Biochemical Characterization of Juices from Three Wild Fruit Species Consumed in Côte d'Ivoire “Adansonia digitata, Parkia biglobosa and Tamarindus indica”

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Abstract:

In the context of the valorization and the development of local products in Côte d'Ivoire, this study is based on juices samples prepared from the pulp of wild fruits of Baobab (Adansonia digitata), Tomi (Tamarindus indica) and Néré (Parkia biglobosa). The physicochemical characteristics such as dry matter (desiccation, 105°C), mineral (spectrophotometer), ash, fat, fiber and protein (AOAC), Energy (coefficients), vitamins A & C (HPLC), organic acids & total polyphenols (HPLC), carbohydrate (by difference), pH and titratable acidity (titrimetry, NaOH) of pasteurized juices (75°C, 5 min) were investigated. Data showed that the juices have been characterized by low protein (0.21-0.28 %), fat (0.26-0.65 %) and ash (0.20-0.47 %) content and high level of total carbohydrates (21-30 %) and energy (85.83-124.43 Kcal/100mL). Baobab and Tomi juices were distinguished by their high acidity (103-159 meq.g / Kg) while Baobab and Néré juices were characterized by their average fiber content (4-5.30 %). The juices of Baobab, Tomi and Néré are very rich in some minerals (K and Mg) but calcium (Ca) and iron (Fe) are not bioavailable (Oxales/Ca and Oxalates/Fe > 2). The juice of baobab is rich in vit A (80 mg/100mL) and vit C (189 mg/100mL) than the others juices. Catechin was the most phenolic content (52.29-110.32 mg/100mL) where tartric acid was the most organic acid (4.02-6.82 mg/100mL) in the juices. The knowledge of the nutritional value of these juices could contribute to a better understanding of the essential role of these three wild fruits in terms of food and trade.
Keywords: Cote d’Ivoire, Baobab, Tomi, Néré, Fruit Juice, Physicochemical characterisatic

Introduction

In Côte d’Ivoire, many wild fruits are eaten by local populations. In the past, these fruits have contributed to the survival of the population during difficult times (especially periods of famine, war, drought, bush fires, invasion of crops by desert locust) (Herzog, 1992) [1]. Still today, they have a great interest in food security. Indeed, they provide many nutrients of very good qualities for a better nutritional balance of the local populations [2, 3]. Among these wild species fruit productions, the baobab (*Adansonia digitata*), the Néré (*Parkia biglobosa*) and the tamarind (*Tamarindus indica*) are more appreciated. They are known under the respective names of *sira*, *néré*, and *tomi* in vernacular name *dioula* in Côte d’Ivoire [4]. Their contribution to food and income generation for local populations (especially women) is well established [5, 6]. However, as in many parts of Africa, despite their importance, these three natural fruit resources are faced with the regression of their population or even their disappearance in favor of economically profitable crops. The scientific work done to date on these three wild fruit species has focused on the study of their ecology and their botanical characteristics. References to the biochemical characteristics of the beverages from their pulps are almost non-existent in Côte d’Ivoire. Only our recent study focused on glycemic index and glycemic of these juices [7]. However, their base pulp is rich in many nutrients of very high quality including protein, carbohydrates, dietary fiber, minerals and vitamin C [8, 9]. Therefore, the evaluation of the biochemical characteristics of juices from the pulp of their fruit would be essential for their valorization. To achieve this, we will produce fruit juice from the already known processes then we will carry out their physicochemical analysis.

Material and Methods

**Raw materials**

This study carried out the fruits of Baobab (*Adansonia digitata*), Tomi (*Tamarindus indica*) and Néré (*Parkia biglobosa*). Material was collected at dry maturity stage in the savannah of the department of Korhogo in the North of Côte d’Ivoire. After harvest, the fruits of baobab, Tomi and Néré have been cleared of their shell, their seeds and their fibers. The pulps obtained were packed in plastics bags and transported of the laboratory for the preparation of the different juices.
Methods

Formulation of the fruit juices

The Baobab (Adansonia digitata) juice was obtained according to the protocol described by Cissé (2012) [10] in which a ratio of powder of pulp / water at 45°C / sucrose (100 g / 1 L / 160 g) was mixed. The process to obtain tamarind (Tamarindus indica) juice (Tomi) was proposed by Grollier et al. (1998) [11] and modified. The pulp was obtained manually by separating it with the ordinary sieve. For the solution of the fruits, a ratio of fresh pulp / water (1 Kg / 4.5 L) was used before. Then 160 g of sucrose per juice liter were also used. The Néré (Parkia biglobosa) juice is based on the method proposed by Ouattara (2011) [12] and modified. The juice was obtained with a ratio of powder of pulp / water at 45°C / sucrose (50 g / 1 L / 160 g). Juices were pasteurized at 75°C in 5 min before analyzes.

Physicochemical characterization

Proximate composition

Dry matter, protein, crude fat, crude fiber, pH, titratable acidity and ash of the juices were determined by standard official methods [13], while carbohydrate was determined by difference [14]. Energetic value was determined according to the Atwater and Rosa (1899) [15] coefficients.

Minerals composition

Minerals (K, Na, Ca, Fe, Mg and Zn) were determined on an atomic absorptions spectrophotometer. The total phosphorus (P) was determined as orthophosphate by the ascorbic acid method after acid digestion and neutralization using phenolphthalein indicator and combined reagent [16].

Nutritional and Anti-nutritional composition

The contents of total phenolic compounds were measured using the Folin-Ciocalteu reagent based on colorimetric essay as described by Julkunen-Tiitto (1985) [17]. Flavonoids were determined by colorimeter method using by (Meda et al., 2005) [18]. The absorbencies of the Tannin were read after color development on a Spectrophotometer (Shimadzu Spectrophotometer UV-120-02) at a wavelength of 760 nm [19]. The total oxalate content was determined using the method developed by Ukpabi and Ejidoh (1989) [20].

HPLC measurement

Vitamins A and C were determined by HPLC (Shimadzu SPD 6A, Juponi) according to this method described. For the extraction of vitamin A, a solution of retinol acetate at 1 µg/µL in methanol was prepared and kept cool (-20°C) in tinted vial. A standard solution of 0.01 µg/mL vitamin A was immediately prepared by simple dilution in methanol to constitute the control solution. A volume of the exactly measured sample is transferred to a breaker of 100 mL. 20 mL of methanol was added. The beaker was protected from light with aluminum
foil. The solution obtained was stirred with a barb liked for 2h 30min at room temperature. The methanol is filtered off and put in 25 mL flask to from the test solutions. As for vitamin C, it was extracted with metaphosphoric acid/acetic acid 100/80 (v/v). A volume of juice (3 mL) was homogenized in 30 mL of a metaphosphoric solution with gentle stirring for 30 min. The samples were filtered using a filter paper (Whatman paper). For the analysis by HPLC, a Lichrosorb column (MH2 25 x 4.6.10 μm) was used with a mobile phase (Acetonitrile/tampon: KH2PO4 0.005M (73:27) to a constant flow rate of 1.00 mL /min. A UV detector (SPP-20A) allowing the detection of peaks, using a wavelength of 268 nm. The injection volume is 20 μL with a detection limit of 0.007 mg/Kg. The column temperature was maintained at 40°C.

Organic acid (Gallic acid, citric acid, benzoic acid) were analyzed by HPLC. Samples weighed in 25 mL flasks and extracted with purified water are centrifuged at 4000 g for 30 min. the supernatant is collected and filtered on Whatman paper no 4 and then through a Millipore filter 0.45 μm (Sartorius AG, Goehingen-Germany). The sample thus treated, are stored at -20°C before the analysis. The HPLC apparatus (Shimadzu Corporation, Jupon)used consists of a pump (Shimadzu LC-20A Liquid Chromatograph) a detector UV (Shimadzu SPD-20A UV Spectrophotometric detector). The chromatographic separation of the organic acids is carried out with a column ODS (250x4 mm, Interchrom) maintained at 20°C using an oven Meta therm. TM (Interchrom, France). The eluent was 0.0125 M sulfuric acid/solution containing 70 g/L of potassium dihydrogenphosphate, 14 g / L of sulfate ammonium and adjusted to pH 2.1 by addition of phosphoric (50:50) and at an elution debit of 0.80 mL /min and the detector is selected at 264 nm. The detection limit was 0.008 mg/kg.

The composition of phenolic compounds was analyzed according to the method described by Donavan et al (1998) [21]. The samples to be analyzed were filtered through on Whatman paper no 4 then through a Millipore membrane 0.45 μm (Carl Roth. Karlsruhe, Germany). The HPLC apparatus (Shimadzu, France) was a system with a binary pump (LC-20A) coupled to a detector UV-VIS (SPD-20A). The column used for this analysis is hypersyl ODS C18, 250 x 4.6 mm, 5 μm (Thero, Runcom, Angleterre). The separation was carried out as an eluent gradient. The mobile phase consisted of 5 mmol/L of potassium dihydrogenphosphate solution, a solution of acetonitrile (82/8, V/V). The flow was 1.00 mL/min and the injected volume was 10 μL with a detection limit of 0.006mg/Kg in the oven temperature at 40°C. The peaks were then identified by comparing the retention times and spectra with the authentic reference substances.

**Statistical analysis**

Statistically significant differences between measurement parameters and samples were verified with one-way analysis of variance using the Statistical Products and Service Solutions Software (SPSS version 17.0, Chicago, USA). The Tukey’s honesty significant differences (HSD) multiple range tests used to determine the differences between group means at the 95.0 % confidence level.
Results

**Proximate composition**

The macromolecular and energy profile of the baobab juice, Néré juice and Tomi juice are presented in table 1. The contents of protein, fat and ash are low for the three different juices. Protein content of these juices was between 0.21±0.00 g/100 mL (Baobab juice) and 0.28±0.00 g/100 mL (Néré juice). Fat content varied between 0.26±0.01 g/100 mL (Néré juice) and 0.65±0.02 g/100 mL (Baobab juice). Ash ranged from 0.20±0.01 g/100 mL (Baobab juice) to 0.47±0.04 g/100 mL (Tomi juice). Total carbohydrates are high in the juices with a content of 20.62±0.03 g/100 mL (Néré juice), 29.44±0.07 g/100 mL (Baobab juice) and 23.92±0.02 (Tomi juice). The crude fibers of the three juices varied from 0.46±0.00 g/100 mL (Tomi juice) to 5.30±0.02 g/100 mL (Néré juice). Juices are also characterized high dry matter content (24.36±0.43 g/100 mL for Néré juice to 32.02±0.65 g/100 mL for Baobab juice). Acidity was also high in these juices especially in Tomi (103.32±0.59 meq.g/L) and Baobab (159.24±0.20 meq.g/L) juices. The pHs varied to 2.4±0.14 (Baobab juice) to 4.27±0.03 (Néré juice). Energy values ranged from 85.94±0.96 kcal/100 mL (Néré juice) to 124.43±3.52 kcal/100 mL (Baobab juice).

<table>
<thead>
<tr>
<th>JUICES</th>
<th>PROTEIN (g/100 mL)</th>
<th>FAT (g/100 mL)</th>
<th>DM (g/100 mL)</th>
<th>ASH (g/100 mL)</th>
<th>FIBER (g/100 mL)</th>
<th>TCH (g/100 mL)</th>
<th>pH</th>
<th>TA (meq.g/L)</th>
<th>ENERGY (Kcal/100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baobab</td>
<td>0.21±0.00 a</td>
<td>0.65±0.02 b</td>
<td>32.02±0.65</td>
<td>0.20±0.01</td>
<td>3.82±0.06</td>
<td>29.44±0.07</td>
<td>2.84±0.14</td>
<td>159.24±0.20 a</td>
<td>124.43±3.52 b</td>
</tr>
<tr>
<td>Tomi</td>
<td>0.26±0.01 b</td>
<td>0.29±0.01 c</td>
<td>27.43±0.22</td>
<td>0.47±0.04</td>
<td>0.46±0.00</td>
<td>23.92±0.02</td>
<td>13.92±0.11</td>
<td>103.32±0.59 b</td>
<td>99.42±0.11 c</td>
</tr>
<tr>
<td>Néré</td>
<td>0.28±0.00 c</td>
<td>0.26±0.01 a</td>
<td>24.36±0.43</td>
<td>0.21±0.01</td>
<td>5.30±0.02</td>
<td>20.62±0.03</td>
<td>4.27±0.03</td>
<td>11.79±0.03 a</td>
<td>85.94±0.96 c</td>
</tr>
</tbody>
</table>

TCH : Total Carbohydrate ; DM : Dry Matter ; TA : Titratable Acidity
Data are means and standard deviation (SD) of three trials; a, b, c, Data on the same column with different letter superscripts are significantly different (p < 0.05) as assessed by Tukey’s test.

**Mineral composition**

The mineral content of the three juices was presented in table 2. Potassium (K) remained the most important mineral in juice with the values of 34.97±0.05 mg/100 mL (Néré juice), 585.19 mg/100 mL (Baobab) and 587.05±2.73 mg/100 mL (Tomi juice). Sodium (Na) was the lowest with a value of 0.09±0.01 mg/100 mL (Néré juice) and 0.97±0.10 mg/100 mL (baobab juice). Calcium (Ca), Phosphorus (P) and Magnesium (Mg) have revealed quite interesting levels in these different juices. Ca content was between 5.17±0.25 mg/100 mL (Néré juice) and 9.54±0.12 mg/100 mL (Tomi juice) while P content oscillated between 3.93±0.06 mg/100 mL (Néré juice) and 4.35±0.10 mg/100 mL (Tomi juice) and the Mg varied from 8.95±0.14 mg/100 mL (Tomi juice) to 11.08±0.08 mg/100 mL (baobab juice). Iron (Fe) content varied from 0.39±0.01 mg/100 mL (Néré juice) to 2.33±0.58 mg/100 mL (Baobab juice) and zinc (Zn) was between 0.16±0.02 mg/100mL (Néré juice) and 0.21±0.01 mg/100 mL (Baobab juice).
Table 2: Mineral composition of juices

<table>
<thead>
<tr>
<th>JUICES</th>
<th>POTASSIUM (mg/100 mL)</th>
<th>SODIUM (mg/100 mL)</th>
<th>CALCIUM (mg/100 mL)</th>
<th>PHOSPHORUS (mg/100 mL)</th>
<th>IRON (mg/100mL)</th>
<th>MAGNESIUM (mg/100mL)</th>
<th>ZINC (mg/100mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baobab</td>
<td>585.19±0.24b</td>
<td>0.97±0.10c</td>
<td>9.16±0.06b</td>
<td>4.15±0.13b</td>
<td>2.33±0.58b</td>
<td>11.08±0.08c</td>
<td>0.21±0.01b</td>
</tr>
<tr>
<td>Tomi</td>
<td>587.05±2.73b</td>
<td>0.69±0.02b</td>
<td>9.54±0.12b</td>
<td>4.35±0.10b</td>
<td>0.46±0.01a</td>
<td>8.95±0.14a</td>
<td>0.19±0.01b</td>
</tr>
<tr>
<td>Néré</td>
<td>34.97±0.05a</td>
<td>0.09±0.01a</td>
<td>5.17±0.25a</td>
<td>3.93±0.06a</td>
<td>0.39±0.01a</td>
<td>9.35±0.09b</td>
<td>0.16±0.02a</td>
</tr>
</tbody>
</table>

Data are means and standard deviation (SD) of three trials; a, b, c. Data on the same column with different letter superscripts are significantly different (p < 0.05) as assessed by Tukey’s test.

Anti-nutritional composition

The anti-nutritional components of the juices studied are presented in table 3. The tannin content is between 167.30±14.20 mg/100 mL (Néré juice) and 622.61±22.78 mg/100 mL (baobab juice) while flavonoids contents ranged from 45.10±2.99 mg/100 mL (Néré juice) to 60.74±4.47 mg/100 mL (Tomi juice). The total phenols varied from 349.53±32.99 mg/100 mL (Néré juice) to 873.34±58.13 mg/100 mL (Baobab juice) and oxalate oscillated between 13.20±3.81 mg/100 mL (Néré juice) and 40.33±6.35 mg/100 mL (Baobab juice).

Table 3: Anti-nutritional factors of juices

<table>
<thead>
<tr>
<th>JUICES</th>
<th>TANNINS (mg/100 mL)</th>
<th>FLAVONOIDS (mg/100 mL)</th>
<th>TOTAL PHENOLS (mg/100 mL)</th>
<th>OXALATES (mg/100 mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baobab</td>
<td>622.61±22.78b</td>
<td>51.87±2.20c</td>
<td>873.34±58.13c</td>
<td>40.33±6.35c</td>
</tr>
<tr>
<td>Tomi</td>
<td>175.56±0.96ab</td>
<td>60.74±4.47c</td>
<td>441.46±13.12b</td>
<td>27.13±5.53b</td>
</tr>
<tr>
<td>Néré</td>
<td>167.30±14.20ab</td>
<td>45.10±2.99b</td>
<td>349.53±32.99a</td>
<td>13.20±3.81a</td>
</tr>
</tbody>
</table>

Data are means and standard deviation (SD) of three trials; a, b, c. Data on the same column with different letter superscripts are significantly different (p < 0.05) as assessed by Tukey’s test.

Organic acids, phenolic compounds and vitamins contents

The organic acids contents of juices studied are returnable in table 4. With a value of 0.89 g/100 mL, the Néré juice was recorded the highest content in malic acid. It is followed by the Tomi juice (0.21 g/100mL) and of the Baobab juice (0.09 g/100mL). For the tartric acid, his stronger content was uncovered in Baobab juice (6.82 g/100 mL) and followed by Néré juice (6.65 g/100mL) and Tomi juice (4.02 g/100 mL). As regards citric acid, its highest content is observed in the juice of Tomi (2.07 mg/100 mL). It is followed by Néré juice (1.97 g/100 mL) and Baobab juice (1.96 g/100mL).
Table 4: Levels of organic acids in Baobab, Tomi and Néré juices

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>ORGANIC ACIDS (g/100mL)</th>
<th>FRUIT JUICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retentions Time (min)</td>
<td>Samples Area</td>
<td>Baobab</td>
</tr>
<tr>
<td>2.534/821/467</td>
<td>109430-514215-3186</td>
<td>Malic Acid</td>
</tr>
<tr>
<td>3.346/320/383</td>
<td>2091835-3754504-12049</td>
<td>Tartaric Acid</td>
</tr>
<tr>
<td>4.416/208/433</td>
<td>245646-21434116-757</td>
<td>citric Acid</td>
</tr>
</tbody>
</table>

A very great variability of phenolic compounds was observed between the three different juices (table 5). The catechin was the most important with a highest content has been revealed in Tomi juice (133.26 mg/100 mL). It is followed by baobab juice (110.32 mg/100 mL) and Néré juice (52.19 mg /100 mL). Likewise, the highest content of coumarin was observed in Tomi juice (8.45 mg/100 mL) and followed by Baobab juice (de 6.55 mg/100mL) and Néré juice (2.93 mg/100 mL). The benzoic acid and gallic acid were only seen in the Tomi and Néré juices. Benzoic acid varied from 2.23 mg/100 mL (Tomi juice) to 3.09 mg/100 mL (Néré juice). The gallic acid oscillated between 5.03 mg/100 mL (Néré juice) and 6.97 mg/100 mL (Tomi juice) while quercetin was only detected in baobab juice (2.72 mg/100 mL).

Table 5: Phenolic compounds content in Baobab, Tomi and Néré juices

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>PHENOLICS CONTENT (mg/100 mL)</th>
<th>FRUIT JUICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retentions Time (min)</td>
<td>Samples Area</td>
<td>Baobab</td>
</tr>
<tr>
<td>2.185/189</td>
<td>270859-222900</td>
<td>Benzoic acid</td>
</tr>
<tr>
<td>3.346-2955</td>
<td>665073-367540</td>
<td>Gallic acid</td>
</tr>
<tr>
<td>3.789/726/583</td>
<td>28018225-278381-1454079</td>
<td>Catechin</td>
</tr>
<tr>
<td>5.112/054/4.875</td>
<td>1993827-1659482-796621</td>
<td>Coumarin</td>
</tr>
<tr>
<td>4.538</td>
<td>65993</td>
<td>Quercetin</td>
</tr>
</tbody>
</table>

nd: not detected

Vitamins A & C contents of the three juices studied are shown in table 6. The vitamin A contents were between 11 mg/100 mL (Néré juice) and 80 mg/100 mL (Baobab juice) while those of vitamin C varied from 19 mg/100 mL (Tomi juice) to 189 mg/100 mL (baobab juice). Néré juice has a vitamin C content (21 mg/100 mL) very close to that of Tomi juice (11 mg/100 mL).

Table 6: vitamins A and C content in Baobab, Tomi and Néré juices

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>VITAMINS (mg/100 mL)</th>
<th>FRUIT JUICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retentions Time (min)</td>
<td>Samples Area</td>
<td>Baobab</td>
</tr>
<tr>
<td>2.425-2.552</td>
<td>787-106</td>
<td>Vitamin A</td>
</tr>
<tr>
<td>3.897-4.215-4.287</td>
<td>12042-122-134</td>
<td>Vitamin C</td>
</tr>
</tbody>
</table>

nd: not detected

Discussion

The juices were characterized by high total carbohydrates levels (20.62±0.03-29.44±0.07 g/100 mL). Carbohydrates represent 87.20 %, 84.64 % and 91.94 % of...
the dry matter of Tomi juice, Néré juice and Baobab juice respectively. These high levels confirmed the richness of carbohydrate in the three basic fruits. Carbohydrates levels were also attributable to the added sucrose (140-160 g) into the different juices. In addition, the relatively low amounts of crude fiber content, especially in Néré juice (5.30±0.02 g/100 mL) and baobab juice (3.82±0.06 g/100 mL) was observed. That could be beneficial for the populations because they would facilitate digestion by increasing gastrointestinal function and preventing constipation as mentioned by some authors [22, 23]. The appreciable values of energy which are 85.94±0.94 kcal/100 mL (Néré juice) and 124.43±3.52 kcal/100 mL (baobab juice) showed that these drinks could be described as energy drink largely attributable to their high carbohydrate content. The low pH (2.84±0.14-4.27±0.03) of these three juices showed that their acid characteristic. Grolier et al. (1998) [11] found similar values ranging from 2 and 4 in tamarind juice. These low pH would be very beneficial for their conservation in the prevention of microorganisms. Baobab juice appeared to be the most acid with a pH closed to those of 3 and 3.06 reported in literature [24, 25]. The pH of Néré juice is sensibly higher than that of 3 reported by Ouattara (2011) [12]. In addition, the protein contents of the three juices are low (0.21±0.00 (Néré juice)-0.28±0.00 g/100 mL (baobab juice)) and confirmed the poverty of the different basic pulp in protein [8, 11, 25]. The protein content (0.21 g/100 mL) of baobab juice is comparable to those ranged from 0.15 to 0.20 % as reported by Cissé et al. (2008)[24] and Diop et al. (2005) [25]. In the same way, these juices revealed very low lipid levels ranging between 0.26±0.01 mg/100 (Néré juice) and 0.65±0.02 mg/100mL (Baobab juice). These rates corroborate the results of many authors who have shown that the pulp of these wild fruits is a low lipid source (Cissé, 2012) [10]. Results also indicated very low ash levels of different juices ranged from 0.20±0.01 g/100 mL (Baoabab juice) to 0.47±0.04 g/100 mL (Tomi juice). The ash content of baobab juice is easily related to that of 0.2 g/100g found by Cissé et al. (2008) [24]. The ash content of food in general, are based on the botanical origin of the food used to make them, the mineral richness of the soil or the degree of maturity of the fruits (Herzog,1994) [1]. These ash contents make it possible to attribute to these three different juices a considerable wealth in minerals.

The three different juices studied recorded the presence of phenolic compounds at fairly interesting rates, among which catechin has the largest quantities oscillated between 52.19 mg/100g (Néré juice) and 133.26 mg/100g (Tomi juice), making them excellent sources of catechins. These juices, which are particularly rich in catechins, could participate effectively in the preservation of the health of consumers because this compound, like other phenolic compounds, helps to protect the human body from free radicals. Indeed, phenolic compounds are powerful anti-oxidants capable of destroying free radicals [26]. Catechin has also revealed anti-carcinogenic properties. As a result, the consumption of these three fruit juices would preserve the consumers of atherosclerosis, cancer and cellular aging [27, 28]. Organic acids were also recorded in the three different juices with quite interesting rates (0.09 g/100 mL-6.82 g/100 mL) and showed that these three juices were excellent sources of organic acids. They could endow them with high antioxidant power (DeCaluwé et al., 2012) [29]. Data of vitamins A and C showed variable and appreciable values. These levels should have been higher if the basic pulps had not undergone various technological treatments [30]. Vitamin C levels especially in baobab juice largely cover daily needs estimated at
0.025 g (Otten et al., 2006) [31]. Also, the no less important levels of vitamin A represented in these juices, could play an important role in the body of the consumer in the sense that it is involved in the treatment of visual impairment disorders in the dark and certain mucosal or cutaneous affections [32].

The mineral composition of fruit juice is a criterion of choice for consumers. These juices are particularly rich in potassium (34.97±0.05 mg /100 mL- 587.05±2.73 mg/100 mL). Its content of 587.05 ±2.73 mg/100 mL in Tomi juice is comparable to those of 597.8 mg /100g reported by Grollier et al. (1998) [11] in tamarind pulp and covered the daily needs necessary for an adult which was estimated at 380 mg /day [33]. The regular consumption of these juices could avoid the risk of arterial hypertension, risk of cerebral vascular accident and heart diseases. Sodium revealed in these three juices are very low especially in the juice of Néré (0.09±0.01 mg/100 mL). Sodium is one of the factors that promotes elevation of blood pressure in genetically predisposed subjects [32] and the ratio Na / K of these three juices was less than 1 and showed that these could be advice effectively to hypertensive subjects. The juices recorded lower levels of calcium (5.17±0.25 mg/100 mL-9.54±0.12 mg/100 mL) and iron (0.39 mg /100 mL-2.33 mg/100 mL) and could covered the daily needs in Fe of the body which was 0.01 mg/ day (Otten et al., 2006) [31]. The different ratios Oxales/Ca and Oxalates/Fe are superior to the critical levels of 2.5 (Ca) and 1.0 (Fe) to impair their bioavailability in the three juices. Phosphorus, magnesium and zinc were weak in juices. Therefore, phosphorus quantity was linear to calcium as reporter in other study [34] and magnesium could be effective in meeting daily needs that are important (250 mg to 500 mg) and plays an important role in the body’s defense process [32, 34]. It is the same of zinc which covered the daily needs of 6 to 9 mg [32].

The presence of significant polyphenols levels in these juices indicate their potential antioxidant activity and medicinal properties as mentioned by Wong et al. (2006) [35]. Thus, the consumption of a large quantity of these juices could help to reduce the oxidative stress [36, 37]. Even if these juices contained tannins which once hydrolyzed in the large intestine, inhibit the absorption of iron and may cause anemia if its action is prolonged [38], and oxalic acid witch binds to divalent metal actions such as calcium (Ca\(^{2+}\)) and iron II (Fe\(^{2+}\)) to form insoluble oxalate crystals [39], the tannins have some positive health effects because of their important antioxidant properties in the prevention of certain cancers and the protection of cellular oxidative damage [40]. The presence of flavonoids in juices would be responsible for the presence of their astringent flavor [41] witch was highly observed in Tomi juice.

**Conclusion**

The juices elaborated were characterized mainly by high energy values and a high carbohydrate contents and some important minerals including potassium. Also, the juices are especially rich in organic acids, vitamins C and anti-nutrients which could give them high antioxidant power. The knowledge of the nutritional value of these juices may be useful to others countries and the findings could
contribute to a better understanding of the essential role of these three wild fruits in terms of food and trade for countries sharing similar food traditions.

References


