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Physical characteristics of some banana plantain cultivars (*Musa* spp.) consumed in Benin

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Caracteristiques physiques de quelques cultivars de bananes plantains (*Musa* spp.) consommés au Bénin

Résumé : Les plantains (*Musa* spp) sont les plantes horticoles les plus cultivées en Afrique de l'Ouest. Diverses variétés et cultivars sont produits au Bénin. Cette étude a évalué les caractéristiques physiques et certains paramètres de la composition proximale des cultivars de plantain couramment consommés au Bénin. Les paramètres physiques, notamment le poids du régime, le nombre de mains et de doigts, le poids des mains et des doigts, le pourcentage de la pulpe et le rendement en farine ont été évalués pour cinq cultivars de plantain (*Aloga, Aloga2M, Gnivlan, Kpahissi, Orishel*e) et pour une banane à cuire (*Pelipita*). De plus, les paramètres de couleur, la teneur en matière sèche ainsi que la teneur en minéraux totaux ont été évalués sur la pulpe des différents cultivars. Les résultats ont montré que les régimes provenant de *Kpahissi* étaient plus lourds et ont plus de mains que les autres cultivars tandis que le cultivar *Aloga 2M* avait les mains et les doigts beaucoup plus lourds que ceux dérivant des autres cultivars. Le nombre de doigts variait de 2 à 12 pour les six cultivars. Le pourcentage en pulpe variait de 51,3 à 70,71%. Concernant les paramètres de couleur, la pulpe de *Kpahissi* était plus brillante mais moins jaunâtre et rougeâtre que la pulpe des autres cultivars. Des différences significatives ont été observées au niveau de la teneur en matière sèche et en minéraux totaux des pulpes avec les valeurs les plus élevées observées pour la pulpe de *Pelipita*. Cette étude fournit une base de référence pour la diversité du plantain en termes de caractéristiques physiques au Bénin. Les résultats peuvent aider les consommateurs à mieux choisir les régimes de plantain au cours de l'achat.

Mots clés : plantes horticoles, plantain, poids, rendement en farine, matière sèche.

Abstract: Plantains (Musa spp) are among the most important cultivated horticultural crops in West Africa. Various varieties and cultivars are produced in Benin. This study aimed at evaluating the physical characteristics and some proximate composition of some plantain cultivars consumed in Benin. Physical parameters including weight of the bunch, number of hands and fingers, weight of hands and finger, pulp percentage and flour yield were assessed using five cultivars of plantain (*Aloga, Aloga 2M, Gnivlan, Kpahissi, Orishele*) and one cooking banana (*Pelipita*). In addition, color parameters, dry matter as well as total minerals contents were assessed for the pulp of the various cultivars. It came out that *Kpahissi* cultivars had heavier bunches and a lot of hands than the other cultivars while *Aloga 2M* had the highest weight of hands and fingers. Finger number varied from 2 to 12 among the six cultivars. The pulp percentage ranged from 51.3 to 70.71%. *Kpahissi* pulp was brighter but less yellow and red than the other pulps cultivars. Significant differences were observed in dry matter and total minerals contents of pulps with highest values for *Pelipita* pulp. This study provides baseline information on plantain

diversity in terms of their physical characteristics in Benin. Results can be helpful in the choice of plantain bunches during purchasing.

Keywords: Horticultural crops, plantain, weight, flour yield, dry matter.

1. Introduction

Plantain is grown in many countries in the world and is considered to be one of the most important sources of energy for people living in the production area. In Sub-Saharan Africa, plantain contributes significantly to food security and provides more than 25% and 10% of the daily intake of carbohydrates and calories, respectively, for more than 70 million people (IITA, 2000). In 2017, Western African production of plantain stands at nearly 39 million tons, with an overall mean growth rate of 1.7% per year, due to an increase in cultivated area combined with an increase in yields (FAOSTAT, 2019). This crop plays an important role in food and nutritional security providing means for income diversification and tools for poverty reduction (Ajayi & Aneke, 2002; Ngoh Newilah et al., 2005).

Plantain fruits are edible and are generally used for cooking. The fruits are consumed unripe (green mature), yellowish-green (fairly ripe), or fully ripe after boiling, steaming, roasting or deep frying (Ngoh Newilah, 2005; Baiyeri et al., 2011). They are often associated with various ingredients during cooking. The unripe fruits are also processed into flour for different utilization. This flour is used as alternative local sources of flour baking and in many local cooking recipes (Ngoh Newilah, 2005).

In Benin, annual production of plantain is around 19 000 tons (Chabi et al., 2018), coming mainly from the Southern and Central regions of the country. This crop plays a significant role in local economy and contributes to satisfy nutritional requirement of population where it is widespread. Despite its economic and nutritional importance, the opportunity attached to plantain is overlooked since this crop is subject to no real development policy. Around 14 local varieties and cultivars as well as hybrid varieties are produced and sold at various stages of ripeness in different local markets (Gandonou et al., 2012; Chabi et al., 2018). Varieties and cultivars such as *Aloga, Aloga 2M, Gnivlan, and Kpahiss*i amount to more than 80% of the total production followed by *Orishele*, and *Pelipita* varieties (Chabi et al. 2018; Kpenavoun Chogou et al. 2019). Most of these varieties and cultivars are easily commercialized due to some characteristics favored by consumers such as the heavier of the bunch, the size of the fingers, the color and the firmness of the pulp (Kpenavoun Chogou et al., 2019). However, data on the physical characterization of varieties and cultivars as well as their flour yield are sometime lacking. Most of these information could help consumers to make better choice during plantain purchasing for different end uses. In other hand, knowledge on flour yield of different varieties and cultivars may help processors to make better choice during plantain purchasing for flour production. In addition, this characterization is important in order to cluster these cultivars in morphotypes. This study aimed at assessing the physical characteristics and flour yield of plantain fruit of some cultivars commonly consumed in Benin.

2. Methodology

2.1. Samples preparation

Five cultivars of plantain commonly produced in Benin such as *Aloga, Aloga 2M, Gnivlan, Kpahissi, Orichele,* and one cooking banana *Pelipita* (Figure 1) were selected because of their availability on the markets and their high demand. Three bunches of each cultivar were randomly harvested at the commercial stage (mature and unripe) in the farm of "Cité de Banane" located in Zè municipality in the Southern Benin.

2.2. Physical characteristics

Bunch weight of each cultivar was recorded using a Salter scale India Ltd (±5 g). The number of hand per bunch for each cultivar was counted and their weight was taken using a Salter scale India Ltd (±5 g). The number of fingers on each hand was counted. The weight of each finger (three fingers per hand) was taken using an electronic balance (±0.1 g). The pulp weight was determined; in fact, three fingers of each hand were washed and peels were removed; the weight of each pulp was recorded using a Salter scale (±0.1 g). The pulp percentage of each cultivar was determined by using the formula developed by Dadzie & Orchard (1997):

$$Pulp\ (\%) = \frac{Weight\ of\ pulp\ of\ fingers * 100}{Weight\ of\ fingers}$$

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Aloga	*Aloga 2M*	*Gnivlan*	*Kpahissi*	*Orishele*	*Pelipita*

Figure 1: Pictures of the different cultivars

Yield of flour: Flour was produced from pulp of each cultivar after slicing (2-3 mm of thickness) and oven-drying at 55°C during 5 hours, followed by cooling, milling and sieving. The yield of flour per cultivar was determined by using this formula:

$$Yield\ of\ flour\ (\%) = \frac{Weight\ of\ flour\ after\ sieving * 100}{Weight\ of\ fingers\ used\ to\ process\ the\ flour}$$

Color characteristics of fresh pulp were carried out using a Hunter colorimeter (Hunter Associates Laboratory Inc. Reston. VA. USA) on the basis of L*, a* and b* values (AOAC, 2002). Dry matter and total minerals contents of the fresh pulp were assessed by using the standard methods of analysis (AOAC, 2002).

2.3. Statistical analysis

Results were expressed by means of values ± standard error of three separate determinations. Comparison of means was performed using one-way analysis of variance (ANOVA) followed by Tukey test ($p < 0.05$). Statistical analyses were run using the computer IBM SPSS Statistic 2020.

3. Results and discussion

Most producers and consumers of cooking banana and plantain usually prefer large size bunches with large or small size fingers and/or long or short fingers (Dadzie & Orchard, 1997). Therefore, assessment of bunch weight and fruit characteristics such as fruit weight, length, circumference and volume are important post-harvest selection criteria. Physical characteristics of plantain cultivars are summarized in Tables 1 and 2 as well as in Figure 2. The bunches weight varied from 5.14 to 15.32 kg. Heaviest bunches were found for *Kpahissi* cultivars (15.32 kg) and the lower bunches were found for *Gnivlan* cultivar (5.14 kg) (Table 1). Apart from the cultivar of *Kpahissi* which bunches were significantly heavier than others, all of the other cultivars studied had bunches weight between 5 and 7 kg, higher than the 4.7 kg of weight of most local landrace of plantain (Agbagba/False Horn) produced in Nigeria, and lower than those found for different hybrid (FHIA and TMP) varieties of plantain (Ferris et al., 1999; Annor et al., 2016). The differences observed among cultivars bunches weight are probably related to the nature of the cultivars; all of the cultivars were harvested in the same field and agro ecological conditions were the same during their production.

The number of hands on the bunch varied from 2 (*Aloga 2M*) to 10 (*Kpahissi*) among the six cultivars. Apart from *Aloga 2M* and *Kpahissi*, the other cultivars had 5 to 7 hands on theirs bunches (Table 1). The hands' numbers on different bunches were similar to those found in Nigeria and Ghana for local and TMP hybrids varieties of plantain (Ferris et al., 1999; Annor et al., 2016). Mean values of weight of hands ranged from 0.71 kg (*Gnivlan*) to 2.69 kg (*Aloga 2*M). Two of the cultivars had their hands weight less than 1 kg. There was significant difference in hands' weight between the cultivars (Table 1). This observation is due to the number of fingers of *Gninvlan* cultivar which is smaller (2-3) than the other and the small size of the fingers of the cultivar of *Pelipita*. The higher the number of fingers, the heavier is the weight of the hand.

The minimum number of fingers per hand varied from 2 (*Gnivlan*) to 10 (*Pelipita*) and the maximum number varied from 3 (*Gnivlan*) to 12 (*Pelipita*) (Figure 2). *Pelipita* cultivars had more fingers which were less heavier than the remaining cultivars. Mean weight value of fingers for all cultivars varied from 73.35 g (*Pelipita*) to 324.04 g (*Aloga 2M*) (Table 1). The small size of *Pelipita's* fingers is the cause of the low weight observed for such fingers. Apart from the weight of *Pelipita's* fingers which were less than 100 g, fingers of the other cultivars had a weight greater than 200 g. These values of fingers weight were higher compared to the fruits weight (100 g-160 g) of TMP hybrids varieties in Nigeria (Ferris et al., 1999).

Table 1: Physical characteristics from 6 plantains varieties

Parameters	*Aloga*	*Aloga 2M*	*Gnivlan*	*Kpahissi*	*Orishele*	*Pelipita*
Bunch weight (kg)	6.41±0.2^{b1}	7.13±0.2^{b}	5.14±0.3^{b}	15.32±0.8^{a}	6.55±0.4^{b}	5.56±0.3^{b}
Number of hand	5±1	2±0	6±1	10±0	6±0	6±1
Hand Weight (kg)	1.51±0.4^{c}	2.69±0.4^{a}	0.71±0.3^{d}	2.03±0.6^{b}	1.65±0.5^{bc}	0.80±0.3^{d}
Fingers weight (g)	266.01±72.1^{bc}	324.04±80.6^{a}	295.50±81.2^{b}	271.52±26.1^{b}	220.49±20.5^{c}	73.35±9.4^{d}

[1] mean±standard error of mean; means followed with the different letters in the same row are significantly different ($p<0.05$)

Table 2: Yield in pulp and flour from 6 plantains varieties

Parameters	Aloga	Aloga 2M	Gnivlan	Kpahissi	Orishele	Pelipita
Pulp (%)	57.8±5.6^{b1}	60.8±6.3^{b}	70.7±4.6^{a}	50.4±5.8^{bc}	53,5±2.8^{b}	51.3±3.4^{bc}
Flour yield (%)	23.4±0.9^{b}	33.4±0.7^{a}	27.1±0.5^{a}	21.7±0.6^{b}	29.1±0.4^{a}	32.1±0.8^{a}

[1] mean±standard error of mean; means followed with the different letters in the same row are significantly different ($p<0.05$)

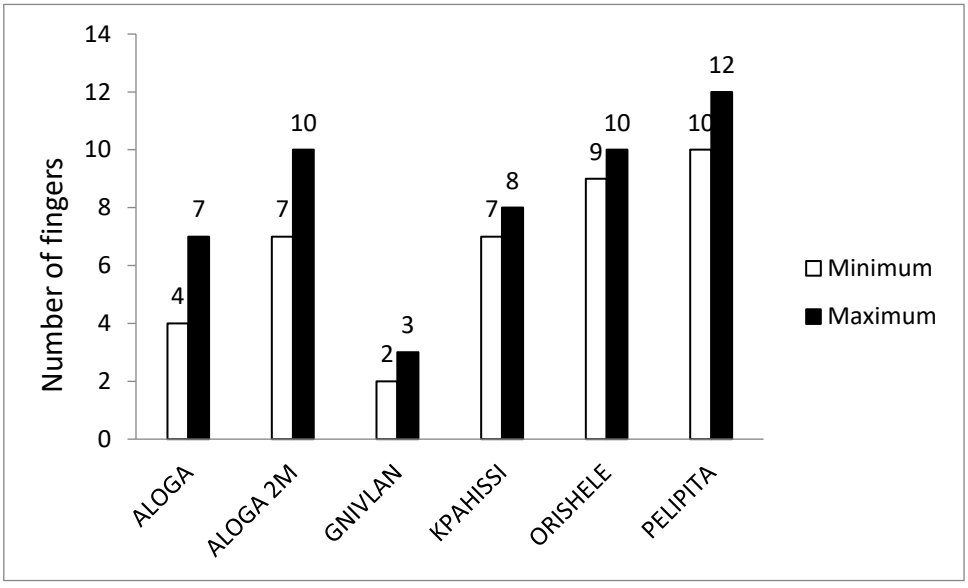

Figure 2: Maximum and minimum number of fingers per hand of plantains cultivars

High percentage of pulp was found for *Gnivlan* (70.7%) followed by *Aloga 2M* (60.8%) while *Pelipita* (51.3%) had the lowest yield of pulp (Table 2). The difference observed is due to the peel weight which varied from one cultivar to another. With the same formula, the rates of pulp found were in line with those found for locals and TMP hybrids varieties in Nigeria (Ferris et al., 1999). Flour yield of different cultivars varied from 21.7% (*Kpahissi*) to 33.4% (*Aloga 2M*) (Table 2). Generally, flour yield is correlated to the dry matter and the weight of the first matter. With regard to this result, cultivars such as *Aloga 2M, Gnivlan* and *Pelipita* would be more suitable to produce flour than the other 3 cultivars.

Colors of fresh pulp were characterized by the brightness (L*), yellowness (b*) and redness (a*). The L* value was significantly affected by plantain cultivars ($p<0.05$); L* values ranging from 66.1 (*Orishele*) to 94.04 (*Kpahissi)* (Table 3). In contrary, the highest value of yellowness was found with pulp of *Orishele* and the lowest value found with the pulp of *Kpahissi*. Positive and significant values of a* were found for various pulps ranging from 3.92 (*Kpahissi)* to 9.77 (*Pelipita*). These results showed that *Kpahissi* pulp was lighter but less yellow and red than the other cultivars' pulps. The lighter generally measures the witness of food product (Wainwright and Hughes, 1989); thus, the lighter of *Kpahissi* pulp may reduce the yellowness of such pulp. However, consumers associate the whiteness of the pulp to the immaturity of the plantain (Dadzie & Orchard, 1997); thus, if the pulp color of plantain is

white, consumers feel that the fruit is immature and if the pulp color is orange/yellow, it indicates that the fruit is mature. Yellow and red colors of fruit and legume are generally associated to the presence of carotenoids (Britton & Khachik, 2009); then, high values of b* and a* in *Orishele*, *Pelipita* and *Aloga 2M* pulp may indicate a high content of carotenoid. However, the color of plantains' pulps contributes more to the assessment of quality by consumers. ΔE indicated total color difference among the three parameters of color; its values ranged from 19.94 (*Kpahissi*) to 31.69 (*Orishele*). Overall, the colors of plantain pulp is related to the cultivar and varied from beige with many nuances to orange (John & Marchal, 1995; Dadzie & Orchard, 1997.).

Plantain pulp dry matter content is important post-harvest quality criteria since it provides a measure of the water content and information in determining whether increased yield is due to higher water content or due to genuine increase in harvested weight which is useful for plant breeders (Dadzie & Orchard, 1997). Dry matter content of fresh pulps of the 6 unripe cultivars varied from 28.88% (*Kpahissi*) to 40.16% (*Pelipita*) (Table 4). These different values were in line with those found for hybrids (FHIA) varieties (Annor et al., 2016). In contrast, these values were different from that recorded in *Agbagba* (local landrace in Nigeria) and TMP hybrids varieties of plantain with dry matters ranging between 31 to 36% (Ferris et al., 1999). In general, dry matter of the pulp is positively correlated with the flour yield. Thus, the more the dry matter content of pulp, the more the flour yields will be. This assumption is in line with the flour yield found for various cultivars.

Ash content represents the total minerals. Its values varied from 0.54% (*Aloga*) to 0.89% (*Pelipita*) in fresh pulps of cultivars (Table 4). Significant differences were observed between the ash content of the 6 cultivars. Mean values of ash in various cultivars were lower than those found in FHIA hybrids varieties (Annor et al., 2016). With these values, *Pelipita* might have a highest amount of minerals.

Table 3: Color characteristics of pulp from 6 plantains varieties

Parameters	Aloga	Aloga 2M	Gnivlan	Kpahissi	Orishele	Pelipita
*l**	87.26±0.25^{b1}	68.09±0.01^{c}	85.26±0.20^{b}	94.04±0.12^{a}	66.10±0.01^{c}	87.75±0.14^{b}
*a**	7.62±0.04^{ab}	5.20±0.02^{b}	7.39±0.06^{ab}	3.92±0.08^{c}	5.12±0.01^{b}	9.77±0.09^{a}
*b**	17.94±0.20^{c}	25.84±0.05^{a}	20.92±0.17^{b}	15.91±0.54^{c}	26.91±0.01^{a}	23.15±0.40^{ab}
ΔE	17.67±0.08^{b}	31.46±0.03^{a}	20.58±0.07^{b}	19.94±0.38^{b}	31.69±0.01^{a}	22.58±0.35^{b}

[1] mean±standard error of mean; means followed with the different letters in the same row are significantly different ($p<0.05$)

Table 4: Moisture and ash contents of fresh pulp from 6 plantains varieties

Parameters	Aloga	Aloga 2M	Gnivlan	Kpahissi	Orishele	Pelipita
Dry matter (%)	28.88±0.27^{b1}	38.85±0.13^{a}	29.78±0.17^{b}	28.53±0.21^{b}	39.66±0.14^{a}	40.16±0.08^{a}
Ash (%)	0.54±0.05^{b}	0.82±0.04^{a}	0.73±0.01^{ab}	0.69±0.07^{ab}	0.74±0.01^{ab}	0.89±0.08^{a}

[1] mean±standard error of mean; means followed with the different letters in the same row are significantly different ($p<0.05$)

5. Conclusion

Regarding the physical characteristics such as bunch, hand and finger weights, as well as hand number, *Kpahissi* and *Aloga 2M* were the best cultivars. In terms of pulp color, *Pelipita* and *Aloga 2M* seem to be the best ones. *Aloga 2M* and *Gnivlan* may be more profitable in terms of the pulp percentage and could be recommended for flour production. This study showed that some physical characteristics can be used to select plantain during purchasing with regards to consumers preferences.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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