Physicochemical and Mineral Composition of Dessert Banana Peduncle Juice during Conservation at Ambient Temperature

Ngoh Newilah Gérard*1,2, Kendine Vepowo Cédric2, Womeni Hilaire Macaire2

1Post harvest Technology Laboratory, African Research Centre on Bananas and Plantains (CARBAP), Njombé, Cameroon, CARBAP, 832 Douala, Cameroon.
2Biochemistry Department, University of Dschang, 67 Dschang – Cameroon.

Background Dessert banana plants produce important quantities of post harvest waste such as pseudo stems, leaf sheaths, peduncles, rachis ...which are either abandoned on the farms or destroyed by incineration. This study aims at promoting peduncles used in agriculture and in food industry through their extracted juice. Methods: Peduncles of bananas (Grande naine cv.) were collected in Cameroon. Data concerning weight, length and circumference were collected on the peduncles before extraction of the juice which was analysed for its physicochemical properties and mineral contents through simple analytical methods. Results During storage at ambient temperature, some physicochemical parameters (pH, total soluble solids, dry matter content) of peduncle juice showed significant increases (p<0.05) meanwhile, a significant decrease (p<0.05) in total titratable acidity was observed. From harvest to day 28, pH, TSS and DMC increased (from 5.4 to 10, 1.8 to 6.5 g/l and 2.7 to 7.5, respectively) while TTA decreased from 20.9 to 7.5 mEq/l. Moreover, mineral analysis of the peduncle juice revealed high amounts of Nitrogen (9.6 to 17.5 mg/g), Calcium (84.67 to 116.36 mg/100g), Sodium (363.16 to 431.83 mg/100g) and Potassium (83.67 to 112.44 mg/100g) from harvest to the 28th day of conservation. During storage, there was a significant increase (p<0.05) in Nitrogen, Calcium and Sodium contents; Meanwhile, a significant reduction (p<0.05) in Iron content was observed. Phosphorus, Magnesium and Potassium contents did not vary significantly during this process. Conclusions: This study contributes considerably to the establishment of the table of composition of dessert banana peduncles, to a better understanding of mineral and physicochemical changes that occur during conservation at ambient temperature. Moreover, the increase in pH and mineral contents are interesting potentials making the peduncle juice suitable to be used either for soil quality improvement, or as manure/fertilizer supplement in the production of bananas or other crops.
LIST OF ABBREVIATIONS

AOAC: Association of Official Analytical Chemists
CARBAP: Centre Africain de Recherches sur Bananiers et Plantains
cm: centimetre
cv: cultivar
DMC: Dry Matter Content
g: gramme
mEq: milliequivalent
mg: milligramme
ml: millilitre
PHP: Plantations du Haut Penja
TSS: Total Soluble Solids
TTA: Total Titratable Acidity

INTRODUCTION

Bananas and plantains are major starch staple crops of considerable importance in the developing world. Agricultural residues, produced from commercial processing of crop plants, are usually considered of a small inherent value and represent a disposal problem. These materials just as those of the banana plant could in many cases represent an inexpensive and readily available source of renewable biomass for different purposes. According to the Philippine Information Agency (2012), Banana peduncle juice can be used to fortify ready-to-drink calamansi juice with potassium and sodium. It can also be used as potassium supplement fertilizer in hydroponics. This can improve the quality of salad vegetables such as lettuce, chives and arugula. Banana peduncle juice was also found to be an effective liquid potassium fertilizer in banana and other high value commodities such as pechay, kale, parsley, carrots, okra, eggplant, and tomato.

In Cameroon, dessert bananas are grown by 3 agro-industrial plantations in two regions (Littoral and Southwest). Their production was estimated by FAO (2011) to 950, 200 tons in 2010. Banana production activities generate a lot of residues since each plant produces only a bunch of banana even though some produce 2 or 3 bunches. After harvest, the pseudo stems, leaves, peduncles and rachis are usually abandoned in the farms to be used as organic matter. The peduncle is the stalk that supports the inflorescence and attaches it to the rhizome (Fig. 1). Banana peduncles management requires costly logistics (vehicles, fuel, etc.), additional labourers for uploading and spreading in farms as well as demanding manipulation (do not cram, spread along the rows, etc.). The decomposition of these residues renders them slippery, thereby creating a danger to labourers. Furthermore, FAO (2011) reported that Cameroon produced 125,000 tons of peduncles in 2010. Initiatives in order to valorise banana peduncles into fibres are being investigated. The processing techniques will obviously deliver peduncle juice that should find a more rational utilisation either in food industries or in agriculture as potential complementary fertilizer.
Previous studies carried out by Cordeiro et al. (2007) on chemical composition of different morphological parts from ‘Dwarf Cavendish’ banana plant revealed that peduncles are important sources of fibres, ash and other nutrients. Thus, biological decomposition of these constituents could liberate the mineral elements essential for the nutrition and growth of banana plants and other crops, thereby reducing the use of chemical fertilizers which are not always safe for consumers’ health. Also, according to a project report cited by Philippine Information Agency (2012), samples of sports drinks in the market contain sodium and potassium ranging from 24.8 to 48.3 mg/100 mL and 11.7 to 19.5 mg/100 mL, respectively. Pure peduncle juice contained 455.2 and 425.8 mg/100 mL sodium and potassium levels, respectively, which were about 9-30 times higher than in the commercial sports drinks. This study aims at evaluating the effect of storage at ambient temperature on the physicochemical characteristics and mineral contents of the banana peduncle juice.

MATERIALS AND METHODS

Materials

According to IPGRI, INIBAP and CIRAD (1996), the peduncle is the stalk that supports the inflorescence, whose female flowers will develop into fruits. It is part of the floral stem that starts from the meristem on the rhizome and shoots through the center of the pseudostem to emerge at the top of the plant. Dessert banana peduncles (Grande naine cv.) were collected at Boubou packing house of PHP (Plantations du Haut Penja, one of the biggest dessert banana producers in Cameroon) in the district of Njombé-Penja subdivision, Littoral region of Cameroon. These peduncles were randomly chosen in October 2013 and transported to Post harvest Technology Laboratory of CARBAP for analysis.

Sampling

A total of 75 dessert banana peduncles were collected for this experiment in three (03) sets of 25 peduncles each, representing three (03) separate trials. Peduncles were used for the assessment of physicochemical parameters of the extracted juice. An additional set of 15 peduncles were collected in order to assess their morphological characteristics. All these analyses were realised over a period of four (04) weeks at intervals of one (01) week (day 0, 7, 14, 21 and 28).
Morphological characterization

The length and the circumference of the peduncles were ascertained using a 1.5m long measuring tape (Fig. 1), while the weight was measured using a balance (KERN HCB 200K500, d=200g).

Extraction of the peduncle juice

The juice was extracted following the flow chart in the figure 2 below. Dessert banana peduncles were washed in the laboratory using current tape water and cut into pieces ≥ 2 cm thickness. These pieces were further ground in ordinary cereal grinding machine without adding water. In order to avoid contaminations, the grinding machine was properly washed before the process. The obtained paste was submitted to manual pressing using a wool cloth with thinner pores (≤ 0.5 mm). This process enabled the separation of peduncle extract called “juice” from peduncle residuals called “fibres” in this study.

![Flow chart of peduncle juice extraction](image)

**Figure 2. Dessert banana peduncle juice extraction flow chart**

Physicochemical analysis

**Volume of juice extracted from the peduncle**

After extraction of the juice, the volume was measured using a 500 ml measuring cylinder. This volume together with the mass of the peduncle juice enabled us to obtain the yield of the peduncle juice using the following formula:

\[
\text{Yield} (\%) = \frac{\text{Mass of juice extracted}}{\text{Mass of peduncle}} \times 100
\]

**Total soluble solids (TSS) of the peduncle juice**

A single drop of the peduncle juice was placed on the prism of a refractometer (REF 113, Brix range from 0-32 % at 20°C) that was finally pointed towards a light source and the percentage of TSS was obtained by subtracting 0.8 from the recorded value.

\[
\text{TSS} (g/L) = \text{Refractive index} - 0.8
\]

**pH and total titratable acidity (TTA)**

The pH of the peduncle juice was measured with a bench top pH meter (HANNA Instruments 2211 pH/ORP meter), while the TTA was assessed manually by titration with 0.1 N Sodium Hydroxide until the endpoint of the reaction characterized by the change in colour of the phenolphthalein indicator (from colourless to pink/red). Results are expressed as milliequivalent per litre sample in terms of malic acid which is the predominant acid present in bananas and plantains according to Josylin (1970).

\[
\text{TTA (mEq/L)} = 10 \times \frac{V_{\text{NaOH}}}{0.1 \text{ N}}
\]

**Dry matter content of the peduncle juice**

Dry matter content was determined by oven drying of a known quantity of the peduncle juice at 105°C for 24 hours.

**Ash content of the peduncle juice**

Ash content was determined by incineration in a muffle furnace of the previously obtained dry matter at 560°C, until obtainment of a constant weight.

**Mineral elements content of the peduncle juice**

Based on the dry matter previously obtained, total Nitrogen content was ascertained using Kjeldhal method of AOAC (1984). Potassium, Calcium, Phosphorus, Sodium, Magnesium and Iron contents
were determined after mineralization of ashes in a mixture of concentrated hydrochloric and nitric acid (1:3). The solution obtained was diluted and forwarded to an Atomic Absorption Spectrophotometer (RAYLEIGH WFX-130B JENWAY) where the readings were obtained.

**Statistical analysis**

The results were expressed as means ± SD (standard deviation). Analysis of variance (ANOVA) was performed on the data using R 3.0.2 statistical software. The means were compared at p<0.05 using Tukey’s ‘Honest Significant Difference’ method.

**RESULT AND DISCUSSION**

**Morphological characteristics of the peduncle**

Significant visual changes were observed in the morphological characteristics (length, weight, circumference and colour) during their storage at ambient temperature. Table 1 indicates peduncle’s length, weight, circumference and colour from harvest to the 28th day of storage. At harvest, the weight of a peduncle is 3.7 kg. During storage at ambient temperature, this value decreases significantly to 0.9 kg on the 28th day. The same trend (significant decrease) was observed with the circumference values of the peduncle from harvest to day 28. They ranged from 26 cm – 19 cm, 20 cm – 11 cm and 13 cm – 6 cm respectively for upper, middle and lower parts of the peduncle. These significant decreases in weight and circumference could be attributed to the loss of water by evaporation from the peduncles. For instance, their lengths (131 cm) did not vary significantly during storage at ambient temperature, thus showing that storage has little or no effect on the peduncle length compared to their weight and circumference. Figure 3 shows the change in colour observed on the peduncle during their storage at ambient temperature. These peduncles changed from green at harvest, to brown on the 28th day. These changes observed could be due to enzymatic browning as described by Jayamurthy et al (2013) who showed that the peduncle of *Musa sapientum* contained high concentrations of phenolic compounds. Oxidation of these phenolic compounds in the presence of polyphenoloxidases led to the production of brown spots as seen on the peduncles.

Table 1: Morphological characteristics of banana peduncle

<table>
<thead>
<tr>
<th>Storage time (day)</th>
<th>Weight of peduncles (kg)</th>
<th>Length of peduncles (cm)</th>
<th>Circumference of peduncles (cm)</th>
<th>Colour of peduncle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Upper</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>3.70 ± 0.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>132.47 ± 16.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.27 ± 1.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>green</td>
</tr>
<tr>
<td>7</td>
<td>2.35 ± 0.62&lt;sup&gt;b&lt;/sup&gt;</td>
<td>131.53 ± 16.74&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.43 ± 2.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td>more brown than green</td>
</tr>
<tr>
<td>14</td>
<td>2.05 ± 0.48&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>131.13 ± 16.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>22.40 ± 1.84&lt;sup&gt;b&lt;/sup&gt;</td>
<td>more green than yellow</td>
</tr>
<tr>
<td>21</td>
<td>1.66 ± 0.29&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>131.13 ± 16.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>22.00 ± 1.69&lt;sup&gt;b&lt;/sup&gt;</td>
<td>more green than yellow</td>
</tr>
<tr>
<td>28</td>
<td>0.92 ± 0.20&lt;sup&gt;d&lt;/sup&gt;</td>
<td>131.00 ± 16.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>19.37 ± 1.64&lt;sup&gt;c&lt;/sup&gt;</td>
<td>brown</td>
</tr>
</tbody>
</table>

Means ± standard deviation with the same letters in the same column are not significantly different at p<0.05 (Tukey’s HSD test)

The means ± standard deviation are data obtained from at least five measurements.
Figure 3. Change in colour observed on the peduncles during storage at ambient temperature
Physicochemical characteristics of the peduncle juice

Juice extraction yield

The quantities of juice extracted from the peduncle during storage are presented in table 2. At harvest 2.3 litres of juice were extracted, with a yield of 59.12 %. This yield decreases to 12.72 % on the 28th day. The decrease observed could be due to the loss of water contained in the peduncle.

### Table 2. Volume of juice extracted and extraction yield

<table>
<thead>
<tr>
<th>Storage time (day)</th>
<th>Volume of juice extracted (ml)</th>
<th>Mass of juice extracted (g)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2264.25 ± 353.83&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2128.398 ± 332.617&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.12 ± 9.24&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>7</td>
<td>1337.67 ± 333.58&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1258.744 ± 313.902&lt;sup&gt;b&lt;/sup&gt;</td>
<td>34.93 ± 8.71&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>14</td>
<td>1218.00 ± 334.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1165.626 ± 320.410&lt;sup&gt;b&lt;/sup&gt;</td>
<td>33.04 ± 9.53&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>21</td>
<td>893.00 ± 215.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>873.354 ± 210.293&lt;sup&gt;c&lt;/sup&gt;</td>
<td>24.31 ± 5.85&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>28</td>
<td>462.67 ± 208.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>457.577 ± 205.771&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12.72 ± 5.72&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means ± standard deviation with the same letters in the same column are not significantly different at p<0.05 (Tukey’s HSD test)

The means ± standard deviation are data obtained from at least five measurements

Total soluble solids (TSS)

The soluble solid content of a fruit is based on soluble compounds such as sugars, acids, vitamin C, amino acid and some pectins. The banana peduncle juice showed considerable amounts of soluble solid contents as illustrated in Figure 4. At harvest, the TSS content was 1.8 g/l, this value significantly increased more than three (03) times on the 28th day (6.51 g/l). These peduncle values are lower than those observed by Ngoh Newilah et al (2009) on dessert and cooking banana pulps grown in Cameroon. In fact they obtained TSS ranging from 1 to 2.3 g/l at harvest. This value increased 3 to 16 times depending on the cultivars and the ripening stage of banana fruits. These low values could be due to the composition of the peduncles, since Cordeiro et al (2007) showed that the banana peduncle was rich in fibres (holocellulose, cellulose and lignin) compared to the fruit which is basically rich in starch. However, according to Palmer (1971), the increase in TSS is attributed to the hydrolysis of starch and the accumulation of sugars i.e. sucrose, glucose, fructose; thus the low starch content of the peduncle to the detriment of the high amounts of fibres could explain the relatively low values obtained in our juice.

![Figure 4: Changes in TSS content of peduncle juice during storage at ambient temperature](image)
pH of the peduncle juice

pH values give a measure of the acidity and alkalinity of a product. Figure 5 shows pH values of the peduncle juice after storage at ambient temperature. At harvest, the pH of the juice was 5.35. During storage, this value increases significantly to 10 on the 28th day. This significant increase is different to that observed on banana and plantain pulps which generally decrease during ripening at ambient temperature depending on the variety studied by Ngoh Newilah et al (2009, 2011). The increase in pH observed could be attributed to the presence of alkaline compounds in the juice such as ammoniac characterised by the pungent urine smell noticed during this experimentation. This pH increase is an interesting potential in agriculture where this juice can be used to reduce the acidic character of soils in farms.

![Figure 5. Evolution of pH of the peduncle juice during storage at ambient temperature](image)

Total Titratable Acidity (TTA)

The TTA gives a measure of the amount of acid present. The values of this parameter are shown in Figure 6. The TTA at harvest is 20.89 mEq/l, this value decreases significantly to 7.47 mEq/l on the 28th day. The results obtained, although different from those observed by Ngoh Newilah et al (2009, 2011) on bananas and plantains pulp, are proportional to the increase observed in pH values.
Dry matter content (DMC) of the peduncle juice.

The DMC of the peduncle juice is illustrated in Figure 7. At harvest DMC of the peduncle juice was 2.67%. This value increased significantly till the 28\textsuperscript{th} day of storage to 7.5%. The increase observed can be attributed to the loss of water from the peduncle by evaporation. However, these values are lower compared to those obtained by Ngoh Newilah et al (2009; 2011) on bananas and plantains pulp. This difference could be due to the nature of the sample which is liquid compared to the pulp of bananas and plantains which are solid, thereby favouring the loss of water by evaporation.
Ash content of the peduncle juice

Figure 8 shows ash content of the peduncle juice after storage at ambient temperature. We observed a significant increase of ash content from 51.13 % at harvest to 64.23 % on the 28th day. This increase could be due to the increase in the DMC previously observed. It should be noted that the ashes obtained differed in colour according to storage time (Fig. 9). The colour changes from orange (day 0 and day 7) to grey (day 14 to day 28). This change in colour could be attributed to the iron content of the juice. In fact, the iron content observed at harvest and after seven days of storage (orange colour of ashes) were similar (p<0.05) but, significantly different (p<0.05) to those observed from day 14 to 28 (grey colour of ashes).

![Graph showing ash content variation](image)

**Figure 8**: Variation of ash content of peduncle juice during storage at ambient temperature

![Ashes images](image)

**Figure 9**: Colour of ashes obtained from the peduncle juice at day 0, 7, 14, 21 and 28
Mineral elements content of the peduncle juice

In Cameroon, chemical fertilisers used for dessert banana production are made relatively of high proportions of nitrogen (N), phosphorus (P) and potassium (K) in various proportions (20:10:10; 20:20:20; 20:10:30; 12:8:20). The trends observed for mineral elements content of peduncle juice varied significantly. In general, a significant increase was observed for total nitrogen, calcium and sodium contents, contrarily to iron content which instead decreased significantly during storage (Table 3). Potassium, phosphorus and magnesium contents did not vary significantly at p<0.05. The increase observed could be due to the evaporation of the water contained in the peduncle which led to an increase in the concentration of these mineral elements. It could also be attributed to the metabolism of microorganisms on the peduncle. The values obtained for calcium and sodium contents ranged from 84.67 to 116.4 mg/100g and 363.2 to 431.8 mg/100g at harvest and on the 28th day of storage respectively. These values are higher than those observed by Wall (2006) in the pulp of dessert banana (AAA variety) i.e. 4.9mg/100g for calcium and 17.4 mg/100g for sodium contents. This difference could be attributed to the role of the peduncle in the nutrition of banana fruits, since it originates from the underground rhizome, thereby harnessing mineral elements essential for the proper growth of fruits. The trends observed in the various mineral elements contents could be due to an antagonistic relationship exiting between these elements.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Day 0</th>
<th>Day 7</th>
<th>Day 14</th>
<th>Day 21</th>
<th>Day 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (mg/g)</td>
<td>9.57 ± 0.73a</td>
<td>10.85 ± 0.35ab</td>
<td>12.83 ± 0.81bc</td>
<td>14.82 ± 1.33cd</td>
<td>17.50 ± 1.85d</td>
</tr>
<tr>
<td>P (mg/100g)</td>
<td>0.058 ± 0.003a</td>
<td>0.058 ± 0.002a</td>
<td>0.058 ± 0.001a</td>
<td>0.058 ± 0.002a</td>
<td>0.058 ± 0.001a</td>
</tr>
<tr>
<td>K (mg/100g)</td>
<td>83.67 ± 10.90a</td>
<td>89.77 ± 10.67a</td>
<td>100.55 ± 19.37a</td>
<td>105.55 ± 18.67a</td>
<td>112.44 ± 14.51a</td>
</tr>
<tr>
<td>Fe (mg/100g)</td>
<td>0.077 ± 0.023a</td>
<td>0.054 ± 0.007a</td>
<td>0.019 ± 0.002b</td>
<td>0.017 ± 0.002b</td>
<td>0.015 ± 0.001b</td>
</tr>
<tr>
<td>Ca (mg/100g)</td>
<td>84.67 ± 15.68a</td>
<td>96.19 ± 13.88ab</td>
<td>109.11 ± 4.90ab</td>
<td>114.83 ± 7.87b</td>
<td>116.36 ± 5.61b</td>
</tr>
<tr>
<td>Na (mg/100g)</td>
<td>363.16 ± 9.92a</td>
<td>371.97 ± 9.78ab</td>
<td>385.93 ± 13.83ab</td>
<td>408.26 ± 21.24bc</td>
<td>431.83 ± 11.33c</td>
</tr>
<tr>
<td>Mg (mg/100g)</td>
<td>39.05 ± 8.07a</td>
<td>38.44 ± 8.19a</td>
<td>37.14 ± 6.66a</td>
<td>36.61 ± 6.71a</td>
<td>31.09 ± 4.23a</td>
</tr>
</tbody>
</table>

Means ± standard deviation with the same letters in the same column are not significantly different at p<0.05 (Tukey’s HSD test)
The means ± standard deviation are data obtained from at least five measurements

CONCLUSION

The main objective of this study was to evaluate the influence of storage at ambient temperature on the physiochemical and mineral characteristics of banana peduncle juice. These conclusions can be drawn: (i) A peduncle at harvest weighs 3.7kg and measures 132 cm with about 59% yield of juice extracted; these parameters decrease significantly during storage at ambient temperature except the length which is always constant; (ii) pH, DMC, TSS of peduncle juice increase significantly during storage at ambient temperature; (iii) Nitrogen, Calcium and Sodium contents increase significantly during storage at ambient temperature.

Peduncle juice can thus be utilized in Cameroon to make a ready-to-drink juice fortified with Potassium and Sodium like in Philippines. Based on these results, it is obvious that banana peduncle juice with its increasing pH and mineral elements content could be ideal for use in agriculture (as a soil improvement agent and as complementary fertilizers) and in food industry as fortification agents. Furthermore, this study will enable fibre producers and dessert banana plantations to establish a strong partnership between banana peduncle providers and their processors.

There is no competing interest for this study defined under the framework of CARBAP Post harvest Technology Laboratory activities.

ACKNOWLEDGEMENT

Authors thank the personnel of CARBAP Post harvest Technology Laboratory. Special thanks go to the managing team of PHP for their collaboration. They also extend their gratitude to Dassou Anicet for his help during statistical analysis of the data and to Mr Fonbah Cletus Chick for his help during primary review of this paper.

REFERENCES
