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Influence of Peasant Conservation Methods on the Organoleptic Quality of Plantains (Musa Spp) in the City of Man in Western Côte D'ivoire

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ABSTRACT

The main objective of ourstudyis to assess the influence of peasant conservation methods on theorganoleptic quality of plantains (Musa spp) in the city of Man, a large plantain-producing region in the Ivory Coast.A survey carried out among planters and wholesalers of the plantain sector in the town of Man, allowed us to list three main storage methods, namely:storage under trees, storage with jute bags, and finally the storage of plantains in the leaves of plantains.The storage method most used in this municipality is storage in the shade of trees. The method of storing in the shade of trees has a green lifespan of between 14 and 21 days while the methods of storing in hessianbags and coveringwith plantain leaves have the same green lifespan of between 3 and 5 days.After the investigation wascarried out, samples were taken to determine the physical and biochemical properties during the identified storage. The different peasant conservation methods have had an impact on the biochemical and physicalproperties of the plantains used. During storage, wenoticed losses in mass, firmness, and dry matter, but on the other hand an increase in the content of reducing sugars, the change in the skin color from green to yellow in stored plantains.

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INTRODUCTION

Plantains are Musaceae grown mainly for their fruits and contribute to food security (Temple et al., 2000; Nkendah, 2001).These fruits are the staple food for the populations of the East, South and West of Côte d'Ivoire (N'guessan et al. 1993; FAO, 2013). Ivorian production is estimated at 1.7 million tonnes and represents the third most important food product (FAOstat, 2017). Its cultivation is especially widespread in Côte d'Ivoire in the humid forest zone, south of a line passing near the towns of Bondoukou-Bongouanou-Dimbokro-Bouaflé-Daloa-Man and Danané (Thiémélé et al., 2017). Plantains are fragile fruits and evolvevery quickly after harvest to reach full maturity (Guillemot, 1976). Under tropical conditions, with an ambient temperature of 30°C, plantains ripen between 4 and 6 days after harvest (Yao and Kamenan, 1989). Most of the time, bananas are ripe when they arrive at the markets. The annual losses of plantains in Côte d'Ivoire are estimated at 40% (FAO, 2013).These losses are mainly linked to poor harvesting, transport, and storage conditions (Lépengué, 1999, FAO, 2013, FAOstat, 2017).The conservation of plantains is a relatively little-studied area given the importance they can have in the regularization of supplies for urban markets, the disposal of any over production in certain regions and at certain times of the year (dry season), and transport problems in general (road infrastructure, poor adaptation of transport to the product, etc….(Anonymous, 1985; Soudain et al., 1987). Some experiments have been carried out for the conservation of plantain bananas:

- The use of polyethylene bags for the conservation of plantain bananas in Côte d'Ivoire has shown that it is possible to extend the green life of plantain bananas at room temperature. The retention times obtained are between 14 and 18 days (Yao et al., 2014),

- packing plantains in airtight plastic and stored at temperaturesbelow13.5°C extended their lifespan by 19.33 days (Narayana et al., 2002),

- storage of plantains at temperatures between 8°C and 12°C and modification of the interior atmosphere of warehouses (Varopquaux et al., 2002),

- refrigeration of plantain bananas by icing, misting or forced air, modulation of vapor pressures, or cooling rates of enclosures (Varoquaux et al., 2002),

- pre-treatment of plantains by washing in chlorinated water and packing them in polythene bags increased their shelf life by more than 60 days in cold storage (at temperatures between 10°C and 15°C) (Chen et al. al., 2000),

- the preservation technique used in the West: reduction of O_2 levels and increase of CO_2 levels in warehouses (Chamara et al., 2000),

- cold storage (8°C) with 95 to 100% relative humidity of horned plantains made it possible to extend their shelf life for 21 days without significantly disturbing the presentation and tasting of the fruits (Anonymous, 1985), etc.

However, these plantain conservation techniques can incur high costs that are incompatible with peasant farms (Lépengué et al., 2010; Yao et al., 2014). The application of post-harvest technology generally has two objectives: the preservation of quality (appearance, consistency, flavor, nutritional value, and safety) and the reduction of losses caused between harvest and consumption (Kaanane, 1998). Proper management during the post-harvest period is rather better than the use of advanced technology (Kaanane, 1998). The main objective of our study is to assess the influence of peasant conservation methods on the organoleptic quality of plantains (Musa spp) in the town of Man in western Côte d'Ivoire. This will specifically be:

- ✓ inventory of the traditional methods of plantain conservation in the commune of Man;
- ✓ Assess the effect of preservation methods on the organoleptic quality of plantains.

I-MATERIALS AND METHODS

I-1-Plant material

The plant material used is plantain (Musa x AAB). These are three local varieties namely: French type bananas, True Horn type bananas, and False Horn type bananas whichwere the subject of our study. These three varieties are the most cultivated and the most marketed in the Man region (Thiémélé et al., 2017).

I-1-1-Geographical location of the city of Man

This study was conducted in the town of Man. The city of Man is located in the west of Côte d'Ivoire, at a latitude of 7° 24' North and a longitude of 7° 33' West. This city is bounded to the north and west by the city of Biankouman and Danané, and the south by Bangolo (Figure 1). It is a mountainous and forested area with a mountain climate, a long rainy season, and a short dry season favoring the formation of dense forest. The commune of Man is one of the major plantain producing regions in Côte d'Ivoire (Kouassi Koffi, 2005;Thiémélé et al., 2017).

Figure No1: Geographical location of the city of Man

I-2- Methods

I-2-1- Survey method

To begin this study, we first carried out fieldwork lasting three (3) months, combining weekly monitoring in four markets in the city of Man: the large market of Koko, the Blon Blaise market in the CAFOP district, the market in the Libreville district and that of the Thérèse district) in collaboration with planters based around the city of Man. This field study was carried out with

survey sheets. It took place in four districts of the city of Man, namely: Koko, CAFOP, Libreville, and the Thérèse district. In these different districts, the planters and wholesalers were very cooperative in answering the various questions asked relating to the method of conservation, the materials used for conservation (biological, chemical, technical, etc.), and also the shelf life of the plantain for each method.

I-2-2-Sampling

A survey was conducted among 100 planters and 100 wholesalers known to the plantain sector in the city of Man. These planters were identified by information received from wholesalers located in the main market of Man and the areas of high production of plantain bananas located around the town of Man. At each planter and wholesaler identified and visited, two (2) bunches of plantain bananas were taken at the beginning and the end of storage after the appearance of a ripe finger. It should also be noted that during the storage period, five (5) plantain fingers are taken every two days from each planter and wholesaler identified and transported to the laboratory for analysis. A total of 400 bunches were sampled and analyzed in the laboratory to determine the physical and biochemical parameters of stored plantains.

I-2-3- Analytical methods

I-2-3-1- Determination of physical and biochemical characteristics

The mass of the fruit (of each cultivar) was determined by weighing on a balance (Berkel: minimum capacity 100 g and maximum capacity 100 kg). Skin color is assessed using the dessert banana color scale defined by Wainwright and Hughes (1989; 1990).Pulp firmness was determined using a penetrometer according to the method described by Dadzié and Orchard (1997). The water content was determined by drying an aliquot of the pulp and the skin for 2 hours at 130°C.The loss of integrity of bananas was measured from the conductivity of the tissues of their epidermis according to the method of Lépengué et al., (2008). The extraction of reducing sugars was done according to the method described by Martinez-Herrera et al. (2006) and the dosage of reducing sugars were made according to the method described by Dubois *et al*., (1956).

I-2-3-2- Statistical analyzes

The analysis of the physical and biochemical parameters was carried out using the XLSTAT 7.5.3 software. The comparison of the means was made according to Duncan's test at the 5% threshold.

II-RESULTS AND DISCUSSION

1-Identified storage methods

1-1-Results

The different storage methods with their percentage and green lifespan are listed in Table 1. According to Table 1, we have listed three main storage methods, namely: storage under trees, storage with jute bags, and finally storage of plantain fruits in plantain leaves. The method of storage under trees is the most used (60%) with a green life of between 14 and 21 days. The second most used method (25%) is that made in plantain leaves with a green life of between 3 and 5 days. Storage in jute bags is less used (15%) with a green life of between 3 and 5 days.

Table 1: Different storage methods identified

Storage method	Storage undertrees	Storage with jute bags	Storage under plantain leaves
Number of people	120^{a}	50^{b}	30^{c}
Percentage (%)	60^{d}	25^{e}	15^{f}
Green life (days)	$14\text{-}21^{g}$	$3\text{-}5^{h}$	$3\text{-}5^{h}$

Values in the same row followed by different letters show significant differences ($p<0.05$). Each value is the mean of the results obtained over 5 determinations ± standard deviation of this mean.

1-2-Discussion

Storage under trees would be the method most used by growers and wholesalers in the locality of Man this method, planters tend to harvest fruits from early plantains. This harvesting method is

identical to that used by Kouadio Kouakou et al., in2013, who claimed that harvesting plantains at an early stage one week after the optimum cutting point for plantains would extend the green life of plantains. The early harvest according to some identified planters would be due to the strong temperate climates and also to the cultivation on the sides of the mountains. Indeed, the locality of Man is a mountainous and forested area with a mountain climate, a long rainy season, and a short dry season (CNRA, 2009).The green life of plantains stored under trees is identical to that obtained by Loa et al., in 2017 on the storage of French and Horn type plantains and that of Yao et al., in 2014 on Affoto cultivars (Horn 1) and Orishélé which is between 14 and 18 days. Horn-type plantains gave green lives of 13-14 days and French-type plantains 17-18 days respectively with the 0.235 and 0.303 mm thick wrappers. Storage methods with jute sacks and under plantain leaves have similar short green lifespans. These short green lifespans are thought to be due to the high heat produced by the jute bags and the plantain leaves on the stored fruits. Indeed, storage conditions play an important role in the rate of ripening of plantains (Soler and N'Da Adopo, 1991). The stage of ripeness at which fruit is harvested greatly influences the green life, or the ability of the fruit to be stored for a long period, and its final taste quality (Harman, 1981; Kader 1994).

2-Physical and biochemical characteristics of stored plantains

Knowledge of the physical and biochemical changes associated with ripening would be an important contribution to the establishment of an appropriate conservation technology that would delay ripening and preserving the quality of the fruit (Kouamé et al., 2010) hence the need to determine the physical and biochemical characteristics of plantain fruits before and after storage. The physical characteristics of plantain fruit bunches and fingers before and after storage are reported in Table 2.

2-1-Results

The fingers of plantain bunches of the Vrai Corne variety are the heaviest with an average mass of 450±2.8 g. The fruits of plantain bananas of the French and False Corne varieties are the weakest with masses between 320±1.5 and 330±1.9 g. These physical characteristics observed on the fingers of the plantains studied are identical to those observed by Thiémélé et al., in 2017 on these same cultivars. These authors noticed that French, False Horn, and True Horn type

plantains had different finger masses between them. Bananas of the True Horn cultivar were the heaviest than those of the French and False Horn types.

The fruits of the False Horn and True Horn varieties are firmer than the fruits of the French variety. The fruits of the False Horn and True Horn varieties have identical and highest firmness (13.5-14 N). The fruits of the False Horn and True Horn cultivars have identical and the lowest dry matter content ([34.2; 34.8%]). While that of French plantains is the highest at 38.8%.

The 3 varieties of plantain bananas studied have the same reducing sugar content of between 0.8 and 1.2 g/100 g DM before storage. These levels of reducing sugars are relatively very low.

Table 2: Physical and biochemical characteristics of plantain fruits during storage

	Fruit mass (g)	Firmness (N)	Dry Matter Rate (%)	Level of reducing sugars (g/100 g DM)	Color of the skin
French DS	$320\pm1,5^{a}$	$11,5\pm0,9^{g}$	$38,8\pm0,4^{f}$	$0,6\pm0,4^{h}$	Green
French SA	$210\pm1,3^{b}$	$9,3\pm0,6^{e}$	$26,4\pm1,5^{g}$	$35,5\pm1,4^{z}$	Yellow
French SFB	$106\pm1,7^{b}$	$7,2\pm0,6^{r}$	$23,2\pm0,6^{h}$	$36,2\pm0,6^{i}$	Yellow
French SSJ	$110\pm1,4^{c}$	$11,2\pm0,7^{g}$	$21,4\pm0,5^{l}$	$36,4\pm0,2^{i}$	Yellow
True Horn DS	$450\pm2,8^{c}$	$13,5\pm0,3^{q}$	$34,8\pm0,8^{u}$	$0,4\pm0,7^{m}$	Green
True Horn SA	$318,7\pm1,5^{a}$	$11,1\pm0,9^{g}$	$23,2\pm1,8^{h}$	$35\pm0,8^{i}$	Yellow
True Horn SFB	$198\pm1,2^{d}$	$9,7\pm0,3^{e}$	$20,7\pm0,4^{k}$	$34,6\pm0,7^{i}$	Yellow
True Horn SSJ	$155\pm1,7^{S}$	$12,5\pm0,3^{v}$	$21,2\pm0,6^{l}$	$35,1\pm0,6^{z}$	Yellow
False Horn DS	$330\pm1,9^{d}$	$14\pm0,5^{q}$	$34,2\pm0,7^{u}$	$0,5\pm0,5^{h}$	Green
False Horn SA	$198,3\pm1,6^{b}$	$11,7\pm0,7^{g}$	$22,5\pm1,1^{l}$	$36\pm1,1^{i}$	Yellow
False Horn SFB	$103,3\pm1,4^{b}$	$9,1\pm0,7^{e}$	$20,3\pm0,3^{k}$	$35,2\pm0,6^{i}$	Yellow
False Horn SSJ	$170,5\pm1,6^{t}$	$10,8\pm0,5^{w}$	$21,6\pm0,4^{l}$	$35,6\pm0,8^{s}$	Yellow

SA: Storage undertrees; **SFB**: Storage under plantain leaves, **SSJ**: Storage with jute bags, **DS**: Beginning of storage,

Values in the same column followed by different letters show significant differences ($p<0.05$). Each value is the mean of the results obtained over 5 determinations ± standard deviation of this mean.

2-2-DISCUSSION

These physical characteristics observed on the fingers of the plantains studied is identical to those observed by Thiémélé et al., in 2017 on these same cultivars. These authors noticed that French, False Horn and True Horn type plantains had different finger masses between them. Bananas of the True Horn Vrai Corne cultivar were the heaviest than those of the French and False Horn types.

This difference in firmness was observed by Loa et al., in 2017 on the French (11 N) and Horn 1 Corne 1 (14 N) cultivars before their conservation.

This difference in firmness between the False Horn, True Horn, and French cultivars is linked to their dry matter content (Bugaud et al., 2011).Indeed, according to these authors, any fruit that is less acidic and has a high dry matter content is less firm than one with a low dry matter content. Also, the dry matter content of bananas is an interesting sensory quality indicator because of its major role in fruit firmness and Brix (Géraldine, 2012).

These low-sugar contents show that the onset of starch hydrolysis has not yet taken place (Collin and Dalnic, 1991). Indeed, the accumulation of reducing sugar levels in plantain fruits is linked to the hydrolysis of starch (Terra et al., 1983; Cordenunsi et al., 1995).However, starches are the most important component of plantain fruit pulp in the green ripening state (Happi Emaga et al., 2008).

The various results obtained show us changes in the physical and biochemical characteristics of the plantain fruits studied. During storage, we noticed losses in mass, firmness, and dry matter but on the other hand an increase in the content of reducing sugars, the transfer of the color of the skin from green to yellow of the stored plantains. However, these physical and biochemical changes are very accentuated at the level of storage with covering of fruits with banana leaves and with jute bags. These changes observed during storage correspond to the ripening of plantain fruits (Happi Emaga et al., 2007a and Happi Emaga et al., 2008).Indeed, fruit ripening

corresponds to a set of biochemical and physiological changes leading to the state of maturity and conferring on the fruit its organoleptic characteristics (Brady, 1987).The very accentuated physical and biochemical changes at the level of storage by covering fruits with plantain leaves and with jute bags would be due to the high temperature caused by banana leaves and jute bags. Indeed, too high a temperature accelerates water loss and premature aging which triggers maturation (Abeles et al., 1992, Soler and N'Da Adopo, 1991). Too much humidity favors the development of fungi which will cause wounds (anthracnoses) on the fruits and lead to their ripening (Soler and N'Da Adopo, 1990).

CONCLUSION

Surveys carried out among growers and wholesalers in the plantain sector in the locality of Man, allowed us to report three main storage methods in this case: storage in the shade of trees, storage with jute bags, and that by covering plantains with plantain leaves. Storage in the shade of trees would have the best green life. The different storage methods would have had an impact on the physical and biochemical characteristics of the plantains used. During storage, there were losses of mass, firmness, and dry matter but on the other hand an increase in the levels of reducing sugars, the transfer of the color of the skin from green to yellow of the stored plantains.

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