ISSN 2349-0837

Assessment of some biochemical parameters of apple juices from two cashew varieties as affected by three regions of Côte d'Ivoire

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ABSTRACT

Some biochemical parameters of juices from two red and yellow cashew applevarietiesfrom three regions of Côte d'Ivoire were analyzed. The parameters such as proteins, total soluble solids, total sugars, dry matters, and ashes had contents in juices ranging from 0.35 ± 0.01 % to 0.65 ± 0.02 %, 9.66 ± 0.28 % to 14.40 ± 0.10 %, 270.20 ± 5.15 g/L to 381.04 ± 9.86 g/L, 8.94 ± 0.02 % to 11.45 ± 0.43 % and 1.19 ± 0.01 % to 1.51 ± 0.03 % respectively. Besides, the Analysis of Variance (ANOVA)indicated that the region and variety had significant effects (P≤ 0.05) on these parameters.It so appeared significant differences (P≤ 0.05) between their contents. As for pH, these values varying from 4.00 ± 0.10 to 4.74 ± 0.10, differed meaningfully (P≤ 0.05) from one variety to another, whatever the region is. Otherwise, the results revealed that both red and yellow cashew apple varieties juices contained high rate of Tannins (1081.99 ± 34.64 -2561.61 ± 95.11 mg/L), Flavonoids (223.83 ± 2.94 mg/L - 490.04 ± 5.32 mg/L)and total phenolic compounds (1587.59 ± 76.99 - 3043.03 ± 69.87 mg/L) whereas the carotenoid (0.97± 0.02 mg/mL -2.94 ± 0.02 mg/L) and Anthocyanin (6.57 ± 0.17 mg/L to 10.38 ± 0.15 mg/L) contents were found low. They also indicated yellow cashew apple variety juice didn't contain Anthocyanin content. Besides, the Analysis of Variance (ANOVA)showed that the region and variety main effect had significant effects (P≤ 0.05) on these parameters.Thus, there were significant differences (P≤ 0.05) between their rates. Furthermore, studies mineral elements (K, P, Mg, and Na) were only affected by improvement zone except to Na and they varied significantly (p≤0.05). Red and yellow Cashew apple juices were the best sources of mineral elements and could be used in the diets of infants and young children. It was also rich in Vitamin C (210.61±5.01 mg/100mL and 403.73 ± 8.88 mg/100mL) and should be considered a potential supply source of adequate daily nutritional requirement for children and adults.

Keywords: Cashew apple; juice;proximate; mineral; antioxidant; region; ANOVA.

Council for Innovative Research
Peer Review Research Publishing System

Journal: JOURNAL OF ADVANCES IN AGRICULTURE
Vol. 5, No. 2

www.cirjaa.com, jaaeditor@gmail.com
editor@cirjaa.com

ISSN 2349-0837

INTRODUCTION

The cashew tree (*Anacardium occidentale* L.) is indigenous to Brazil and is an evergreen nut-bearing tropical plant that grows in latitude 15° north and south of the equator. It is a multipurpose tree crop with great economic importance to third world countries including Benin Republic, Brazil, Côte d'Ivoire, Guinea Bissau, Ghana, India, Mozambique, Nigeria, Phillippines, Sri Lanka, Tanzania and Vietnam [1].

In Cote d'Ivoire, the first cashew plantations have been established in the years 1960-70 as part of the reforestation initiative. The cashew tree was associated with other plants such as teak and acacia [11]. Its cultivation in so thrived in the North to the center. These areas receiving a rainfall ranging range 1000 to 1400 mm/year [22].Cashew tree bears cashew nut (true fruit) and cashew apple (pseudo fruit), accounting for 10 % and 90 % of the total fruit weight respectively. The apple along with nut falls on the ground at the ripening stage and the nut is detached from the apple for further processing. Cashew apples are elongated, round or pear-shaped fibrous fruits. It is a non-climacteric fruit found in three colors: yellow, orange and red, with the same pale yellow pulp, weighs about 75-80 g and is 6-10 cm in length [34]. Cashew apple is a valuable source of minerals and vitamins. Like any other fruit juices, cashew apple juice is notably characterised by sugar, organic acids and vitamin C [5]. Indeed, cashew apple juice is reported to contain 5times as much vitamin C as citrius juice [5, 12] and 10 times as pineapple juice [43]. Besides, it contains thiamine, niacin, riboflavin and precursors of vitamin A. Cashew apple juice is also found to be good source of minerals such as copper, zinc, sodium, potassium, calcium, iron, phosphorous and magnesium [33]. Otherwise, the juice also contains sulphur, silicon, chlorine, aluminium and bromine [4]. The cashew apple juice also has medical uses. For instance, its high tannin content makes it suitable remedy for sore throat and chronic dysentery in Cuba and Brazil [41]. It is also reported to have anti-bacterial, anti-axidant [17]and anti-mutagenic[16]. Otherwise, the effect of the environment on the chemical composition of fruits has been studied for a number of crops [51] such as grappes [50], cashew apple juice [33] and edible fruits in Ceara (Brazil)[20]. The main difference attributed in nutrient quality of the fruits could be attributed to the type of soil on which the cashew is being cultivated, climate, ecological zone and environment. The difference could be also attributed to the stage of maturation and the type of fruit.To the best of our knowledge, a little study has been done on the juice from cashew originating from the three agro-ecological zones in Côte d'Ivoire with respect to the effect of environment on the biochemical composition of the apple juice and how they vary between the red and yellow apples among the unknown source of the population stands of Côte d'Ivoire's cashew. Therefore, this survey seeks to assess the differences that may exist in the contents of apple juice ofthe red and yellow cashew apple from three agro-ecological zones and interaction between environment and cashew apple variety.

MATERIALS AND METHODS

Plant material

The fully ripened and undamaged fresh cashew apple fruits of two varieties (Red and Yellow) were harvested from cashew cultivation fields of three regions of Côte d'Ivoire that are "Zanzan", "Gbèkè" and "Marahoué". Then, theywerebrought to the laboratory for further processing.The harvest was carried out during the 2014 and 2015 cashew seasons (March to May).

Methods

Juice extraction

Cashew apples transported to the laboratory, was detached from the nuts. The apples were washed thoroughly with clean water. Then the apples were 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 analyses.

Proximate Composition Analysis

The pH was determined using a pH-meter (pH meter C861, Consort, bio block, Belgium). The determination of total soluble solids (TSS) was determined by the method of Soyer *et al.* (2003) [55] using a refractometer type ATR-W2 plus (2009/230, United Kingdom) equipped with a digital display (S/N: 32853, United Kingdom). Dry matters were determined by drying in an oven at 105ºC during 24 h to constant weight[7]. Ash was determined by incinerating in a furnace at 550ºC [7]. Method described by Dubois *et al*. (1956)[21] was used to determine total sugars. Protein was calculated from nitrogen (Nx6.25) obtained using the Kjeldahl method by AOAC (1990)[7].

Mineral composition analysis

Minerals content of samples such as Sodium (Na), magnesium (Mg), phosphorus (P) and potassium (K) were quantitatively determined from the digest using strong acids and the atomic absorption spectrophotometer with appropriate hollow cathode lamps. Accuracy was assessed by analyzing the samples in triplicate (AOAC, 1990)[7].

Nutritive and antioxidant analyses

Total phenolic compounds content determination

Total phenolic content was estimated by using the Folin-Ciocalteau method [52]. An aliquot (1 mL) of each cashew apple juice was mixed with 1 mL of distilled water and 0.5 mL Folin Ciocalteau reagent (2N). the mixture was incubated for 5 min. Then, 1 ml of 5% (w/v) Na_2CO_3 (2N) was added and incubated in the dark for 1 h. The solution is centrifuged at 3000

rpm for 15 min and the supernatant was obtained. The absorbance was measured at 750 nm using a UV/VIS (JASCO-V-530). A standard curve was generated using gallic acid with concentrations ranging from 25 to 200 µg/ml. The polyphenol concentrations of apple juice were expressed as weight of gallic acid equivalent.

Tannin content determination

Tannin content was determined using the method described by Bainbridge et al. (1996) [13]. 1 ml of each apple juices sample was mixed with 5 ml of reaction solution (50 g of vanillin + 4 ml of hydrochloric acid in 100 ml distilled water). The mixture was incubated at in the dark for 20 min. The absorbance was read at 500 nm against a blank (without sample). Tannic acid (1 mg/ml) was used as standard. The results were expressed in µg/ml tannic acid equivalents.

Flavonoid content determination

The flavonoid content of the samples of various cashew apple juices was carried out as method described by Meda et al. (2005) [38]. An aliquot of 0.5 mL of each apple juice was added to 0.5 ml of distilled water and 0.5 mL of aluminum chloride (10%, w/v). The mixture was centrifuged at 6000 for 5 min. 0.5 mL of sodium acetate at 1 M and 2 mL of water distilled were added. The absorbance was measured at 760 nm using Shimadzu UV-1650 PC Spectrophotometer (Kyoto, Japan) against a blank (without sample). The results were calculated in terms of quercetin equivalents.

Anthocyanin content determination

The assessment of anthocyanin content of apple juice sample was performed using the method of Ribereau and Stonestreet (1965) [48]. To 1 mL of sample, 1 mL of ethanol and 20 mL of HCl solution were added successively. Then 10 mL of the mixture were evenly distributed in two tanks. The first tank contained 5 mL of the mixture and 2 mL of distilled water. As for the second tank, it contained 5 ml of the mixture and 2 ml of bisulfate. These tanks are read in a spectrophotometer at 520 nm.

Carotenoid content determination

Carotenoids content was carried out according to Rodriguez-Amaya (2001) [49]. An aliquot of 2 mL of each apple juice were mixed three times with 50 mL of acetone until loss of pigmentation. The mixture obtained was filtered and total carotenoids were extracted with 100 mL of petroleum ether. Absorbance of extracted fraction was then read at 450 nm by using a spectrophotometer Shimadzu UV-1650 PC Spectrophotometer (Kyoto, Japan). Total carotenoids content was subsequently estimated using a calibration curve of β-carotene (1 mg/mL) as standard.

Vitamin C content determination

Vitamin C content in analyzed cashew apple juice samples was determined by titration using the method described by Pongracz et al. (1971) [47]. About 10 g of each sample were soaked for 10 min in 40 mL metaphosphoric acid-acetic acid (2 %, w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 mL of bi-distilled water. Ten (10) mL of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L.

Statistical analysis

All analyses were carried out in triplicates. Results were expressed by means of ± SD. Statistical significance was established using two-way analysis of Variance (ANOVA) models to estimate the effect of region and variety main effects and their interaction on some biochemical parametercontents of apple juices from cashew at 5 % level. Means were separated according to Duncan's multiple range analysis ($P < 0.05$), with the help of the software STATISTICA 7 (Statsoft Inc, Tulsa-USA Headquarters) and XLSTAT-Pro 7.5.2 (Addinsoft Sarl, Paris-France).

RESULTS

Proximate composition

The proximate composition of juices extracted from yellow and red cashew apple varieties from three improvement regionzonesis shown in Table 1.

pH

The pH of apple juices from cashew tree was ranged from 4.00 ± 0.10 to 4.74 ± 0.10 in yellow and red fruit respectively (Table1). The highvalues of pH were obtained with the red apple variety,whatever the region is. The juice of yellow apple variety from "Zanzan" region had the lower value of pH (4.00 ± 0.10) whereas the highest value of pH (4.74 ± 0.10) was found in red apple variety from "Marahoué" region. Otherwise, the Analysis of Variance (ANOVA)revealed that the region and variety main effects appeared significant ($P \leq 0.05$) (Table 2). Indeed, the pH of apple juice varied significantly ($P \leq 0.05$) from one variety to another, whatever the region is

Total soluble solids (TSS)

The TSS of apple juices from cashew tree was varied from 9.66 ± 0.28 % to 14.40 ± 0.10 % for red and yellow fruit respectively (Table1). The least values of TSS were found in red apple variety, whatever the region is.The juice of red apple variety from "marahoue" region had the lowest value of TSS (9.66± 0.28) while the highest value of TSS (14.40 ±0.10) was obtained with the juice of yellow apple from "Zanzan". Furthermore, the Analysis of Variance

ISSN 2349-0837

(ANOVA)indicated that the region and variety main effects and their interaction appeared meaningful (P≤ 0.05) (Table 2). Indeed, the TSS of apple juice varied meaningfully (P≤ 0.05) from one variety to another, whatever the region is.

Dry matter content

The dry matter content of apple juices from cashew tree was ranged from 8.94 ± 0.02 % to 11.45 ± 0.43 % for red and yellow fruit respectively (Table1). The juice of red apple variety from "Zanzan" region had the lowest dry matter content (8.94 ± 0.02 %), while the highest dry matter content (11.45 ± 0.43 %) was found in juice of red apple variety from "Zanzan". Besides, the Analysis of Variance (ANOVA)indicated that the region main effect and the variety and region interactionhad significant effects (P≤ 0.05)on dry matter content (Table 2).Thus,there were meaningful differences (P≤ 0.05) between the dry matter content in apple juice from one variety to another, whatever the region is.

Ash content

The total ash content of apple juices from cashew tree was ranged from 1.19 ± 0.01 % to 1.51 ± 0.03 % in red and yellow fruit respectively (Table1). The ash content inyellow apple variety juice was slightly higher than those determined in red apple variety juice, whatever the region is. The juice of yellow apple variety from "Gbèkè" region had the highestash content (1.19 ± 0.01 %), wheras the least ash content (1.51 ± 0.03 %) was found in red apple variety from "Marahoué" region. Otherwise, the Analysis of Variance (ANOVA)revealed that the region and variety main effects and their interactionhadn't meaningful effect on ash content (P≥0.05) (Table 2). The ash content of apple juice didn't so vary statistically (P≥ 0.05) from one variety to another, whatever region is.

Total sugar content

The total sugar content of apple juices from cashew tree was varied from 270.20 ± 5.15 g/L to 381.04 ± 9.86 g/L in yellow and red fruit respectively (Table1). The lowest total sugar content was found in juice of yellow apple variety from "Gbèkè" region, whereas the highest total sugar content was obtained with the juice of red apple variety from "Zanzan". Besides, the Analysis of Variance (ANOVA)revealed thatregion and variety main and their interaction effects appeared significant (P≤ 0.05) (Table 2). Thus, the total sugar content of apple juice varied meaningfully (P≤ 0.05) from one variety to another, whatever region is.

Protein content

The crude protein content of apple juices from cashew tree was ranged from 0.35 ± 0.01 % to 0.65 ± 0.02 % in yellow and red fruit respectively (Table1). The juice of yellow apple variety from "Gbèkè" region had the lowestprotein content (0.35 ± 0.01 %) while the highest protein content (0.65 ± 0.02 %) was found in red apple variety from "Zanzan" region. Otherwise, the Analysis of Variance (ANOVA)revealed that the region and variety main effects had meaningful effect on crude protein content (P≤ 0.05) (Table 2). It appeared also statistically differences (P≤ 0.05)between the protein contents of apple juice from one variety to another, whatever the region is.

Table 1: Proximate composition of juices extracted from yellow and red cashew apple varieties from three improvement regions

	Samples					
Parameters	YCAVJZ	YCAVJM	YCAVJG	RCAVJZ	RCAVJM	RCAVJG
pH	4.0 ± 0.10^{a}	4.5 ±0.10^{e}	4.1 ± 0.00^{b}	4.13 ± 0.10^{d}	4.74 ± 0.10^{f}	4.11 ± 0.00^{c}
TSS (%)	14.40 ± 0.10^{e}	11.33 ± 0.28^{a}	12.16 ± 0.28^{d}	11.01 ± 0.01^{a}	9.66 ± 0.28^{b}	10.33 ± 0.57^{c}
Dry matters(%)	9.50 ± 0.20^{c}	10.16 ± 0.01^{b}	10.46 ± 0.02^{a}	8.94 ± 0.02^{a}	9.41 ± 0.65^{e}	11.45 ± 0.43^{d}
Ashes (%)	1.43 ± 0.10^{a}	1.36 ± 0.01^{a}	1.51 ± 0.03^{b}	1.19 ± 0.01^{a}	1.25 ± 0.01^{a}	1.37 ± 0.02^{a}
Total sugars (g/L)	364.88 ± 11.74^{a}	328.54 ± 3.07^{b}	270.20 ± 5.15^{c}	381.04 ± 9.86^{a}	331.20 ± 7.61^{b}	376.85 ± 3.62^{a}
Proteins (g/100g)	0.44 ± 0.02^{a}	0.64 ± 0.02^{b}	0.35 ± 0.01^{c}	0.65 ± 0.02^{b}	0.44 ± 0.01^{a}	0.57 ± 0.01^{d}

Each value is an average of three replicate.

Values are mean ± standard deviation.

Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of Duncan.

YCAVJZ: yellow cashew apple variety juice from "Zanzan" region

YCAVJM: yellow cashew apple variety juice from "Marahoue" region

YCAVJG: yellow cashew apple variety juice from "Gbèkè" region

RCAVJZ: red cashew apple variety juice from "Zanzan" region

RCAVJM: red cashew apple variety juice from "Marahoue" region

RCAVJG: red cashew apple variety juice from "Gbèkè" region

Table 2: ANOVA table for two-way of main effects of region and variety on proximate composition of juices extracted from yellow and red cashew apple varieties

Parameters	Effect	Degrees of Freedom	Sum of squares	Mean square	F-ratio	P-value
	Region	2	1.150	0.575	86.230	7.58E-8*
	Variety	1	0.072	0.072	10.830	0.006*
	Regions*Variety	2	0.040	0.020	2.980	0.089ns
	Error	12	0.080	0.007		
pH	Total	17	1.3416			
	Region	2	16.111	8.056	39.130	5.52E-06*
	Variety	1	25.537	25.537	124.04	1.11E-07*
	Region*Variety	2	2.233	1.116	5.42	0.021*
	Error	12	2.471	0.206		
TSS	Total	17	46.352			
	Region	2	11.471	5.736	63.600	4.10E-07*
	Variety	1	0.014	0.014	0.150	0.702ns
	Region*Variety	2	3.722	1.861	20.64	1.13E-04*
	Error	12	1.082	0.090		
Dry matters	Total	17	16.289			
	Region	2	0.348	0.174	1.302	0.307ns
	Variety	1	0.006	0.006	0.043	0.840ns
	Region*Variety	2	0.478	0.239	1.787	0.209ns
	Error	12	1.605	0.134		
Ashes	Total	17	2.43680			
	Region	2	239519	119759	1974.37	7.77E-16*
	Variety	1	5715	5715	94.21	4.94E-07*
	Region*Variety	2	70038	35019	577.33	1.18E-12*
	Error	12	728	61		
Total sugars	Total	17	315999			
	Region	2	0.107025	0.053512	9.4343	0.003*
	Variety	1	0.035467	0.035467	6.2528	0.027*
	Region*Variety	2	0.052070	0.026035	4.5900	0.033*
	Error	12	0.068065	0.005672		
Proteins	Total	17	0.262627			

-The symbol of * state shows significant difference at 5% level

- The ns sign shows not significant difference at 5% level

Nutritive and antioxidant properties

The nutritive and antioxidant properties of juices extracted from yellow and red cashew apple from three improvement regionare presented in Table 3.

ISSN 2349-0837

Total phenolic compounds

The total phenolic compounds content in juices was ranged from 1587.59 ± 76.99 to 3043.03 ± 69.87 mg/L (Table1). The juice of yellow apple variety from "Gbèkè" region had the lowest total phenolic compounds content (0.35 ± 0.01 %) while the highest total phenolic compounds content (3043.03 ± 69.87 mg/L) was found in red apple variety from "Zanzan" region. Besides, the Analysis of Variance (ANOVA) indicated that the improvement region and variety main effects and their interaction appeared meaningful (P≤ 0.05) (Table 2). Thus, Total phenolic compounds content of apple juice varied statistically (P≤ 0.05) from one variety to another, whatever the improvement region is.

Tannin content

The tannin content of apple juices from cashew tree was ranged from 1081.99 ± 34.64 to 2561.61 ± 95.11 mg/L in yellow and red fruit respectively (Table 3). The highesttannin content (2561.61 ± 95.11 mg/L) was found in juice of red apple variety from "Zanzan" region, whereas the leasttanninconten t (1081.99 ± 34.64) was obtained with the juice of yellow apple variety from "Marahoué" region. The tannin content in juice from red cashew apple was generally higher than those found in juice from yellow cashew apple for the same regions.Furthermore, the Analysis of Variance (ANOVA)revealed that the region and variety main effects and their interaction appeared significant (P≤ 0.05) (Table 4). Also, the tannin content of apple juices varied meaningfully (P≤ 0.05) from one variety to another except to those of "Gbèkè" region.

Flavonoid content

The flavonoid content in apple juices from cashew tree was ranged from 223.83 ± 2.94 mg/L to 490.04 ± 5.32 mg/L (Table 3). The juice of red apple variety from "Marahoué" region had the lowest flavonoid content (223.83 ± 2.94 mg/L) while the highest flavonoid content (490.04 ± 5.32 mg/L) was found in red apple variety from "Zanzan" region. Furthermore, the Analysis of Variance (ANOVA)revealed that the regionmain effectand the region and variety interaction had meaningful effect (P≤ 0.05) on flavonoidscontent (Table 4). So, flavonoidcontent of apple juice varied significantly (P≤ 0.05) from one variety to another, whatever the improvement region is.

Anthocyanin content

Theanthocyanin content of apple juices from cashew tree was varied from 6.57 ± 0.17 mg/L to 10.38 ± 0.15 mg/L (Table 3). The data showed that the anthocyanin content wasn't detectable inthe juice from yellow apple variety, whatever the improvement region is.Besides, The juice of red apple variety from "Marahoué" region had the least total anthocyanin content (6.57 ± 0.17) while the highest total anthocyanin content (10.38 ± 0.15 mg/L) was found in red apple variety from "Zanzan" region. Otherwise, the Analysis of Variance (ANOVA)revealed that region main effecthad meaningful effect (P≤ 0.05) on total anthocyanin content (Table 4). Thus, there were significant differences (P≤ 0.05) between theanthocyanin content in juice from red cashew apple variety.

Total carotenoid content

The total carotenoid content of apple juices from cashew tree was varied from 0.97± 0.02 mg/mL et 2.94 ± 0.02 mg/L in yellow and red fruit respectively (Table 3). The lowest total carotenoids content (0.97± 0.02 mg/mL) was obtained with the juice of yellow apple variety from "Zanzan" region, whereas the highest total carotenoid content was found in juice of red apple variety from "Gbèkè". Furthermore, the Analysis of Variance (ANOVA)indicated that the region and variety main effects and their interaction appeared significant (P≤ 0.05) (Table 4).also, there were meaningful differences (P≤ 0.05) between thecarotenoid content of apple juice from one variety to another, whatever the region is.

Vitamin C

The cashew apple juice from the three improvement zones was found to contain between 210.61 ± 5.01 mg/100mL and 403.73 ± 8.88 mg/100mL vitamin C (Table1). The least vitamin C content (210.61 ± 5.01 mg/100mL) was obtained with the juice of red apple variety from "Gbèkè" region whereas the highest vitamin C content (403.73 ± 8.88 mg/100mL) was found in juice of yellow apple from " Marahoué " region. Besides, the Analysis of Variance (ANOVA)indicated that the region and variety main effects and their interaction appeared significant (P≤ 0.05) (Table 2). Indeed vitamin C content of apple juice varied meaningfully (P≤ 0.05) from one variety to another, whatever the improvement region is.

ISSN 2349-0837

Table 3: Nutritive and antioxidant composition of juices extracted from yellow and red cashew apple varieties from three improvement regions

Parameters	Samples					
	CAJYVZ	CAJYVM	CAJYVG	CAJRVZ	CAJRVM	CAJRVG
TPC (mg/L)	2598.43 ± 121.62^{a}	2275.02 ± 21.62^{ab}	1587.59 ± 76.99^{c}	3043.03 ± 69.87^{e}	2356.36 ± 79.83^{b}	2167.67 ± 57.48^{a}
Tannins (mg/L)	2125.83 ± 107.96^{b}	1917.47 ± 99.18^{c}	1081.99 ± 34.64^{a}	2561.21 ± 95.11^{b}	2083.77 ± 100.19^{b}	1092.44 ± 97.90^{a}
Flavonoids (mg/L)	406.26 ± 10.12^{d}	334.73 ± 4.05^{a}	334.03 ± 3.47^{a}	490.04 ± 5.32^{e}	372.44 ± 4.40^{c}	223.83 ± 2.94^{b}
Anthocyanins (mg/L)	ND	ND	ND	10.38 ± 0.15^{a}	8.48 ± 0.45^{b}	6.57 ± 0.17^{c}
Carotenoids (mg/L)	0.97 ± 0.02^{b}	1.75 ± 0.00^{a}	1.74 ± 0.03^{a}	1.45 ± 0.01^{b}	2.94 ± 0.02^{e}	1.27 ± 0.02^{c}
Vitamin C (mg/100g)	276.73 ± 6.18^{a}	403.54 ± 8.88^{e}	226.14 ± 5.96^{c}	264.54 ± 4.41^{a}	342.22 ± 10.64^{d}	210.61 ± 5.01^{b}

ND: Not detected

Each value is an average of three replicate.

Values are mean ± standard deviation.

Means not sharing a similar letter in a line are significantly different $p \leq 0.05$ as assessed by the test of Duncan.

ISSN 2349-0837

Table 4: ANOVA table for two-way of main effects of region and variety on nutritive andantioxidant composition of juices extracted from yellow and red cashew apple varieties

Parameters	Effect	Degrees of Freedom	Sum of squares	Mean square	F-ratio	P-value
	Region	2	2672808	1336404	224.33	0*
	Variety	1	611644	611644	102.67	0*
	Region*Variety	2	199529	99765	16.75	0.0003*
	Error	12	71488	5957		
Total phenolic compounds	Total	17	3555470			
	Region	2	6494520	3247260	294.093	6.38E-11*
	Variety	1	474575	474575	42.981	0.0002*
	Region*Variety	2	587511	293756	26.604	0.0001*
	Error	12	132499	11042		
Tannins	Total	17	7689106			
	Region	2	84705	42353	999.72	4.50E-14*
	Variety	1	31	31	0.74	0.4061ns
	Region*Variety	2	31957	15978	377.16	1.47E-11*
	Error	12	508	42		
Flavonoids	Total	17	117202			
	Region	2	21.7835	10.8917	311.09	8.71E-07*
	Erreur	6	0.2101	0.0350		
Anthocyanin	Total	8	21.9936			
	Region	2	4.05603	2.02802	1372.34	6.77E-15*
	Variety	1	0.76056	0.76056	514.66	3.19E-11*
	Region*Variety	2	2.08468	1.04234	705.34	3.60E-13*
	Error	12	0.01773	0.00148		
Carotenoids	Total	17	6.91900			
	Region	2	46699	23349	104.089	2.62E-08*
	Variety	1	2845	2845	12.684	0.0039*
	Region*Variety	2	36100	18050	80.465	2.12E-07*
	Error	12	2692	224		
Vitamin C	Total	17	88336			

-The symbol of * state shows significant difference at 5% level

- The ns sign shows not significant difference at 5% level

Mineral composition

Table 5 summarizes some mineral composition of juices extracted from yellow and red cashew apple from three improvement regions. Na, Mg, K and P contents in apple juices were ranged from 34.43 ± 0.69 mg/100 mL to 40.13 ± 1.03 mg/100 mL, 150.63 ± 2.59 mg/100 mL to 193.40 ± 2.29 mg/100 mL, 2056.94 ± 37.33 mg/100 mL to 2295.02 ± 59.98 mg/100 mL and 130.99 ± 1.76 mg/100 mL to 221.15 ± 1.37 mg/100 mL respectively. Besides, the ANOVA indicated that the factor variety hadn't significant effect (P≤ 0.05) on mineral such as Na, Mg and P. On the other hand, the factor region had meaningful effect (P≤ 0.05) on Na, Mg, K and P contents. Significant differences (P≤ 0.05) were observed between Mg, P, and K contents in the both apple varieties juices excepted to Na content, whatever the improvement zone is. The values K/Na ratio was ranged from 54.23 ± 1.21 to 61.86 ±7.66 for Juice of apple yellow variety from "Zanzan" region and for Juice of apple yellow variety from "Gbèkè" region

ISSN 2349-0837

Table 5: Mineral composition of juices extracted from yellow and red cashew apple varieties from three improvement regions

Each value is an average of three replicate.

Parameters	Sample					
	CAJYVZ	CAJYVM	CAJYVG	CAJRVZ	CAJRVM	CAJRVG
Na (mg/100mL)	39.22±1.58^{ab}	40.13 ± 1.03^{b}	35.51± 5.50^{ab}	34.43 ± 0.69^{a}	35.12± 1.14^{a}	39.04 ± 1.16^{ab}
Mg (mg/100mL)	193.40 ± 2.29^{b}	150.63± 2.59^{c}	188.48 ± 1.40^{d}	174.08±2.62^{a}	192.62 ±2.27^{b}	172.32 ± 1.91^{a}
P(mg/100mL)	127.13±1.08^{a}	221.15±1.37^{c}	127.60±0.64a	130.99 ± 1.76^{b}	214.50± 2.14^{d}	132.84± 0.69^{b}
K(mg/100mL)	2125.76 ± 38.22^{ab}	2295± 59.98^{c}	2168.68 ± 71.54b^{a}	2083.84 ± 51.58^{ab}	2056.94 ± 37.33^{a}	2268.36± 57.12^{c}

Values are mean ± standard deviation.

Means not sharing a similar letter in a line are significantly different p ≤ 0.05 as assessed by the test of Duncan.

DISCUSSION

Proximate composition

The obtained values of pH in juice from red and yellow cashew apple varieties from three improvement region were all low. They varied significantly (P≤0.05) from one variety to another, whatever the improvement region is. This change was reported by Adou *et al*. (2012)[3] and Lowore and Agyente (2009)[33] in cashew apple juices from Yamoussoukro (Côte d'ivoire) and from four regions of Ghana respectively. Similar change was indicated by Sivagurunathan et al. (2010)[53] in cashew apple juices from five ecological zones of india. The results of this study were similar than those observed by Lowore and Agyente (2009)[33] who reported the values of pHranging from 4.19 to 4.59. Similarly, the pH of the fruit was observed as 4.5 in cashew apple [55]. Otherwise, the values of pH were higher than those found in apple juice by Daramola (2013)[19], who indicated the values of pH varying from 3.61 to 3.82. One the other hand, the obtained values of pH were lower than those recorded by Sivagurunathan et al. (2010)[53] who found the values of pH ranging from4.19 to 4.59. Our results justified that cashew apple juice was classified as acid food same class as that of orange [27].

The TSS of apple juice varied meaningfully (P≤ 0.05) from one variety to another, whatever the improvement zone is. This variation could be attributed to the climate and the variety [29]. Indeed, the variety influenced nutrient mobilization for raw sap synthesis. As for climate, it influenced by the change of intensity of sunlight[2]. Besides, excepted tored cashew apple variety juice from "Marahoué" zone, the obtained TSS contents were above the minimum value required by Brazilian law which is 10 °Brix [15]. This observation could return juice from cashew apple of Côte d'Ivoire as competitive on the international market of the fruit juices.

Dry matter content of apple juice differed meaningfully (P≤ 0.05) from one variety to another, whatever the improvement region is. This change in dry matter content of cashew apple juices could be attributed to the type of soil on which the cashew is being cultivated, climate, ecological zone and environment [57].The value of dry matter content recorded in this study was lower than those reported by Morton (1987)[41] (12-16%).

The ash content of apple juice didn't vary statistically (P≥ 0.05) from one variety to another, whatever region is. This result indicated that the both factors variety and region didn't also influence the ash content. Our results were similar to those published by Adou et al. (2012)[3] who found the respective values of 1.20% and 1.50% for juice from yellow and red cashew apple varieties.

The total sugar contents in cashew apple juice varied meaningfully (P≤ 0.05) from one variety to another, whatever the region is. The variability of these levels may be due to the hydrolysis of polysaccharides of into simple sugars during repining stage. Our results were found higher than those noted by Wu et al (2007)[62] in cashew apple juice (125 g/L). They were also higher than those obtained in juice from yellow and red apple varieties reported by Sivagurunathan et al (2010)[53] who mentioned 151 g/L et 143 g/L respectively. Total sugar contentsin juice from red cashew apple were generally significantly higher (p≤0.05) than those of yellow cashew apple juice for the same improvement region. Similar results were indicated by Lowore and Agyente (2009)[33] in juice from two cashew apple varieties. Again, the indication was that red cashew apples may be more for wine production in relation to high alcohol content.

The protein content in cashew apple juice differed meaningfully (P≤ 0.05) from one variety to another, whatever the region is. Low protein contents obtained in cashew apple juice were in accordance with previous studies. Protein content reported in this work was lower than those foundin cashew apple (*Anacardium occidentale*L.) fruits collected from Ariyalur District by Sivagurunathan *et al*. (2010)[53] (1.48%-6.21%). These values were also lower than that recorded in malay apple by Lim and Rebeta (2013)[32], who noted the rate of 1.21%. The low obtained content in cashew apple juice testified that it was poor in protein.

Nutritive and antioxidant composition

The total phenolic compounds content differed significantly (P≤ 0.05) from one variety to another, whatever the region is. The data revealed that the total phenolic compounds content in juice from red cashew apple was higher than those found in yellow cashew apple juice for same improvement region. These changes could be attributed to the type of soil on which the cashew is being cultivated, climate, ecological zone and environment [57]. The obtained total phenolic compounds content was very high compared to some studies fruits. This could be advantageous for cashew producing countries. Indeed, several studies have shown that phenolics are effective in reducing risk of cardiovascular disease [46, 36]. Yet 80% of deaths from cardiovascular disease occur in countries with low or middle income where people who have little access to effective health services [60]. The cashew apple juice appears to be an alternative for these countries including Côte d'Ivoire, through better knowledge and extension. Our results were very higher compared to 184.7-412mg/100 mL for cashew apple juice from four regions of Ghana and to 295.25 mg/100g for apple juice reported by Lowor and Agyente-Badu (2009)[33] and Melo et al. (2006) [39] respectively. Otherwise, Phenolic compounds were also responsible for the bitterness and astringency associated with many foods.

The tannin content in apple juices varied meaningfully (P≤ 0.05) from one variety to another except to those of "Gbèkè" region. It was also higher in juice from red cashew apple than that recorded in yellow cashew apple juice for same improvement region. The values were higher compared to 8.53.40mg/100g DW for Banana fruit juice, 8.5mg/100g DW for Apple fruit juice reported by Onibon *et al*. (2007)[44]. The astringent flavour of the juice could be associated with the high tannin content; tannin in the biological system has the ability to chelate protein making it impossible or difficult to digest [6].

As for the flavonoid content, the data revealed that the factors variety and region had significant effect (P≤ 0.05) on its content. Obtained flavonoid content in this work was higher than that recorded by Gliszezynska and Tyrackonoka (2003) [25](20.3-92.11 mg/L).Similar results were observed in cashew apple juice by Adou (2013) [2]. Flavonoids of cashew apple juice have been reported to possess health-promoting benefits. Indeed, flavonoids and phenolic acids are examples of antioxidants, which are important ingredients of many foods, and keenly sought in many 'health foods'. They are thought to help protect against diseases like cancer, cardiovascular disorders, neurodegenerative diseases and ageing by mopping up potentially damaging free radicals that are released in the body [45].

Vitamin C content in apple juice varied meaningfully (P≤ 0.05) from one variety to another, whatever the region is. This change wasn't in accordance with previous studiescarried out by assounção and Mercadante (2003)[10] and Lowor and Agyente-Badu (2009)[33], who indicated that the location and colour of apple didn't significantly influence the amount of vitamin C in the juice. One the other hand, our results were similar to those found by these authors who revealed that the vitamin C in juice from yellow variety was higher compared to the red. The found value was slightly lower than 44.10g/100g dry weight in apple fruit juice and 41.82g/100g DW in pine apple fruit juice mentioned by Marcelino *et al*. (2005)[35]. The recorded value of vitamin C in this study indicated that both cashew apple juice varietiesweregood sources of vitamin C which is essential for collagen formation, and aids iron to stay in reduced state [14]. Besides, Vitamin C contributes to the antioxidant properties of vegetables by protecting the membrane erythrocyte, maintaining the blood vessel flexibility and improving the blood circulation in the arteries of smokers as well as facilitating the absorption of iron in the body [42].

The carotenoid content in juices of red and yellow cashew apple varieties from three locations differed meaningfully (p≤0.05). This difference could be attributed to the degree of maturity, the variety and the growing location. These factors influenced significantly this component and also the components such as lycopene and β-carotene [30, 24]. Our results were higher than those found in fruits of tomatoes for industrial processing by Mendelova et al. (2010)[40], who reported total carotenoid content ranging from 4.41 to 7.85 mg/100 g. They were high compared to the amount of 2.63 to 6.55 mg100 g in fresh tomato fruits. In plants, vitamin A occurs in the form of provitamin A carotenoids which amount determines their bioavailability in human diet [49, 59]. Furthermore, carotenoids contents of studied cashew apple juicecould cover the standard values (3.6-4.8 mg/day) recommended by FAO (2004)[23].

The results of this study indicated that all juices from yellow cashew apple didn't contain anthocyanin. One the other hand, they revealed anthocyanin contents in juice from red cashew apple. These contents varied significantly (p≤0.05). The change in anthocyanin content could be due to the degree of maturity and the growing location. According to Lee et al (2005)[31], Anthocyanins are plant pigments responsible for the red, blue, and purple colours of various flowers and plants. This would explain the absence of anthocyanin in juice from yellow cashew apple variety. Our obtained results were lower than the respective amount of 4118 mg/L, 3042 mg/L and1544 mg/mL for elderberry, chokeberry and black currant juices published by Jakobek et al. (2007)[28]. High amount of anthocyanin content may be desirable to ensure that minimum acceptable levels remain after loss through storage or processing.

Mineral composition

Potassium (K) is the most abundant element in the allcashew apple juice samples followed by magnesium (Mg), phosphorus (P) and sodium (Na). This result was in agreement with the result observed by Onibon et al. (2007)[44], who

worked on some Nigerian fruits and also noted that potassiumwas the most abundant mineral in the fruits.Significant differences (P≤ 0.05) were observed between, phosphorus (P), and potassium (K) contents in the both apple varieties juices except to sodium (Na) content, whatever region is. These differences could arise from the different soil and improvement conditions between agro-ecological zones. Such results support the thesis that soil characteristics can markedly influence the mineral content of the product [37]. Besides, the biological activity and pH of the soil can influence the bioavailability of the minerals [26]. As for Na content, the obtained differences could also arise from the variety. Our results for Mg and K were in agreement with that found in cashew apple juice from four location of Ghana by Lowor and Agyente-Badu (2009)[33], who showed that colour was found not to significantly influence the levels, however, location had a significant effect. One the other hand, our data for phosphorus (P) didn't agree with the findings of Lowor and Agyente-Badu (2009)[33]. Theses authors found rates of phosphorus (0.04-0.07 mg/100 mL), Magnesium (5.52-16.70 g/mL) and Potassium (30.80-156.20 g/mL) in apple juice very lower than those obtained in this work. Potassium and sodium macroelements were required for the maintenance of cellular water balance, acid-base balance and nerve transmission and are required in large amounts in the body [58, 61]. Deficiencies of these macroelements lead to muscle cramps, mental confusion, loss of appetite and irregular cardiac rhythm[61]. Concerning Mg, it was required for our body's muscular contraction. Therefore, Consumption of cashew apple juice was desirable as they serve as good sources of these macroelement. The K/Na ratio (54.23 -61.86) was close to the recommended 5.0 [56]. Dietary changes leading to reduce consumption of potassium than sodium have health implications. Dietswith higher ratio K/Na are recommended and these are found usually in whole foods [9]. Foods,naturally higher in potassium than sodium, may have a K/Na ratio of 4.0 or more [18]. The high K/Nasuggests that the juice from red and yellow cashew apple could be suitable inhelping to ameliorate sodium-related health risk [8].

CONCLUSION

The results of this work indicated that the region and variety factors had significant effect (p≤0.05) on some proximate, antioxidant and mineral parameters of red and yellow cashew apple juices. Indeed, the rates of parameters such as TSS, Dry matter, Ash, Vitamin C, Na, Mg and K in juice from yellow cashew apple were found higher than those recorded in red cashew apple juice for the same region. One the other hand, the obtained values of pH, Total sugars, protein, total phenolic compounds, tannin, flavonoid, anthocyanin, carotenoid and P were relatively high compared to those determined in yellow cashew apple juice. Concerning improvement region, the study revealed that the cashew apple juice from "Zanzan" region contained relatively high contents in TSS, total sugar, protein, Tannin, flavonoid, anthocyanin and Mg, while the higest rates of carotenoid, pH, Vitamin C, Na, and P were obtained with the cashew apple juice from "Marahoue" region. As for cashew apple juice from "Gbèkè" region, it had relatively high contents in dry matter, Ash and K. Otherwise, the result of this work indicated that cashew apple juice was the best sources of mineral elements and could be used in the diets of infants and young children. It was also rich in Vitamin C and should be considered a potential supply source of adequate daily nutritional requirement for children and adults.

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