{a}	471.98 ± 1.89^{a}	1.01 ± 0.01^{b}
Afoto	28.7 ± 1.2^{b}	13.9 ± 0.4^{c}	271.88 ± 1.37^{f}	1.04 ± 0.01^{a}
Attiébana	27.90 ± 1.9^{b}	15.3 ± 0.3^{b}	353.43 ± 1.74^{c}	0.97 ± 0.01^{c}
N'glétia	17.43 ± 1.7^{d}	12.7 ± 0.5^{d}	162.94 ± 1.95^{g}	1.02 ± 0.01^{ab}

In a column the means followed by the same letter are not significantly different from the Tukey averages comparison test at p ≥0.05.

Table 3. Pulp/skin ratio, thickness of skin, finger mass, pulp mass and skin mass

Cultivars	Pulp/skin ratio	Thickness of skin (cm)	Finger mass (g)	Pulp mass (g)	Skin mass (g)
Banaboi	1.62 ± 0.01^{d}	0.3 ± 0.1^{a}	388.76 ± 0.99^{b}	240.49 ± 0.67^{b}	147.57 ± 0.52^{b}
Banakpa	1.66 ± 0.03^{d}	0.3 ± 0.1^{a}	340.03 ± 1.41^{c}	212.09 ± 1.75^{d}	127.34 ± 1.46^{c}
Banablé	1.80 ± 0.01^{c}	0.3 ± 0.1^{a}	332.28 ± 1.14^{d}	213.50 ± 0.61^{d}	118.34 ± 0.55^{d}
Banadié	2.11 ± 0.01^{a}	0.4 ± 0.1^{a}	280.33 ± 0.62^{e}	189.86 ± 0.42^{e}	90.03 ± 0.02^{e}
Olègna	1.21 ± 0.02^{g}	0.3 ± 0.1^{a}	147.33 ± 1.46^{g}	80.42 ± 1.22^{h}	66.35 ± 0.53^{g}
Ataplègnon	1.40 ± 0.01^{e}	0.4 ± 0.2^{a}	476.70 ± 0.72^{a}	277.80 ± 0.56^{a}	197.95 ± 0.25^{a}
Afoto	1.36 ± 0.02^{ef}	0.3 ± 0.1^{a}	282.76 ± 1.85^{e}	162.48 ± 0.75^{f}	119.57 ± 1.35^{d}
Attiébana	1.91 ± 0.01^{b}	0.3 ± 0.2^{a}	342.80 ± 1.55^{c}	225.01 ± 0.92^{c}	117.59 ± 1.09^{d}
N'glétia	1.34 ± 0.03^{f}	0.4 ± 0.1^{a}	166.19 ± 1.19^{f}	94.82 ± 1.08^{g}	70.98 ± 0.79^{f}

In a column the means followed by the same letter are not significantly different from the Tukey averages comparison test at p ≥0.05.

Table 4. Fruit yield in pulp and skin

Cultivars	Pulp yeld (%)	Skin yeld (%)
Banaboi	61.86 ± 0.03[e]	37.96 ± 0.09[d]
Attiébana	65.64 ± 0.20[b]	34.30 ± 0.23[g]
Banakpa	62.38 ± 0.41[d]	37.45 ± 0.42[e]
N'glétia	57.05 ± 0.34[h]	42.71 ± 0.55[b]
Banadié	67.73 ± 0.03[a]	32.11 ± 0.07[h]
Banablé	64.25 ± 0.07[c]	35.61 ± 0.11[f]
Olègna	54.58 ± 0.33[i]	45.03 ± 0.22[a]
Afoto	57.46 ± 0.43[g]	42.29 ± 0.22[b]
Ataplègon	58.28 ± 0.05[f]	41.53 ± 0.05[c]

In a column the means followed by the same letter are not significantly different from the Tukey averages comparison test at p ≥0.05.

Table 5. Fruit yield in pulp and skin

	Axis 1	Axis 2
Number of hands	0,647357	-0,449082
Number of fingers	**0,923187**	0,158395
Mass of bunch	-0,198645	**-0,833195**
Finger mass	**-0,994393**	0,056847
Pulp mass	**-0,984596**	-0,052412
Skin mass	**-0,941451**	0,227967
Finger length	**-0,92168**	0,053428
Finger circumference	**-0,950712**	0,033325
Thickness of skin	-0,534943	-0,1461
Finger density	-0,104182	-0,665813
Pulp/skin ratio	-0,364351	-0,637403
Finger volume	**-0,989786**	0,101346

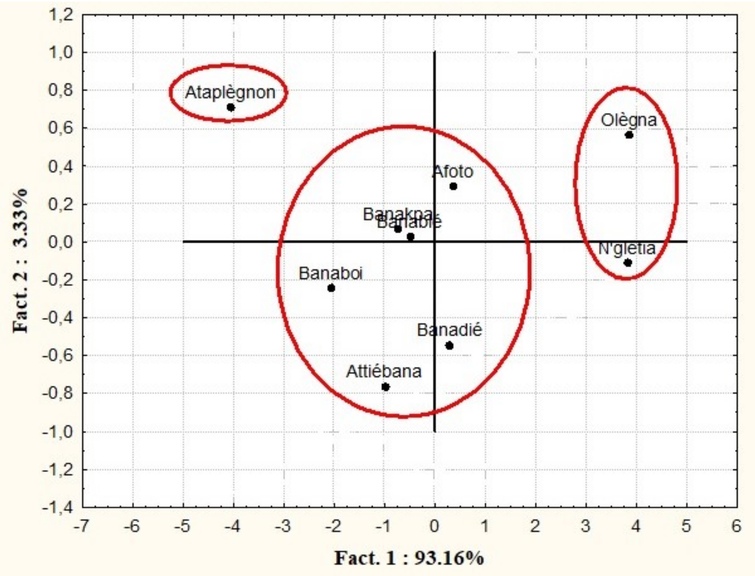

Figure 1. Nine plantain cultivars projection in the plane formed by the factorial axes 1 and 2

PCR made from the 12 parameters analyzed for each cultivar allowed to retain two axes (axis 1 and 2) which explain 60.98% of the variability of the physical parameters (Table 5). These factorial axes 1 and 2 respectively express 93.16% and 3.33% of the variability of all the physical parameters (Figure 1). Thus, the approximation of the cultivars according to these two axes on the basis of the relationships between the physical parameters reveals three groups of plantain. The first group consists of the cultivar *Ataplègnon*, the second group includes the cultivars *Banaboi*, *Attiébana*, *Afoto*, *Banakpa*, *Banablé*, and *Banadié* and the third group is composed of cultivars *Olègna* and *N'glétia*.

3.2. Biochemical Parameters of the Pulps

Protein content of the cooked pulp of the different plantain cultivars decreased significantly (p <0.05) as the cooking time increased (Figure 2). Indeed, before cooking, protein levels ranged from 4.71 ± 0.22 g / 100 g DM (*Afoto*) to 3.02 ± 0.26 (*Ataplègnon*). After 10 min of cooking the pulps, the protein contents were between 3.70 ± 0.02 g / 100 g MS (*Afoto*) and 2.10 ± 0.10 g / 100 g DM (*Ataplègnon*). These levels of protein reached values ranged from 3.50 ± 0.10 g / 100 g DM (*Afoto*) to 1.90 ± 0.10 g / 100 g DM (*Ataplègnon*) when the cooking time is 15 min. The decline in protein levels continued at 20 min of cooking and the values recorded were between 3.17 ± 0.06 g / 100 g DM (*Afoto*) and 1.77 ± 0.12 g / 100 g DM (*Ataplègnon*). Except for cultivars *Ataplègnon*, *Attiébana*, and *Banakpa*, lipid levels of all other cultivars did not decrease significantly (p ≥ 0.05) during boiling (Figure 3). The lipid contents of these three cultivars (*Ataplègnon*, *Attiébana* and *Banakpa*) ranged respectively from 0.72 ± 0.01 g / 100 g DM, 0.69 ± 0.01 g / 100 g DM, 0.62 ± 0.01 g / 100 g DM before boiling to 0.69 ± 0.02 g / 100 g DM, 0.61 ± 0.01 g / 100 g DM and 0.56 ± 0.01 g / 100 g DM after 20 min of cooking. Concerning ash contents of boiled pulps of plantain cultivars, results indicated a significant decrease (p <0.05) when cooking time increases (Figure 4). These rates ranged from 2.63 ± 0.06 g / 100 g DM (*Banadié*) to 1.99 ± 0.01 g / 100 g DM (*Banaboi*) before cooking and then from 2.31 ± 0.02 g / 100 g DM (*Banadié*) to 1.44 ± 0.02 g / 100 g DM (*Afoto*) after 10 min of cooking. After 15 min of cooking, the ash levels obtained ranged from 2.09 ± 0.02 g / 100 g DM (*Banadié*) to 1.36 ± 0.02 g / 100 g DM (*Afoto*). However, falls observed between 10 and 15 min were seven times less for the *Afoto* cultivar, 2 times less for *Banaboi* and *Banakpa* cultivars, and about 1 time less for the other cultivars compared to the falls observed after 10 min of cooking. Rates decreases observed after 20 min of cooking were almost identical to that observed between 10 and 15 min. The rates thus, pass to values between 1.98 ± 0.01 g / 100 g DM (*Banadié*) and 1.33 ± 0.03 g / 100 g DM (*Afoto*).

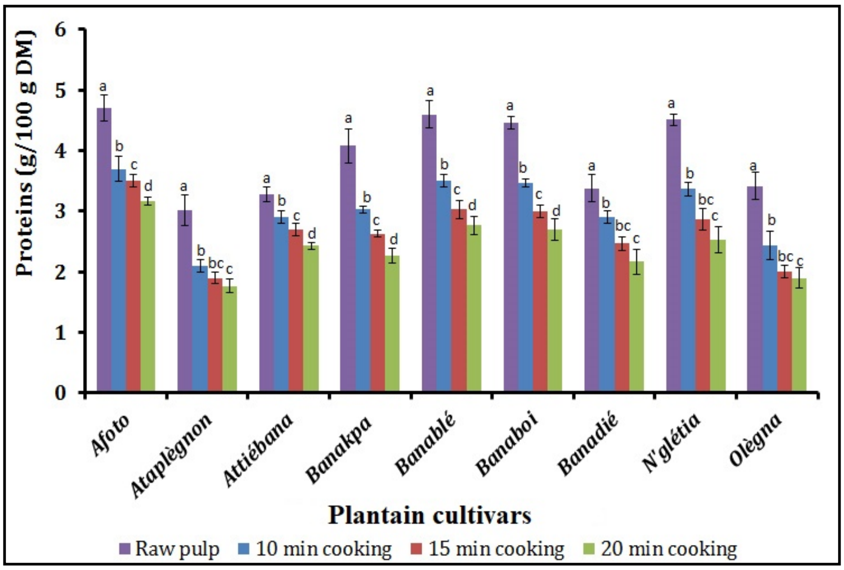

Figure 2. Levels of proteins of the boiled pulp of nine local plantain cultivars (Means, represented by bands ± standard deviation with different letters at a cultivar level, indicate a significant difference at $p < 0.05$ according to the Tukey test)

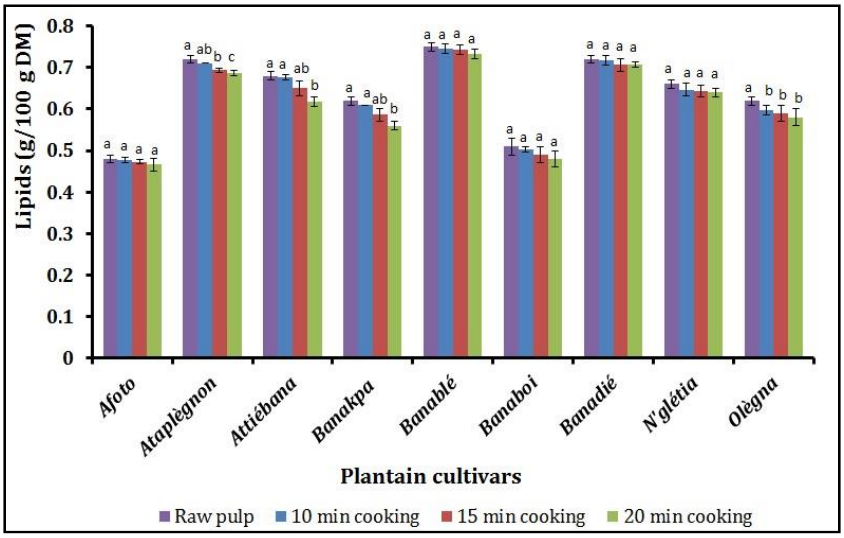

Figure 3. Levels of lipids of the boiled pulp of nine local plantain cultivars (Means, represented by bands ± standard deviation (symbolized by I) with different letters at a cultivar level, indicate a significant difference at $p < 0.05$ according to the Tukey test)

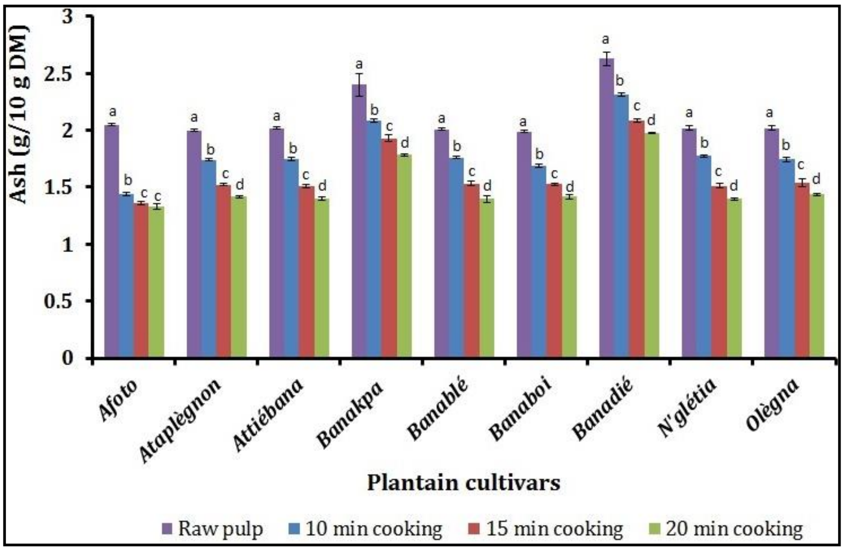

Figure 4. Levels of ash of the boiled pulp of nine local plantain cultivars (Means, represented by bands ± standard deviation with different letters at a cultivar level, indicate a significant difference at $p < 0.05$ according to the Tukey test)

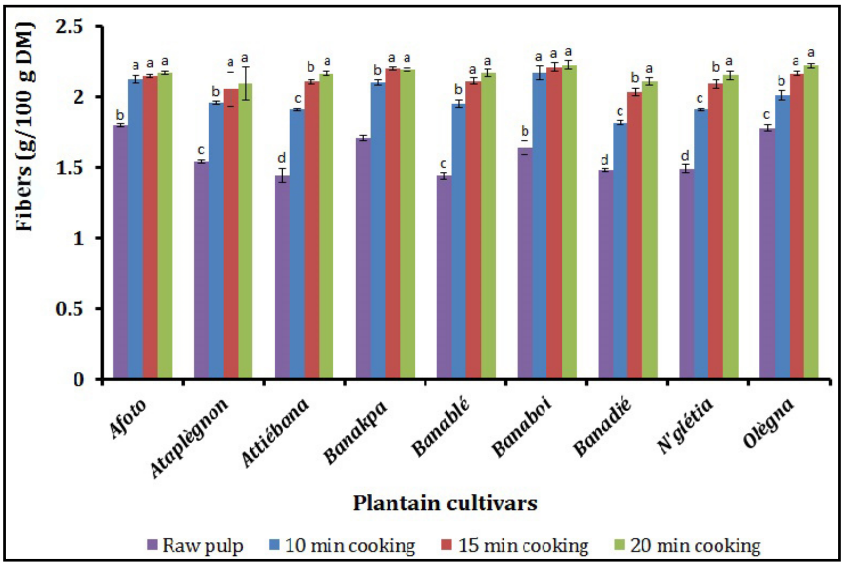

Figure 5. Levels of fibers of the boiled pulp of nine local plantain cultivars (Means, represented by bands ± standard deviation with different letters at a cultivar level, indicate a significant difference at $p < 0.05$ according to the Tukey test)

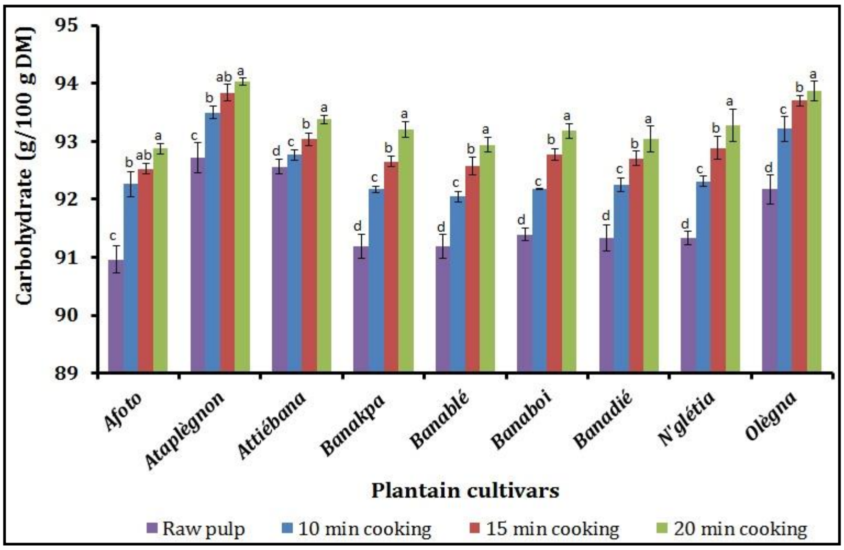

Figure 6. Levels of carbohydrate of the boiled pulp of nine local plantain cultivars (Means, represented by bands ± standard deviation with different letters at a cultivar level, indicate a significant difference at $p < 0.05$ according to the Tukey test)

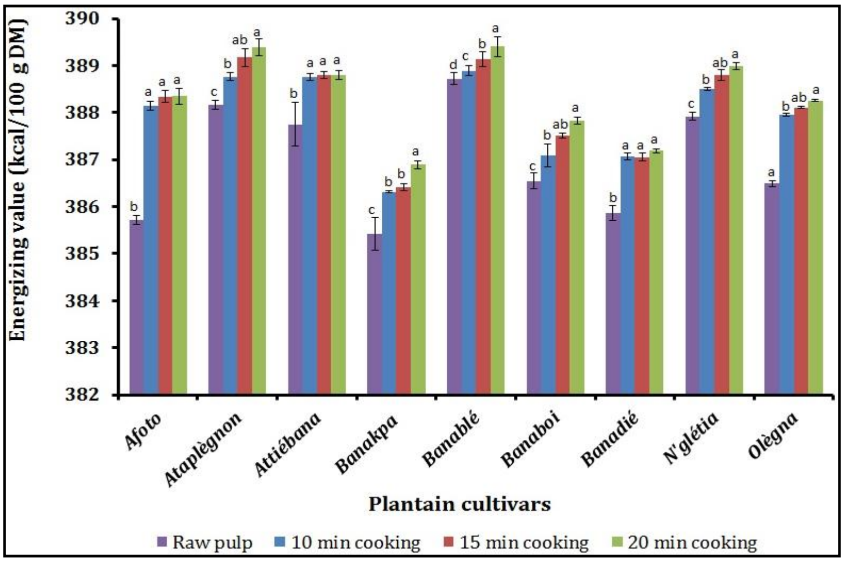

Figure 7. Levels of energy value of the boiled pulp of nine local plantain cultivars (Means, represented by bands ± standard deviation with different letters at a cultivar level, indicate a significant difference at $p < 0.05$ according to the Tukey test)

Fiber content of plantain pulps increased significantly (p <0.05) during boiling (Figure 5). Before cooking, the contents were between 1.44 ± 0.02 g / 100 g DM (*Banadié*) and 1.80 ± 0.01 g / 100 g DM (*Afoto*). However, after 10 min of cooking, the rates ranged to values between 1.82 ± 0.02 g / 100 g DM (*Banadié*) and 2.17 ± 0.05 g / 100 g DM (*Banaboi*). At 15 min of cooking, fiber levels increased significantly (p <0.05) for all cultivars, except *Afoto* (2.12 ± 0.01 to 2.15 ± 0.02 g / 100 g DM) and *Banaboi* (2.17 ± 0.03-2.21 ± 0.03 g / 100 g DM) which remain constant. At 20 min of cooking, only the rates of the cultivars *Attiébana* (2.11 ± 0.02 to 2.17 ± 0.05 g / 100 g MS), *Banadié* (2.03 ± 0.01 to 2.11 ± 0.01 g / 100 g DM) and *N'glétia* (2.09 ± 0.01 to 2.15 ± 0.03 g / 100 g DM) showed a significant increase (p <0.05).

Carbohydrate levels of pulp increased significantly (p <0.05) for all cultivars after 10 min of cooking (Figure 6). These levels ranged between 90.96 ± 0.24 g / 100 g DM (*Afoto*) and 92.71 ± 0.26 g / 100 g DM (*Ataplègnon*) before boiling, reaching values of between 92.04 ± 0.10 DM (*Banablé*) and 93.49 ± 0.11 g / 100 g DM (*Ataplègnon*) after 10 min of cooking. At 15 min of cooking, the values evolved from 92.52 ± 0.09 g / 100 g DM (*Afoto*) to 93.83 ± 0.14 g / 100 g DM (*Ataplègnon*). At 20 min of cooking, the levels increased significantly (p <0.05) and reached values ranged from 92.87 ± 0.24 DM (*Afoto*) to 94.04 ± 0.26 g / 100 g DM (*Ataplègnon*).

Energy values of the pulp of these plantain cultivars increased significantly (p <0.05) after 10 min of cooking (Figure 7). These values ranged from 385.42 ± 0.44 kcal / 100 g DM (*Banakpa*) to 388.72 ± 0.13 kcal / 100 g DM (*Banablé*) before cooking evolve and reached values between 386.32 ± 0.02 kcal / 100 g DM (*Banakpa*) and 388.89 ± 0.11 kcal / 100 g MS (*Banablé*). At 15 min of cooking there was a significant increase (p <0.05) in the energetic values of cultivars such as *Ataplègnon* (388.76 ± 0.19 to 389.17 ± 0.18 kcal / 100 g DM), *Banablé* (388.89 ± 0.16 to 389.13 ± 0.21 kcal / 100 g DM), *Banaboi* (387.09 ± 0.05 to 387.50 ± 0.08 kcal / 100 g DM), *N'glétia* (388.50 ± 0.12 to 388.99 ± 0.07 kcal / 100 g DM) and *Olègna* (387.96 ± 0.02 to 388.11 ± 0.02 kcal / 100 g DM). At 20 min of cooking, only the energy values of *Afoto*, Attiébana, and *Banadié* cultivars remained constant, but *those* of all other cultivars increased significantly (p <0.05). The energy values ranged from 386.89 ± 0.08 kcal / 100 g DM (*Banakpa*) to 389.38 ± 0.18 kcal / 100 g DM (*Ataplègnon*) after 20 min of cooking.

4. Discussion

The masses of each of the nine plantain cultivars are close to those of the plantain Africa (11.8 kg) and CRBP 39 (11 kg) varieties obtained by Coulibaly et al. [19] and higher than the cultivar *Apantu pa* (7.8 kg) obtained by Annor et al. [20] and to most of those varieties studied by Fernande et al. [21]. The number of fingers of the cultivars N'glétia (85 fingers) and Olègna (83 fingers) were superior to those of hybrids PITA 3 and PITA 8 (59 fingers) reported by Kouadio et al. [22] and CRBP 39 (70 fingers) obtained by Coulibaly et al. [19]. On the one hand, they are close to those of the hybrids FHIA 21 (89 fingers) obtained by Coulibaly [19]. Differences in the physical parameters of the regime from one cultivar to another are due to climatic conditions, soil types and to the characteristics of each cultivar [23]. Indeed, the mass of regimes and the presence of many fingers on the regime are assets, since it allows obtaining a better yield to the production per area and thus contributing to the increase of the income of the producers.

The fingers of these cultivars are longer than those of hybrids FHIA 21 (21.1 cm), PITA 3 (26 cm) and PITA 8 (26.5 cm), and those of FHIA 3 (17.5 cm), FHIA 19 (23 cm) and FHIA (22.5 cm) reported by Orellena et al. [24], Kouadio et al. [22] and Annor et al. [20], respectively. Except the fingers of *Olègna* cultivar, the circumferences of the fingers of all the other cultivars are superior to those of the hybrids FHIA 21 (11.5 cm), CRBP 14 (10.9 cm) and CRBP 39 obtained by Coulibaly [19] and Orellena et al. [24]. All cultivars studied had larger fingers than CRBP 14 (112.6 cm3), FHIA 21 (120.6 cm3), CRBP 39 (134.7 cm3), PITA 3 (200.7 cm3) and PITA 8 (203 cm3) studied by Coulibaly [19] and Kouadio et al. [22], except the fingers of the cultivars Olègna (153.47 cm3) and N'glétia (162.94 cm3) which are less voluminous. Length, circumference, and volume of fruits are factors that influence the commercialization of plantain because consumers are most often attracted by the size and length of fruits as observed at the Ataplègnon cultivar. Variation of fruits densities from one cultivar to another would be related to the mineral composition of these fruits [19]. These densities are close to those of the FHIA 21, CRBP 14, CRBP 39 and Orishélé cultivars obtained by Coulibaly [19], whose values vary from 1.02 to 1.04 and also those of PITA 3 and PITA 8 (1.0) reported by Kouadio et al. [22]. Pulp/skin ratios of all cultivars are similar to those of PITA 3 and PITA 8 (1.7), then those of hybrids FHIA 19 (1.24) and FHIA (1.45) respectively obtained by Kouadio et al. (2013) and Annor et al. [20]. Moreover, fingers skin thicknesses of cultivars Banadié, Ataplègnon and N'glétia (0.4 cm) are almost identical to those of the hybrids CRBP 14 (0.38 cm), FHIA21 (0.38 cm), PITA 3 and PITA 8 (0.4 cm) obtained by Coulibaly [19] and Kouadio et al. [22]). Indeed, according to Stover and simmonds (1987), pulp/skin ratio and skin thickness of the fruits represent a reliable indicator of the maturity of bananas. Except the finger masses of the cultivars Olègna (174.33 g) and N'glétia (166.2 g), all of the cultivars have fingers whose average mass is significantly higher than that of the CRBP 39 hybrids (135.6 to 192.3 g), FHIA 21 (124.5 g), PITA 3 (196.8 g) and PITA 8 (200 g) whose average finger mass is 20 g [19, 22]. Otherwise, the cultivars Banadié, Attiébana, Banablé, Banakpa, Banaboi and Ataplègnon have better pulp yields (58.28 to 67.73%) than those of the plantain hybrids FHIA 21, CRBP 14, CRBP 39 with rates ranging from 52% to 56.4% [19]. Indeed, when the yield of skin is higher than an average of 40%, the amount of waste produced is very high and thus represents a significant loss when the products are destined for industrial purposes [25]. Heterogeneity observed between the physical parameters of the fruits of the plantain cultivars studied is designed during fruit growth and depends fundamentally on the activity of the functional leaves present during the appearance of the inflorescence [26].

The decrease in protein rates could be attributed to protein solubilization and diffusion in cooking water [27]. These results are consistent with those of Adeniji et al. [28] and Adepoju et al. [29], who also observed a decrease in protein levels in Plantain (Musa paradisiacea) and plantain hydrides during cooking. Some low fat contents of the pulps would be melted by heat during boiling in the cooking water, resulting in a reduction in the lipid content observed in the boiled pastes [30]. The decrease in ash rates during cooking may be due to the leaching of minerals in boiling water. This implies that the potential capacity of these plantains to supply essential minerals is reduced when duration of cooking is prolonged [21]. These observations are in agreement with those of Adepoju et al. [29] and Tsamo et al. [32] on boiled plantain cultivars. Moreover, the increase in raw fibers could be explained by their concentration in the pulps following the leaching of certain soluble constituents during boiling (Inyang et al., 2015). Concerning carbohydrates, the rates being made by difference, the reduction of the components such as lipids, ashes and proteins would be a cause of the increase in the carbohydrate content in the cooked pasta relative to the dry matter. The increase of the energy values of boiled pulps would be linked to the increase of the carbohydrate content, the main energy source of pulp of these plantains.

5. Conclusion

Each of nine plantain cultivars studied have physical characteristics that can give them good market value. Except cultivars Olègna and N'glétia, whose fingers are short and less bulky, all other cultivars can better compete with the hybrids designed to be productive and resistant. In addition, these Olègna and N'glétia cultivars have high finger numbers per regime and can compete with the hybrid for which this factor is a main feature. Although results on cooking pulps show reduced levels of certain nutrients, it is necessary to ensure proper digestion of plantain. Pulp boiling results in a slight reduction of the levels of lipids, proteins and ash. Moreover, cooking increases the carbohydrate content and allows an increase of energy values of the boiled pulps. Thus, cooked pulps could be useful for the energetic needs of consumers. Cooking the pulps during 20 min further affects the nutritional quality of the pulps. In order to avoid the massive loss of nutrients, it would be ideal to boil the pulps for 15 min.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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