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RESEARCH ARTICLE

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 physiochemical 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'Ívoire, Baobab, Tomi, Néré, Fruit Juice, Physicohemical 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 thetamarind (*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*) juicewas obtained according of the protocol described by Cissé (2012) [10] in whicha ratio of powder of pulp / water at 45°C / sucrose (100 g/1 L/160 g) was mixed. The process to obtain tamarind (*Tamarindusindica*) juice (Tomi) was proposed by Grollier et *al.* (1998) [11] and modified. The pulp was obtained manually by separated 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*) juiceis based on themethod 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, Jupon) according to this method described. For the extraction of vitamin A, a solution of retinol acetate at 1µg/µL in methanol was prepared and kept cool (-20°C) in tinted vial. A standard solution of 0.01µg/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: KH2PO40.005M (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, Goëhingen-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).

Table1. Biochemical composition and energetic value of juices

JUICES	PROTEIN (g/100 mL)	FAT (g/100 mL)	DM (g/100 mL)	ASH (g/100 mL)	FIBER (g/100 mL)	TCH (g/100 mL)	pH	TA (meq.g/L)	ENERGY (Kcal/100 mL)
Baobab	$0.21±0.00^{a}$	$0.65±0.02^{c}$	$32.02±0.65^{c}$	$0.20±0.01^{a}$	$3.82±0.06^{b}$	$29.44±0.07^{c}$	$2.84±0.14^{a}$	$159.24±0.20^{c}$	$124.43±3.52^{c}$
Tomi	$0.26±0.01^{b}$	$0.29±0.01^{b}$	$27.43±0.22^{b}$	$0.47±0.04^{c}$	$0.46±0.00^{a}$	$23.92±0.02^{b}$	$329±0.11^{b}$	$103.32±0.59^{b}$	$99.42±0.11^{b}$
Néré	$0.28±0.00^{c}$	$0.26±0.01^{a}$	$24.36±0.43^{a}$	$0.21±0.01^{b}$	$5.30±0.02^{c}$	$20.62±0.03^{a}$	$4.27±0.03^{c}$	$11.79±0.03^{a}$	$85.94±0.96^{a}$

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

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

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

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

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

CHARACTERISTICS		ORGANIC ACIDS	FRUIT JUICES		
Retentions Time (min)	Samples Area	(g/100mL)	Baobab	Tomi	Néré
2.534/821/467	109430-514215-3186	Malic Acid	0.09	0.21	0.89
3.346/320/383	2091835-3754504-12049	Tartric Acid	6.82	4.02	6.65
4.416/208/433	245646-21434116-757	citric Acid	1.96	2.07	1.97

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

CHARACTERISTICS		PHENOLICS CONTENT	FRUIT JUICES		
Retentions Time (min)	Samples Area	(mg/100 mL)	Baobab	Tomi	Néré
2.185/189	270859-222900	Benzoic acid	nd	2.23	3.09
3.346-2955	665073-367540	Gallic acid	nd	6.97	5.03
3.789/726/583	28018225-278381-1454079	Catechin	110.32	133.26	52.29
5.112/054/4.875	1993827-1659482-796621	Coumarin	6.55	8.45	2.93
4.538	65993	Quercetin	2.72	nd	nd

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

CHARACTERISTICS		VITAMINS	FRUIT JUICES		
Retentions Time (min)	Samples Area	(mg/100 mL)	Baobab	Tomi	Néré
2.425-2.552	787-106	Vitamin A	80	nd	11
3.897-4.215-4.287	12042-122-134	Vitamin C	189	19	21

nd: not detected

Discussion

The juices were characterized by high total carbohydrates levels (20.62±0.03-29.44±0.07 g/100 mL). Carbohydratesrepresent 87.20 %, 84.64 % and91.94 % 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/100mL) 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 witch 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 g7100 mL) of baobab juice is comparable to those ranged from 0.15 to 0.20 % as reported by Cissé et *al.* (2008)[24] andDiop 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 three 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 (Baobab juice) to 0.47±0.04 g/100 mL (Tomi juice). The ash content of baobab 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

[1] Herzog, F., 1994. Multipurpose shade trees in coffee and cocoa plantations in Côte d'Ivoire. Agroforestry Systems, 27: 259-267.

[2] Kouamé, N.M.T., Gnahoua, G.M., Konan, E.K., Traoré, D., 2008. "Les plantes spontanées alimentaires de la région du Fromager (Gagnoa): Flore, habitats et organes consommés". Sciences & Nature, 5(1) : 61-70.

[3] Kouamé, N.M.T., Soro, K., Mangara, A., Diarrassouba, N., Coulibaly, A.V., Boraud, N.K.M., 2015."Etude physico-chimique de sept (7) plantes spontanées alimentaires du centre-ouest de la Côte d'Ivoire". Journal of Applied Biosciences, 90 : 8450-8463,

[4] Ambé, G., 2001. "Les fruits sauvages comestibles des savanes guinéennes de Côte d'Ivoire: Etat de la connaissance par une population locale, les Malinkés". Biotechnologie, Agronomie, Société et Environnement, 5(1) : 45-58.

[5] Becker, B., 1983. "The contribution of wild plants to human nutrition in the Ferlo (Nor them Senegal)", Agroforestry Systems, 1: 257-267.

[6] Bergeret, A., Ribot, J.C., 1990. L'arbre nourricier en pays sahélien. Editions de la Maison des sciences de l'homme, Paris, p 237.

[7] Kouassi, A.K., Beugré, G.A.M., Kouassi, K.N, N'dri, Y.D, Amani, N.G., Gnakri, D., 2018. Glycemic Index and Glycemic Load of juice from Edible Wild Fruits «Adansonia digitata, Tamarindus indica and Parkia biglobosa» Consumed in Côte d'Ivoire. Journal of Biosciences and Medicines, 6: 63-74.

[8] Favier, J., Ireland-Rippert, J., Laussucq, C., Feinberg, M., 1983. Répertoire général des aliments: Table de composition des fruits exotiques et fruits de cueillette d'Afrique In (Vol. Tome 3). Paris France Lavoisier.

[9] Soloviev, P., Niang, T., Gaye, A., Totte, A., 2003. "Variabilité des caractères physico-chimiques des fruits de trois espèces ligneuses de cueillette, récoltés au Sénégal: Adansonia digitata, Balanites aegypriaca et Tamarindus indica". Fruits, 59: 109-119.

[10] Cissé, I., 2012. Caractérisation des propriétés biochimiques et nutritionnelles de la pulpe de baobab des espèces endémiques de Madagascar et d'Afrique continentale en vue de leur valorisation. Thèse, Ecole doctorale : Sciences des Procédés-Sciences des Aliments. Montpellier Supargro, France. 6-77.

[11] Grollier, C., Debien,C., Domier, M.,Reynes, M., 1998. "Principales caractéristiques et voies de valorisation du tamarin". Fruits, 53: 271-280.

[12] Ouattara K., 2011. Essai de production de nectar de pulpe de néré (Parkia biglobosa) et sa caractérisation. Mémoire de fin d'études pour l'obtention de la licence professionnelle en Agroalimentaire, Université Polytechnique de Bobo-Dioulasso, Burkina Faso, 65 p.

[13] AOAC, 1990. «Official Methods of Analysis», 13th Edition, Association of Official Analytical Chemists. Washington DC.

[14] Antia, B.S., Akpan, E.J., Okon, P.A., Umoren, I.U., 2006 Nutritive and Anti-nutritive Evaluation of Sweet Potatotoes (Ipomoea batatas) Leaves. Pakistan Journal of Nutrition, 5(2): 166-168.

[15] Atwater, W. and Rosa, E., 1899. A new respiratory calomrimeter and experiments on the conservation of energy in human body. II-Physical Review, 9: 214-251.

[16] A.P.H.A., 1995. Standard methods for examination of water and waste water, 19th ed., American Public Health Association, USA, 113-11

[17] Julkumen-Tiitto, R., 1985. Phenolic constituents in the leaves of northern willows: methods for the analysis of certain phenolics. Journal of agricultural and Food Chemistry. 33(2): 213-217.

[18] Meda, A., Lamien, C.E., Romito, M., Millogo, J., Nacoulma, O.G., 2005. Determination of the total phenolic, flavonoid and proline contents in Burkina Faso honey, as well as their radical scavenging activity. Food Chemistry, 91: 571-577.

[19] Swain, T. 1979. Tannis and Lignins In: Herbivores: Their Interreactionswith Plant Metabolites, Roental, G.A. and D.H. Janen (Eds), Academic Press, New York.

[20] Ukpabi, U.J., Ejidoh, J.I., 1989. Effect of deep oil frying on the oxalate content and the degree of itching of cocoyams (Xanthosoma and Colocasia spp). Technical paper presented at the 5th Annuel Conference of the Agricultural Society of Nigeria, Federal University of Technology Owerri, Nigeria, 3-6.

[21] Donovan, G.A., Dohoo, L.R., Montgomery, D.M., Bennett, F.L., 1998. Calf and disease factors affecting growth in female Holstein calves in Florida, USA. Preventive Veterinary Medicine, 33: 1-10.

[22] Zhao, H.L., Grossman, H.B., Hernandez, L.M., Dinney, C.P., Wu, X., 2007. "Dietary isothiocyanates, GSTM1, GSTT1, NAT2 polymorphisms and bladder cancer risk", International Journal of Cancer, 120: 2208-2213.

[23] Murphy, N., Norat, T., Ferrari, P., Jenab, M, Bueno-de-Mesquita B, Skeie, G. et al. 2012. Dietary Fibre Intake and Risks of Cancers of the Colon and Rectum. European Prospective Investigation into Cancer and Nutrition (EPIC). PLoS ONE, 7(6): e39361, 10p. https://doi.org/10.1371/journal.pone.0039361.

[24] Cissé, M., Sakho, M., Dornier, M., Diop, C., Reynes, M., Sock, O., 2008."Caractérisation du fruit du baobab et étude de sa transformation en nectar". Fruits, 64 : 19-34.

[25] Diop, N., Ndiaye, A., Cisse, M., Dieme, O., Dornier, M., Sock, O., 2010. Le ditax (Detarium senegalense J. F. Gmel.): principales caractéristiques et utilisations au Sénégal. Fruits,65: 293-360.

[29] DeCaluwé, E., Halamova, K., Van Damma, P., 2010. "Tamarindus indica L." A Review of traditional use, phytochemistry and pharmacology. Africa focus, 1(23): 11-51

[26] Amic, D., Davidovic, A.D., Beslo, D., Trinajstic, N., 2003. Structure-radical scavenging activity relationship of flavonoids. Croatica Chemica Acta, 76: 55-61.

[27] Hagerman, A.E., Riedl, K.M., Jones, G.A., Sovik, K.N., Ritchard, N.T., Hartzfeld, P.W., Riechel, T.L., 1998. High molecular weight plant phenolics (tanins) as biological antioxidants. Journal of Agricultural and Food Chemistry, 46: 1887-1892.

[28] Kumar, P.A., Saadatdous, Z., Mohd, E.N., Hailawati, H., Ismail, A., 2015. Diatary cocoa protects against colitis-associated cancer by activating the Nrf2/Keapl pathway. BioFactors, 41: 1-14.

[30] Pai, M.L., 1957. Influence of cooking of the nutritional value of foods. II. Riboflavin, nicotinic-acid and ascorbic-acid content of some cooked foods. Indian Journal of Medical Research, 45: 635-643.

[31] Otten J.J., Hellwig P.J, Meyers D.L., 2006. Dietary references intakes.The Essential Guide to Nutrient Requirements. Institute of Medicine of the National Academies. The National Academies Press. Washington, D.C. www.nap.edu. http://www.nap.edu/catalog/11537.html, 1329 p

[32] Thoulon-Page, C., 1995. Nutriments, aliments et technologies alimentaires. SIMEP, 2: 11-37.

[33] INIBAP, 2001. Annual rapport 2001. International network for improvement of banana and banana plantain, Montpelier, France, p 24.

[34] Pamplona, R.G.D., 2006. Croquez la vie! Des aliments qui guérissent et qui préviennent. Tafferes Gråficos Penalara, 5(1): 81-93.

[35] Wong, S.P., Leong, L.P, Koh, J.H.W., 2006. Antioxidant activities of aqueous extracts of selected plants. Food Chemistry, 99: 775-783.

[36] Mullen, W., Marks, S.C., Crozier, A., 2007. Evaluation of phenolic compounds in commercial fruit juices and fruit drinks. Journal of Agricultural and Food Chemistry, 55: 3148-3157.

[37] Shen, S.S., Callaghan, D., Juzwik, C., Xiong, H.Q., Huang, P.L., Zhang, W.D., 2010. ABCG2 reduces ROS-mediated toxicity and inflammation: A potential role in Alzheimer's disease. Journal of. Neurochemistry. 114: 1590-1604.

[38] Brune, M., Rossander, L., Hallberg, L., 1989. Iron absorption and phenolic compounds: importance of different phenolic structures. European Journal of Clinical Nutrition, 43: 547-557.

[39] Coe, F.L., Evan, A., Worcester, E., 2005. Kidney stone disease. Journal of clinical Investigation, 115(10): 2598-2608.

[40] Chung, K.T., Wong, T.Y., Wei, C.I., Huang, Y.W., Lin, Y., 1998. Tannins and human health. Critical Reviews Food Science and Nutrition, 38(6): 421-464.

[41] Hii, C.L., Law, C., Suzannah, S., Misnawi, S.J., Cloke, M., 2010. Polyphenols in cocoa (Theobroma cacao L.). Asian Journal of Food and Agro-Industry, 2: 702-722.