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RESEARCH ARTICLE

PHYSICO-CHEMICAL CHARACTERIZATION OF CASHEW APPLE JUICE (*ANACARDIUM OCCIDENTALE*, L.) FROM YAMOUSSOUKRO (CÔTE D'IVOIRE)

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Abstract

In this study the changes in physico-chemical properties of the juice of two apples varieties (yellow and red) from Yamoussoukro were analyzed. The overall objective of this study is a better understanding of the composition of cashew apple for a better use of it. Thus, the vitamin C content varies between 370.9 and 480.3 mg/100 g ; total sugars ranged from 162.7 to 168.1 g/L. Concentrations (g/L) of glucose, fructose and sucrose vary respectively between 47.2 to 65.8, 100.7 to 110.3 and 2.5 to 5.3. At the level of organic acids, citric acid leads with levels (µg/ml) ranged from 290.7 and 1092.1, followed by tartaric acid 497.5 to 693.3; from acetic acid 48.2 to 266.5, from oxalic acid 197.8 to 204.3 and finally to fumaric acid. The pH of the juice is between 4.37 to 4.5, titratable acidity between 0.5 to 0.85 %, the total soluble solids content between 10.2 to 10.9 °Brix; dry matter between 7.80 -10.0 % and ash from 1.31 to 1.88 %. The protein content varies from 0.51 to 0.53 g/100 g and key amino acids in order of size are leucine, cysteine and asparagine. Except the pH, color and maturity of apples influenced ($p<0.05$) significantly the parameters analyzed.

Keywords: Cashew apple, juice, color, physico-chemical composition

Introduction

The cashew tree (*Anacardium occidentale* L., *Anacardiaceae*) is a tree native to the northeastern coast of Brazil where it was cultivated by indigenous peoples long before its discovery by the Portuguese, who will introduce the latest in their African colonies and Asia (Olher, 1967; Rao and Swamy, 1994; City, 1995). The first cashew plantations have been established in Côte d'Ivoire in the years 1960-70 as part of the reforestation initiative. The cashew tree was associated with other plants such as teak and acacia (Aubertin, 1983). The cultivation of cashew in so thrived in the North to the center. These areas receiving a rainfall ranging range 1000 to 1400 mm/year (Dugué, 2002). The value of this tree has focused on the cashew that is the subject of international trade and which gives the cashew notoriety (Lacroix, 2003). In 2008, Côte d'Ivoire has exported 330,000 tones of cashew nuts (Anonymous 1, 2008). Apart from the cashew nut, the apple is fairly valued except in India and Brazil, especially in the form of juice (Lautie *et al*., 2001, Cavalcante *et al*., 2003). In the most producing countries, the cashew apple rots in the soil at the expense of nuts (Campos *et al*., 2002; Rocha et al. 2007; Grio et al., 2009). Yet several studies have shown the richness of the apple juice that contains minerals, three to six times more vitamin C than orange juice (Price *et al*. 1975; Moura, 1998; Akinwale, 2000; Assuncao & Mercandante, 2003, Adou *et al*., 2011) and ten times more than pineapple juice (Ohler, 1988). The

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cashew apple juice is also rich in tannin and polyphenols (Adou *et al*., 2012), which gives it antioxidant properties and makes it an effective remedy against chronic dysentery in Cuba and Brazil (Morton, 1987, Kubo *et al*., 1999, Kubo *et al*., 2006, Carvalho *et al*., 2006). Despite the wealth of this fruit and its effects on health, the cashew apple is unknown to the public and Ivorian scientific. There is no publication on the cashew apple except the economic field (Anonymous 2, 2002). Yet, several factors such as species, growing region, climate, cultural practices, maturity at harvest (Drake and Eisele, 1997), the storage atmosphere (Drake and Eisele, 1994), conditions storage (Drake et al. 2002; Drake and Eisele, 1999) are known to affect the chemical composition of apple juice. So, faced with the challenge of transforming raw materials and given the large amounts of product destroyed at the expense of cashew nuts, a study of the physicochemical characterization of the cashew apple grown in Cote d'Ivoire is required. This study will therefore focus on general knowledge of the composition of the apple for a better use of it.

Material and methods

The plant material consists of red and yellow cashew apple from Yamoussoukro (Center of Côte d'Ivoire). In addition to these colors of apple, have been associated red and yellow apples with greenish tasks. Ripe and intact cashew apples harvested in these regions were transported to the laboratory refrigerated for juice extraction and analysis. The city of Yamoussoukro (Lake District), located in the center of the country at 380 km from Abidjan is a region regarded as unfavorable to the cultivation of cashew. The apples were harvested in two different dates. Ripe apples with greenish tasks were also collected. The aim was to study the impact of the maturity period, the grade of maturity and inter-varietal variations on the mineral content (Table 1).

Juice extraction

Cashew apples transported to the laboratory, are detached from the nuts. The apples were washed thoroughly with clean water. Then the apples are cut and ground to Mixer (Blender LB20E, Torrington, USA, 2002). The juice obtained by pressing the mash was filtered through a 0.5 mm mesh sieve and then stored frozen at – 80 °C for different analysis.

Table 1. *Origin of cashew sample*

N°	Samples	Abbreviation
1	Yellow apple (1st taking)	YA_1
2	Yellow apple (2^{e} taking)	YA_2
3	Red apple (1st taking)	RA_1
4	Red apple (2^{e} taking)	RA_2
5	Yellow apple with greenish tasks	YAGT
6	Red apple with greenish tasks	RAGT

Determination of dry matter of juice

The dry matter was determined as described by the collection of the "Bureau Interprofessionnel d'Etude Analytique" (BIPEA, 1976).

Determination of pH

The pH was determined using a pH-meter (pH-meter C861, Consort, bio block, Belgium). The calibration of the instrument is ensured by the use of two buffer solutions at pH 7 and 4. It was systematically done before the pH measurements. The measurement is done by immersing the electrode in 5 ml of sample.

Determination of total soluble solids (TSS)

The TSS was determined by the method of Soyer *et al.* (2003) using a refractometer type ATR-W2 plus (2009/230, United Kingdom) equipped with a digital display (S/N: 32853, United Kingdom).

Determination of titratable acidity

The total titratable acidity (% citric acid) was determined by placing 10 ml of juice in a beaker and titrating with a solution of 0.1 N sodium hydroxide to pH 8.2 ± 0.1 (AOAC, 2000).

Determination of ash

The ash content was determined by the method of incineration. A volume of 15 ml sample was poured into a pre-weighed crucible. The whole was weighed and placed in muffle furnace and the temperature gradually increased. After 3 h, the temperature was set at 550 °C for 4 h. The crucible was then cooled in a desiccator and then weighed again.

Determination of reducing sugar and total sugar

The concentration of D-glucose was determined before and after hydrolysis of sucrose by β-fructosidase (invertase) (Kunst *et al.*, 1988). The content of D-fructose from cashew apple juice is determined subsequent to the determination of D-glucose, after isomerization of the D-glucose by phospho-glucose isomerase (Beutler, 1988). The concentration of D-sucrose was determined by the method of Outlaw and Mitchell (1988). The total sugars were assayed by the phenol sulfuric acid method (Dubois *et al.*, 1956).

Determination of total nitrogen

Total nitrogen was determined by volumetric after digestion and distillation method of Kjeldahl (BIPEA, 1976) which takes place in two stages. In the presence of catalyst ($CuSO_4$), organic matter was digested with sulfuric acid. The ammoniac formed and released by sodium hydroxide, was distilled and collected in a boric acid solution. The ammonium borate formed was determined by a sulfuric acid solution.

HPLC analysis

Extraction of amino acids

The free amino acids (partial) were determined by the method of Deguine and Hau (2001). A 5 g of cashew juice were added to 20 ml of 0.2 N sodium citrate (pH 2.3). The homogenized mixture was centrifuged and the supernatant was collected and filtered through Whatman paper N° 4 and then through a 0.45 mm Millipore membrane (Sartorius AG, Goettingen, United Kingdom). The samples thus treated were stored at -20 °C until analysis.

Extraction of vitamin C

The vitamin C was extracted by the method of Wimalasari and Wills (1983). A 20 g of cashew juice are added to 30 ml of citric acid 3% (w/v). The mixture was homogenized and centrifuged at 1500 g for 25 min at 0 °C. The supernatant was collected and filtered through Whatman paper N° 4 and then through a 0.45 mm Millipore membrane (Sartorius AG, Goettingen, United Kingdom). The samples thus treated were stored at -20°C until analysis.

Extraction of organic acids

The cashew juice samples were centrifuged at 1500 g for 20 minutes. The supernatant was collected and filtered through Whatman No 4 paper and then through a 0.45 mm Millipore membrane (Sartorius AG, Goettingen, United Kingdom). The samples thus treated were stored at -20 °C until analysis.

Equipment and operating conditions

The HPLC equipment (Shimadzu Corporation, Japan) consists of a pump (Shimadzu LC-6A Liquid Chromatograph), an UV detector (Shimadzu SPD-6A UV spectrophotometry detector) and an integrator (Shimadzu CR 6A Chromatopac). Chromatographic separation of organic acids was performed with an ion exclusion column ICSep ICE ORH-801 (40 cm x 5 mm, Interchom, France) maintained at 35 °C using an oven Meta ThermTM (INTERCHROM, France). The eluent was sulfuric acid at 0.004 N with the flow rate of 0.6 ml/min and the detector was set at 210 nm. Chromatographic separation of amino acids was performed with an ion exclusion column Hypersil C_8 (25 cm x 4.6 mm x 5 µm, Interchom, France) maintained at 35 °C using the same oven. The eluent was a buffer solution of phosphate/methanol (88:12) with a flow rate of 0.6 ml/min and the detector was set at 280 nm. Chromatographic separation of vitamin C was performed with a column RP 8 (250 mm x 4.6 mm, Interchom, France) maintained at 35 °C using the same oven. The eluent was a solution of acetic acid/acetonitrile (85:15) with a flow rate of 1.3 ml/min and the detector was set at 265 nm. A volume of 20 µl of each centrifuged and filtered sample was injected for HPLC analysis. The standards were filtered and injected separately and the analysis was performed in triplicate. Amino acids, organic acids and vitamin C were identified and quantified by comparison of their retention time and peak area with those of standard solutions.

Statistical Analysis

The statistical analysis was made by SPSS 11.5. The significance of changes in different chemical compounds of different cashew apples juices was determined with the Duncan test at significance level P <0.05.

Results and discussion

A total of six samples from Yamoussoukro were analyzed. Tables 2 to 5 give the physico-chemical composition of cashew apple juice and figures 1 to 3 show the different chromatograms. Table 2 gives the values of pH (4.37 to 4.5), titratable acidity (0.56 to 0.85 %), total soluble solids (10.2 to 10.9°Brix), of dry matter (7.80 to 10.0 %) and the ash content (1.31 to 1.88 %). The variation of pH shows that there was no significant difference (P<0.05) between the samples of juice. The total titratable acidity (ATT) varied between 0.56 and 0.85 %. The results showed that there was no difference between juices of different colors (yellow and red). As against, this difference was significant (P <0.05) between juices of different colors (YA_1, YA_2, RA_1, RA_2) and juices from apples with greenish tasks (YAGT and RAGT). The dry matter content varied from 7.80 to 10.2 %. The dry matter is influenced significantly (P<0.05) by the color of apples. The levels of total soluble solids ranged between 10.2 and 10.7. The ash content varied from 1.3 to 1.88 % and was also significantly influenced (P<0.05) by color.

Table 2. *Biochemical characteristics of cashew apple juice*

	Samples					
Parameter	**YA_1**	**YA_2**	**RA_1**	**RA_2**	**RAGT**	**YAGT**
pH	4,43±0,10 ^{a}	4,37 ±0,10^a	4,43±0,10^a	4,5±0,00^a	4,47±0,10^a	4,4±0,00^a
TTA (%)	0,56±0,01^a	0,56±0,02^a	0,58± 02 ^{a}	0,59±0,01^a	0,75±0,02^b	0,70±0,10^b
SST (°Brix)	10,9±0,20^a	10,2±0,20^b	10,3±,03^b	10,7±0,06^a	10,6±0,14^a	10,3±,04^a
Dry matter (%)	10,0±0,20^a	10,20±0,00^a	8,9±0,12^b	9,2±0,12^b	7,80±0,00^c	8,07±0,12^c
Ash (%)	1,5±0,07^a	1,4±0,10^a	1,3±0,20^b	1,3±0,40^b	1,88±0,16^c	1,77±0,16^c

Value with similar superscripts arranged vertically is not significantly different from each other (p<0,05) in the same variety of mineral, value are expressed as mean±**SEM** (n = 3 determinations), TTA: Total Titratable Acidity. YA_1: Yellow Apple 1; YA_2: Yellow Apple 2 ; RA_1 : Red Apple 1 ; RA_2: Red Apple 2 ; RAGT : Red Apple with Greenish Tasks ; YAGT : Yellow Apple with Greenish Tasks.

Table 3. *Levels of reducing sugars and total sugars of cashew apple juice*

	Samples					
Parameter	**YA_1**	**YA_2**	**RA_1**	**RA_2**	**RAGT**	**YAGT**
Total sugars (g/L)	168,1±1,3^a	162,9±1,2^b	165,4±1,8^a	162,7±0,2^b	165,5±2,2^a	168,1±1,9^a
Glucose (g/L)	56,8±0,4^a	54,2±0,5^a	65,8±0,2^b	64,5±0,7^b	49,6±0,8^c	47,2±0,5^c
Fructose (g/L)	105,6±1,6^a	105,0±0,4^a	100,7±0,6^b	103,4^b±0,2	106,2^a±1,9	110,3^a±0,5
Sucrose (g/L)	2,6±0,5^a	2,5±0,3^a	4,2±0,5^b	5,3±0,3^b	2,6±0,1^b	2,5±0,2^a

Value with similar superscripts arranged vertically is not significantly different from each other (p<0,05) in the same variety of mineral, value are expressed as mean±**SEM** (n = 3 determinations), YA_1: Yellow Apple 1; YA_2: Yellow Apple 2 ; RA_1 : Red Apple 1 ; RA_2: Red Apple 2 ; RAGT : Red Apple with Greenish Tasks ; YAGT : Yellow Apple with Greenish Tasks.

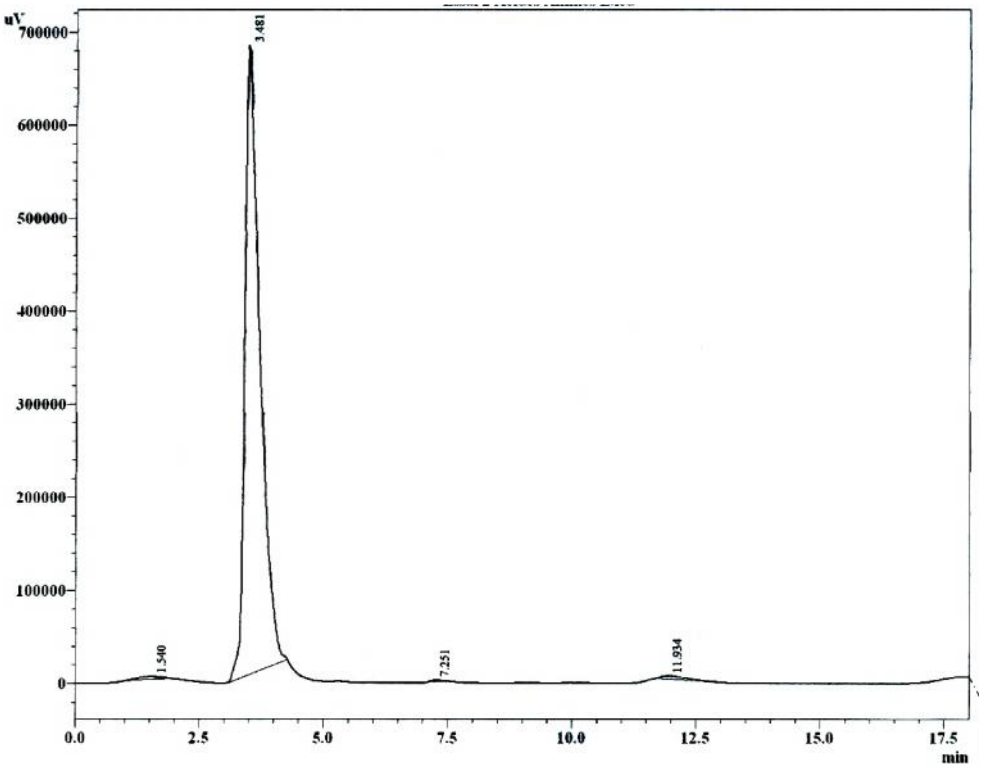

Figure 1. *HPLC chromatogram of free amino acids of juice YAGT*
The values expressed in the chromatogram are retention times of each compound. Asparagine (3.48 min), tryptophan (7.25 min) and lysine (11.93 min). The compound eluting at 1.54 min was not identified.
YAGT: yellow Apple with greenish task.

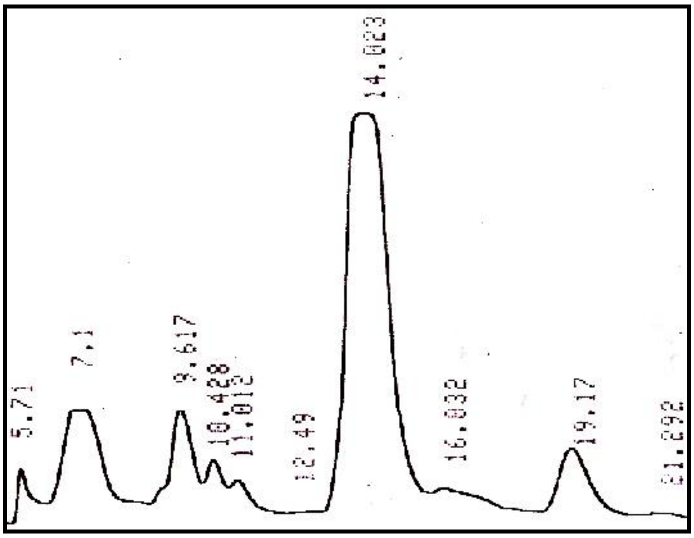

Figure 2. *HPLC Chromatogram of organic acids of juice RA_2*
The values expressed in the chromatogram are retention times of each compound. Acetic acid (12.49 min), oxalic acid (7.1 min), citric acid (9.617 min), tartaric acid (10.428 min), fumaric acid (16.032 min) propionic acid (19, 17 min). The compounds eluting at 5.71 min; 11.012 min and 21.292 min were not identified.
RA_2: Red Apple 2.

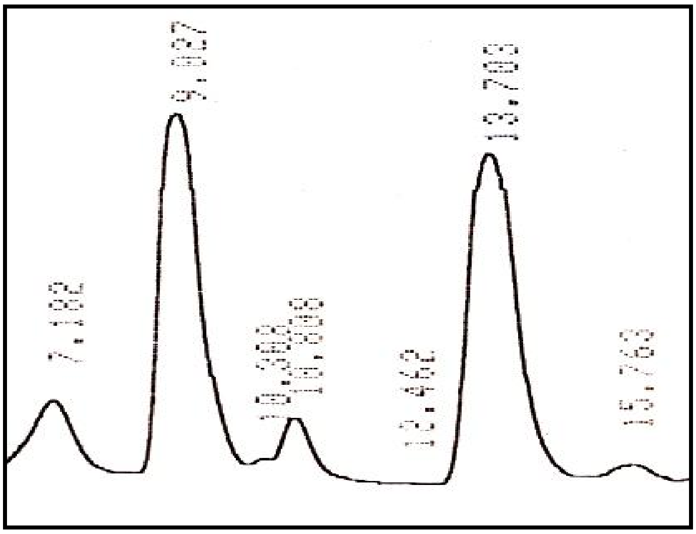

Figure 3. *HPLC Chromatogram of ascorbic acid of juice YA[1]*
The value expressed in the chromatogram is the retention time of ascorbic acid (9.027 min). The compounds eluting at 7.182 min; 10.308 min; 10.808 min; 12.462 min; 13.703 min and 15.663 min were not identified.
YA[1]: yellow Apple 11

Table 3 shows the levels of total sugars, glucose, fructose and sucrose in samples of apples juices. Total sugar contents were ranged from 162.7 to 168.1 g/L. The total sugar contents of apples juices from the first sampling (YA_1 and RA_1) are higher than those of apples juices from the second sampling (YA_2 and RA_2). Regarding the level of free sugars, glucose levels in the juice varies between 47.2 and 65.8 g/L, those of fructose between 100.7 and 110.3 g/L and those of sucrose between 2.5 and 5.3 g/L. The variations of free sugars show a significant difference between the apples of different colors.

Table 4 shows the levels of ascorbic acid (vitamin C) of cashew apple juice. These levels range from 370.9 to 480.3 mg/100 g of apple juice. Comparison of the levels shows a significant variation ($P<0.05$) between yellow apple juice and those of the red apple juice but also with apple greenish tasks. Outside of vitamin C, five organic acids have been characterized. Citric acid leads, followed by tartaric, acetic acid, oxalic acid and finally by fumaric acid. Concentrations of the characterized organic acids are significantly different ($P<0.05$). In other words, the color of the cashew apple influences the content of organic acid.

Table 5 shows the composition of protein and some free amino acids from the analysis of samples of cashew apple juice. The protein content varies from 0.51 to 0.53 g/100g and reflects a general poverty of apple juice in protein. The major amino acids found are in order of magnitude, cysteine, leucine and asparagine.

The change in pH of samples of this study was similar to the results found by Lowore and Agyente, (2009) in samples of cashew apple juices from four regions of Ghana and range between 4.19 and 4.59. Sousa *et al.* (2007) have also observed an average of 4.5 pH. Yet, those results were lower than those observed (4.86 to 5.54) in five ecological zones of India (Sivagurunathan *et al.*, 2010). But overall, the pH reflects the acidic nature of cashew apple juice. The difference of the total titratable acidity between the juices (YA_1, YA_2, RA_1, RA_2) and juices from apples which greenish tasks (YAGT and RAGT) was corroborated by the fact that the composition of the fruit was influenced by various parameters including the degree of maturity (Pinheiro *et al.*, 2006). However, the levels recorded in this study were in the range 0.45 to 1.26 % from the analysis of cashew juice samples collected from different brands on the Brazilian market by the same authors. The values of total soluble solids found were above the minimum value required by Brazilian law which is 10 °Brix (Brasil leis, 20

The dry matter variation was within the margin left by the water content which is 84-88 % (Morton, 1987). The yellow apples seemed to have the highest rates, followed by the red apples and the apples which greenish tasks. For the ash, the apple juice with tasks has the higher content.

Table 4. *Levels in Vitamin C (mg/100g) and organic acids (µg/ml)*

Parameter	Samples					
	YA_1	YA_2	RA_1	RA_2	RAGT	YAGT
Vitamin C	$476,3\pm11,1^a$	$480,3\pm13,3^a$	$406,6\pm5,1^b$	$407,0\pm17,7^b$	$430,4\pm9,9^c$	$370,9\pm2,9^d$
Acetic acid	$48,2\pm8,8^a$	$55,2\pm8,21^a$	$258,2\pm59,5^b$	$266,5\pm13,4^b$	$186,1\pm14,4^c$	$194,8\pm24,8^c$
Oxalic acid	$204,3\pm23,6^a$	$197,8\pm16,2^a$	$359,5\pm15,4^b$	$364,4\pm14,5^b$	$291,8\pm4,8^c$	$296,0\pm8,9^c$
Citric acid	$1092,1\pm91,1^a$	$997,7\pm39,5^a$	$290,7\pm33,6^b$	$304,7\pm64,9^b$	$397,6\pm9,8^c$	$379,3\pm5,4^c$
Tartric acid	$497,5\pm18,2^a$	$518,8\pm15,2^a$	$544,5\pm19,7^b$	$536,7\pm9,2^b$	$693,3\pm8,3^c$	$638,3\pm15,8^c$
Fumaric acid.	$18,0\pm8,0^a$	$22,7\pm5,1^a$	$84,0\pm10,3^b$	$78,4\pm3,9^b$	$49,4\pm3,7^c$	$51,7\pm5,9^c$

Value with similar superscripts arranged vertically is not significantly different from each other (p<0,05) in the same variety of mineral, value are expressed as mean**±SEM (**n = 3 determinations)
YA_1: Yellow Apple 1; YA_2: Yellow Apple 2 ; RA_1 : Red Apple 1 ; RA_2: Red Apple 2 ; RAGT : Red Apple with Greenish Tasks ; YAGT : Yellow Apple with Greenish Tasks.

Table 5. *Protein content (g/100 g) and amino acids (µg/ml)*

Parameter	Samples					
	YA_1	YA_2	RA_1	RA_2	RAGT	YAGT
Protein	$0,53\pm0,02^a$	$0,51\pm0,01^a$	$0,52\pm0,01^a$	$0,51\pm0,0^a$	$0,52\pm0,01^a$	$0,53\pm0,02^a$
Asparagin	$330,9\pm8,4^a$	$262,7\pm5,84^b$	nd	$136,4^c\pm1,9$	$257,1^b\pm1,1$	$350,5^a\pm10,3$
Glycin	nd	$3,68\pm0,135^a$	$3906,0\pm11,0^b$	nd	nd	nd
Cystein	$316,7\pm6,04^a$	$7628,9\pm57,6^b$	nd	$4853,7\pm25,1^c$	$7048,1\pm29,1^b$	nd
Tryptophan	$0,1\pm0,01^a$	$0,28\pm0,03^a$	nd	nd	nd	$0,01\pm0,0^b$
Lysin	$0,67\pm0,01^a$	$0,21\pm0,0^b$	nd	$0,37\pm0,02^b$	$0,02\pm0,0^c$	$0,5\pm0,02^a$
Leucin	$388,6\pm8,9^a$	$3191,3\pm154,9^b$	$4141,9\pm0,0^b$	nd	$1275,9\pm167,8^c$	nd
Tyrosin	nd	$2000,9\pm68,1^a$	nd	nd	nd	nd
Prolin	nd	nd	nd	nd	$8,8\pm0,0^a$	nd
Phenylalanin	nd	nd	nd	nd	nd	nd

Value with similar superscripts arranged vertically is not significantly different from each other (p<0,05) in the same variety of mineral, value are expressed as mean**±SEM (**n = 3 determinations), nd = no detected;
YA_1: Yellow Apple 1; YA_2: Yellow Apple 2 ; RA_1 : Red Apple 1 ; RA_2: Red Apple 2 ; RAGT : Red Apple with Greenish Tasks ; YAGT : Yellow Apple with Greenish Tasks.

For sugar content as noted by several other authors, glucose, fructose and sucrose are the major sugars found in apple in general (Wallrauch and Faeth, 1988; Fuleki *et al*., 1994) and especially in the cashew apple (Sivagurunathan *et al*., 2010). There is a difference of the total sugar content between apples juices from the first sampling (YA_1 and RA_1) and those of apples juices from the second sample (YA_2 and RA_2). In general, the levels of sugar determined in the present study are higher than those found by some authors in their respective regions. Thus, Wu *et al.* (2007) reported 125.0 g/L and Sivagurunathan *et al.* (2010) up to 151g/L and 143 g/L respectively in the yellow and red apples juices. Concerning the three sugars study, fructose is the predominant sugar compared to glucose and sucrose and this is consistent with the work of Wu *et al.* (2007) who found that fructose was more abundant in the apple juice followed by glucose. Although there is a difference in the levels of sugars, different samples of apples juices studied show a good provision as a substrate to fermentation. Indeed, Diop *et al.* (2008) showed that the cashew apple juice could be a good substrate for fermentation if the inhibition parameters (pH, tannins, richness of field) are better control.

The levels of ascorbic acid (vitamin C) of cashew apples juices confirm the trend in vitamin C of cashew apple juice as shown by several authors (Morton, 1987; Moura, 1998; Akinwale, 2000; Azam and Judge, 2001). Unlike studies of some authors, who concluded that the color did not influence the vitamin C (Assunção and Mercadante, 2003; Lowore and Agyente, 2009), in the present study the color has an influence on this level. The yellow apples juices have the highest levels and this is consistent with the conclusions of the authors raised. In addition, levels of vitamin C in this study are significantly higher than those found by Morton (1987) which is 372 mg/100 g, and by Lowore and Agyente (2010) which vary between 206.2 and 268.6 mg/100 g. Higher levels in this study could be explained by two facts. First, the majority of dosages of vitamin C were carried out by titration (AOAC, 1980) while the method used in this study is the high performance liquid chromatography (HPLC) which is more sensitive and better quantifies the item determined (Wimalasari and Wills, 1983). Secondly, the medium used in the stabilization of vitamin C in the sample of juice was citric acid, unlike other assays using 6% meta-phosphoric acid. In fact, Albuquerque *et al.* (2005) have shown through their study that citric acid was a better stabilizer of vitamin C. But first of all, these figures reveal the richness of apples studied in vitamin C. The biological functions of vitamin C are numerous in the body. Vitamin C plays a relative role in the immune system, the biosynthesis of collagen, iron absorption and inhibition of the formation of nitrosamines (Vannuchi and Jordão, 1998). Its antioxidant property is associated with reduced cancer incidence in the body (Lupulescu, 1990; Lupulescu, 1993). Moreover, these high levels are an important asset for the preservation of vitamin C during the heat treatments such as pasteurization, despite his state of thermolability (Walingo, 2005). In short, vitamin C is a very important component for the metabolism of the organism and the inventory of these functions is very broad. With regard to the five organic acids characterized, apart from the citric acid content where yellow apples juices are the richest, red apples contain the highest levels of other organic acids. The identification and determination of organic acids in fruit juices are very important because they provide useful information about the authenticity of the product. Their presence can affect the chemical and sensory characteristics of the matrix (eg pH, total acidity, microbial stability, softness, overall acceptability) and can provide valuable information on product safety and on how to improve some selected technological processes (Chinnici *et al*., 2005). More specifically, fumaric acid is considered an important parameter that gives an indication of microbial spoilage (Trifir *et al*., 1997). Its natural concentration in apple juice in general, is not more than 3 mg/L. High level of fumaric acid can reveal a microbial growth or an intentionally added of synthetic malic acid in the field (Kvasnicka and Voldrich, 2000). In this study the concentrations of fumaric acid in juice samples are below the target value above and reflect a state of fresh juices analyzed. Similarly, in all of cashew apple juice analyzed, organic acids were measured in concentrations below this target.

The results of protein and free amino acids are lower than those found by Wu *et al.* (2007) in apple juice in China. This is explained by the fact that the amino acids measured in this study are those in the free state in the juice.

In 2008, Côte d'Ivoire produced 330,000 tons of cashew nuts. Based on the fact that the nut is 10% the weight of the cashew apple (Honorato *et al.*, 2007) this would represent 3.3 million tons of apples left rot in the fields. Like the cashew apples of other producing countries, the apple of Côte d'Ivoire is rich and deserves to be exploited.

Conclusions

The physico-chemical analysis of six samples of cashew apple juice from Yamoussoukro has revealed the tremendous nutritional potential of this fruit in terms of vitamin C, sugar, organic acids, dry matter and ash. Juices showed a significant variation in all measured compounds related to color and maturity. The cashew apples juices of this area are rich in vitamin C compared to the same varieties in other parts of the world. The cashew apple juice can be a good alternative to daily supplementation with vitamin C for children and adults. Moreover, the levels of sugars in the juice of cashew apples are a good substrate for fermentation for the production of wine, alcohol, vinegar. The cashew apple is rich in nutritional composition but is ignored because of its astringency. It is a product with high added value and the Ivorian government need to undertake policy to propagandize it as it is the case in some countries such as India and Brazil.

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