

Storing Plantain Using A Traditional Cold Jar

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Abstract.

Optimizing the use of plantains depends not only on increasing its production but also on improving post-harvest operations before it reaches the final consumer. Proper management during the post-harvest period is better than using advanced technology. The main objective of this study is to preserve plantains in a traditional cold pot in the locality of Man. To carry out this experiment, we used a device consisting of a large pot containing a small pot and clay filling the space between the pot and the large pot. This device, commonly known as the “desert fridge”, has enabled us to obtain green lifespans for the Corne 1 and Agnrin cultivars of between 15 and 22 days. During our conservation, the physical and biochemical characteristics of plantains were determined. The analyzes revealed a slight lower mass loss: Horn 1 (6.85 ±0.2%) and Agnrin (7.4 ±0.5%), loss of firmness and dry matter, reduction in starches and dietary fiber. 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.

Keywords: Preservation, refrigerating pot, traditional, Horn 1 and Agnrin.

I. INTRODUCTION

Plantain is a food crop of great food and economic importance in the humid tropical and intertropical forest zones (Kwa and Temple, 2019). Its production has increased considerably in recent years (FAOstat, 2019). However, optimising its use depends not only on increasing production but also on improving post-harvest operations before it reaches the final consumer (Fao, 2007). Plantains, as you know, are fragile fruits and ripen very quickly after harvest to reach full maturity (Guillemot, 1976; FAOstat, 2017). Under tropical conditions, ambient temperature at 30 °C, plantains ripen between 4 and 6 days after harvest (Yao and Kamenan, 1989). Most of the time, plantains are ripe when they reach the market. Annual losses of plantains in Côte d'Ivoire are estimated at 40% (FAO, 2013; FAOstat, 2017). These losses are mainly related to poor harvesting, transport and storage conditions (Lépengué, 1999, FAO, 2013, FAOstat, 2017).

The application of post-harvest technology to plantains generally has two objectives: preservation of quality (appearance, consistency, flavour, nutritional value and safety) and reduction of losses between harvest and consumption (Kaanane, 1998; Fao 2007). Proper management during the post-harvest period is rather better than the use of high technology (Kaanane, 1998). Large-scale farmers can usually benefit by investing in expensive handling equipment and using high-tech post-harvest processes. However, such choices are not usually profitable for smallholders, as their means are limited (Kaanane, 1998). Indeed, simple and inexpensive techniques are better suited for commercial farms with limited capacity and resources, for farmers marketing their plantain production directly. The main objective of this study is to enhance the conservation of plantains using a traditional cooling pot in the locality of Man. The locality of Man is a major plantain producing region in Côte d'Ivoire (Thiémiélé et al., 2017).

L'objectif principal de cette étude est de valoriser la conservation des bananes plantains à l'aide d'un pot réfrigérant traditionnel dans la localité de Man. La localité de Man est une grande région productrice de bananes plantains en Côte d'Ivoire (Thiémélé *et al.*, 2017). Specifically, it will involve :

- preserve plantains in a traditional cooling pot,
- evaluate the physical and biochemical parameters during storage.

II. MATERIALS AND METHODS

Plant material

The study was carried out on two varieties of plantain (*Musa* × AAB) consumed in the locality of Man. Namely, the Horn 1 cultivar and the French (Agnrin) cultivar. These fruits were harvested at 70 days for the Horn 1 cultivar and 75 days of physiological maturity for the French (Agnrin) cultivar, and were obtained from village plantations located around the town of Man.

Materials for conservation

For conservation, we needed two pots (a large pot and a small clay pot), river sand, plastic bags, a jute bag.

Sampling

A quantity of three (3) bunches of plantain of the variety Horn 1 and three other bunches of plantain of the variety Agnrin were used. Our study was carried out on a total of six (6) bunches of plantain. For each cultivar, thirty plantain fingers were taken. Three plantains from the same cultivar were packed in plastic bags. In total, twenty packages of three plantains were obtained and used for the experiment. The pots used were six (6) small pots and six (6) large pots. The experiment was carried out with a total of six (6) cooling pots, three (3) per cultivar.

Manufacturing of a traditional cooler

The fabrication of a traditional cooler was done according to the method described by Marson in (2014). The traditional cooler is shown in Figure 1



Fig 1. Presentation of a traditional cooler

Preservation method

Plantains were preserved according to the method described by Marson in (2014). This method was done in six (6) steps numbered from 1 to 6 see figure 2. A quantity of ten (10) plantains of each cultivar are selected and weighed. After weighing, the plantains are washed and put in the small pot already contained in the large pot. The space between the small and large pots is filled with clay. The clay is regularly watered during the storage of the plantains and the device is covered with a breathable cloth to allow gas exchange. Every two days, three plantains are taken and analysed to determine the physical and biochemical parameters during storage.

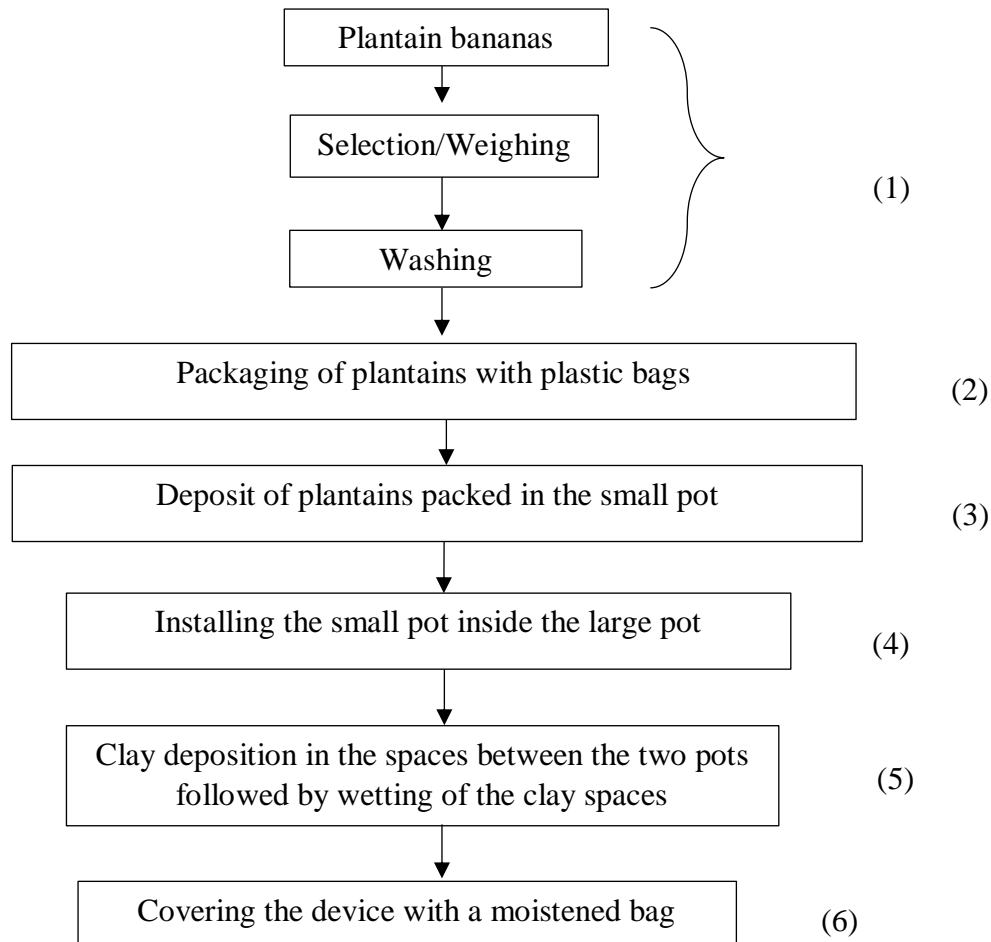


Fig 2. Method of preserving plantains using a traditional cooler.

NB: Never let the bag and the clay dry out.

Determination of physical characteristics

The mass of the fruit (of each cultivar) was determined by weighing on a scale (Berkel: minimum capacity 100 g and maximum capacity 100 kg). The loss of mass (%M) of the bananas was evaluated according to the Lépengué et al. method (2010). The colour of the peel was assessed using the dessert banana colour scale defined by Wainwright and Hughes (1989; 1990). The firmness of the pulp was determined using a penetrometer according to the method described by Dadzié and Orchard (1997). Moisture content was determined by drying an aliquot of the pulp and peel at 130 °C for 2 h. The loss of integrity of the bananas was measured from the conductivity of their skin tissues according to the method of Lépengué et al. (2008)

Determination of the biochemical parameters of the plantains used

The determination of the starch content was done according to the method of Faithful (1990) modified by Abu et al. The dietary fibre content was determined according to the BIPEA. (1976) using sulphuric acid. The extraction of reducing sugars was done according to the method described by Martinez-Herrera et al. (2006) and the determination of reducing sugars was done according to the method described by Dubois et al.(1956).

Statistical analysis

The results were analysed using XLSTAT 7.5.3 software. The comparison of the means was done according to the Duncan test at the 5% threshold.

III. RESULTS AND DISCUSSION

Physical and biochemical characteristics of preserved plantains

The knowledge of physical and biochemical changes related to ripening would be an important contribution to the implementation of an appropriate preservation technology that would delay ripening and

maintain 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 the bunches and fingers of plantain fruits before and after storage are reported in Table I. Our preservation method allowed us to obtain green lives of preserved plantains between 15 and 22 days. The green life of plantains from the Horn 1 cultivar is 22 days, while that of plantains from the Agnrin cultivar is 15 days. These results attest to the effectiveness of this traditional preservation method, which is accessible to all and less expensive ; Indeed, using this method, we were able to obtain longer green lives than those of Horn 1 and Orishélé plantains stored at room temperature using polyethylene bags of different thicknesses between 14 and 18 days obtained by Yao et al. in 2014. And also these obtained green lives are higher than those obtained by Loa et al. in 2017 on Horn 1 and Agnrin plantains preserved with polypropylene bags between 14 and 20 days. This difference in green life could be linked to the storage method and conditions. According to Bugaud and Lassoudière (2005), the green life of bananas varies according to the storage conditions of the fruit. In particular, it is linked to the storage temperature.

Our plantains were stored in a traditional refrigerated pot whereas the other authors mentioned kept their plantains at room temperature between 26°C and 30°C. On the other hand, the difference could be related to the degree of maturity (Loa et al., 2017). Indeed, these authors noted that the degree of maturity has a significant influence on the green life of plantains stored in 0.235 mm thick polypropylene bags. During storage we noticed a change in colour. The green skin of the plantains before storage turned yellow at the end of storage. This colour shift during storage of plantains was also observed by Assemamand et al. in 2012 during ripening of the cultivars Orishélé and Horn 1. Plantain fingers of the Horn 1 cultivar are heavier than those of the Agnrin cultivar. The average weight of the Corne 1 plantains is 210 ± 1.5 g, whereas the average weight of the Agnrin plantains is 150 ± 1.6 g before storage. At the end of our storage, the plantain fingers of the Horn 1 cultivar weighed 195.6 ± 1.6 g, while those of the Agnrin cultivar weighed 138.9 ± 1.2 g. We note a slight loss of mass in the preserved plantains.

This loss of mass is less than 10% with $6.85 \pm 0.2\%$ loss of mass for the cultivar Horn 1 and $7.4 \pm 0.5\%$ loss of mass for the cultivar Agnrin. The mass losses of plantains observed during our conservation was also observed by Lépengué et al., 2010 on their conserved plantains. The mass losses of their plantains were less than 10%. Horn 1 cultivars are firmer than Agnrin cultivars. The average firmness of the Corne 1 cultivars is 15.4 ± 1.6 N while that of the Agnrin cultivars is 12.2 ± 1.1 N before storage. The firmness of the different plantain fruits decreased during storage. The average firmness of the Horn 1 cultivars decreased from 15.4 ± 1.6 N to 13.2 ± 1.3 N while that of the Agnrin cultivars decreased from 12.2 ± 1.1 N to 9.8 ± 0.9 N. Loss of firmness during storage of plantains has been observed by several authors: Loa et al. (2017) on Horn 1 and Agnrin cultivars stored in polypropylene bags, Lépengué et al. (2010) on a Horn 1 cultivar stored with a combination of peanut oil, vermiculite and polyethylene bag. This difference in firmness between these two cultivars is thought to be related to their dry matter content (Bugaud et al., 2011). 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 indicator of sensory quality because of its major role on the firmness of the fruit and the Brix (Géraldine, 2012).

Table 1. Physical characteristics of preserved plantains

	Green life (day)	Mass of fruit (g)	Mass loss rate (%)	Skin colour	Firmness (N)
<i>Corne 1 DC</i>	0	210 ± 1.5^c	0	green	15.4 ± 1.6^g
<i>Corne 1 FC</i>	15 ^a	195.6 ± 1.6^d	6.85 ± 0.2^w	Yellow	13.2 ± 1.3^h
<i>Agnrin DC</i>	0	150 ± 1.6^e	0	green	12.2 ± 1.1^i
<i>Agnrin FC</i>	22 ^b	138.9 ± 1.2^f	7.4 ± 0.5^w	Yellow	9.8 ± 0.9^j

DC: Start of Conservation; **FC:** End of Conservation

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

II-2-Biochemical characteristics of preserved plantains

The biochemical parameters of the plantains studied before and after storage are given in Table II.

The fruits of the Agnrin plantain have the highest dry matter content. Their dry matter content is $41.6 \pm 1.6\%$, whereas that of the Horn 1 banana fruits is $40.8 \pm 1.3\%$ at the beginning of storage. At the end of the storage period, the dry matter content of the different plantain fruits decreased. The dry matter content of the fruits of the Agnrin cultivar, which was $41.6 \pm 1.6\%$ at the beginning, became $38.3 \pm 1.4\%$.

The same applies to fruits of the cultivar Corne 1, which dropped from $40.8 \pm 1.3\%$ to $37.3 \pm 1.8\%$. This drop in dry matter content during storage of plantain fruits was also observed by Assemmand et al. (2012) during ripening of fruits of the cultivars Orishélé (green stage: 41.53%; yellow stage: 38.16%) and Agnrin (green stage: 42.8%; yellow stage: 39.32%).

Starch contents vary during storage of the plantains studied:

- the starch content of plantains of the cultivar Horn 1 was 87.2 ± 1.7 g/100 g DM at the beginning of storage and at the end of storage becomes 85.4 ± 1.2 g/100 g DM
- Fruits of the cultivar Agnrin had a mean starch content of 81.3 ± 1.9 g/100 g DM at the beginning of storage and at the end of storage the starch content became 74.2 ± 1.6 g/100 g DM.

The dietary fibre content varies during storage. The dietary fibre content of fruits of the cultivar Horn 1 decreased from $0.92 \pm 0.3\%$ to $0.32 \pm 0.1\%$ at the end of storage. The dietary fibre content of fruits of the cultivar Agnrin decreased from $9.2 \pm 1.1\%$ to $8.42 \pm 1.4\%$ at the end of the experiment. The fruits of the two cultivars had statistically identical reducing sugar contents at the 5% threshold: Horn 1 (0.8 ± 0.6 g/100 g DM) and Agnrin (0.6 ± 0.3 g/100 g DM). During storage the reducing sugar content increased. The reducing sugar content of the fruits of the Horn 1 cultivar at the end of storage is 35.7 ± 0.7 g/100 g DM while that of the fruits of the Agnrin cultivar is 35.1 ± 0.4 g/100 g DM. The low sugar levels would indicate that the initiation of starch hydrolysis has not yet taken place (Collin and Dalnic, 1991). Indeed, the accumulation of reducing sugars in plantain fruits is linked to starch hydrolysis (Terra et al., 1983; Cordenunsi and Lajolo, 1995). Starch is the most important component of plantain fruit pulp in the green ripening state (Happi Emaga et al., 2008). The different results obtained show changes in the biochemical characteristics of the plantain fruits studied. During storage, we noted losses in mass, firmness and dry matter, but an increase in reducing sugar content, and a change in skin colour from green to yellow in stored plantains. 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 ripeness and giving the fruit its organoleptic characteristics (Brady, 1987).

Table 2. Biochemical parameters of preserved plantains

	Dry matter content (%)	Starch content (g/100 g DM)	Fibre content Dietary (%)	Reducing sugar content (g/100 g DM)
<i>Corne 1 DC</i>	40.8 ± 1.3^k	87.2 ± 1.7^a	0.9 ± 0.3^t	0.8 ± 0.6^r
<i>Corne 1 FC</i>	37.3 ± 1.8^l	85.4 ± 1.2^b	0.3 ± 0.1^f	35.7 ± 0.7^s
<i>Agnrin DC</i>	41.6 ± 1.6^m	81.3 ± 1.9^c	9.2 ± 1.1^g	0.6 ± 0.3^r
<i>Agnrin FC</i>	38.3 ± 1.4^n	74.2 ± 1.6^d	8.42 ± 1.4^h	35.1 ± 0.4^s

DC: Start of Conservation; **FC:** End of Conservation

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

IV. CONCLUSION

The different results obtained during our experiment allow us to affirm the effectiveness of this technique, which is simple to carry out, less expensive and accessible to all. With this technique, our low-income farmers will be able to preserve their plantains for about twenty days without altering the quality of the fruit. We strongly recommend this method of preservation to wholesalers and plantain growers in rural areas.

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