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Nutritional Profile and Chemical Composition of Juices of Two Cashew Apple's Varieties of Benin

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Abstract

Despite the innumerable virtues of cashew apple juice, and considering its astringency and the fact that its consumption with milk constitute taboo in several African countries, the cashew apple remains abandoned in its production areas. The present study aims to promote agro-resources and reduce post-harvest losses by highlighting the nutritional value and chemical composition of the cashew apple. For this purpose, two varieties of cashew apple collected in Central Benin were analyzed for nutrient and phenolic compound contents. The antiradical activity of the apple juice was evaluated by DPPH test. From the results obtained, it appears that the high juice content of the cashew apple (87.25 ± 4.14% and 80.90 ± 3.53% respectively for yellow and red varieties) confirms its character of perishable foodstuff. The juice of the cashew apple (especially the red variety) is rich in vitamin C (0.99% to 1.01%), minerals (3609.93 ± 1.15 mg/L of potassium, 218.03 ± 0.22% of sodium, 44.80 ± 0.11 mg/L of iron and 19.75 ± 0.02 mg/L of manganese) and phenolic compounds (45.99 ± 1.15 g/L of total polyphenols). This richness in vitamin C and phenolic compounds gives this juice its antioxidant power (IC_{50} = 4.8 mg/mL). The therapeutic and nutritional virtues of the cashew apple show that this agro-resource can be used as an interesting food.

Keywords

Cashew Apple Juice, Nutrients, Phenolic Compound, Valorization

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1. Introduction

The cashew tree (Anacardium occidentale L.) is a booming cash crop and represents a great opportunity for Africa to export its nuts. World production almost doubled in one decade from 2 361 384 tons in 2002 to 4 152 315 tons in 2012, thanks in particular to the renewed interest of some African countries in this crop [1]. With a national production of 170 000 t, Benin is ranked fifth among the world's leading exporters of raw nuts in 2012 [2], after Vietnam (1 190 900 t), Nigeria (836 500 t), India (680 000 t) and Côte d'Ivoire (450 000 t).

The cashew apple is the false fruit of the cashew tree. It corresponds to the hypertrophied peduncle of the walnut and represents five to nine times the nut mass [3]. The cashew apple is most often considered a by-product of the cashew industry and remains very poorly valued despite its richness in secondary metabolites such as phenolic compounds, carotenoids, aromatic compounds [4] and is not consumed because of its astringency due to the presence of tannins [5].

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Indeed, in addition to the water content (86%), the cashew apple has a high tannin content which limits its conservation for useful purposes [6]. However, it is processed in some countries into several products such as juice, jam, wine, vinegar and alcohol [7]. The food value of the cashew apple as a percentage of dry matter (12.32% DM) is in the range of 6.45 to 12.5% crude protein, 3.5 to 10.85% total fiber, 6 to 54.7% total sugar (glucose), 30.8 mg/100 g vitamin C and 12.48 MJ/kg energy and minerals [8]. A better valorization of cashew apple, co-produced from nuts production, will contribute to stabilize cashew trees exploitation. It will also help to create new economic activities that create jobs [4]. Fruits have been incorporated into the daily human diet ever since. Having very attractive colors, tastes and aromas, they are one of the essential elements for a balanced diet and are known for their role in the interview of the vital functions of the human organism. Fresh or in the form of processed products, fruits constitute an inexhaustible source of nutrients whose secondary metabolites are among the most important [9]. They are often considered as "functional foods" thanks to their richness in metabolites such as phenolic compounds (known especially for their high antioxidant power), minerals, vitamins, etc. The raw juice of apple cashew is less appreciated by consumers because of its astringency [4], despite its richness in water, sugars, vitamins, minerals, phenolic compounds; these latter being mainly responsible for the antioxidant activity. In this context, the objective of the presented work was to evaluate the nutritional value of the raw juice of the cashew apple and its chemical composition.

2. Material and Methods

2.1. Study Areas and Sampling

The present study focused on juices extracted from two varieties of cashew apples collected in the cotton zone of Center-Benin in the communes of "Bantè" and Savalou. The municipality of "Bantè" is located at 8°25'00 "north latitude and 1°58'32" east longitude. The commune of Savalou is located at latitude 7°55'41 "North and longitude 1°58'32" East. The different varieties of cashew apples collected by field picking were transported in ice-strengthened "Eskimo" iceboxes and stored in the freezer at -10°C until analysis.

2.2. Cashew Apple Juice Extraction

The juice of the different varieties of cashew apple was extracted by mechanical pressing using a screw press. The volume of juice collected was measured on the graduated test-tube before characterization. The apple juice yield (R) was calculated using the formula below:

$$R\ (\%) = \frac{\text{Juice volume} \ * \text{volumic mass of juice}}{\text{Fresh cashew apple masse used}} * 100$$

2.3. Biochemical Characterization of Cashew Apple Juice

Calcium, magnesium and total hardness were measured by titrimetric method while total iron and manganese were determined by a HACH DR/2400 UV-Visible spectrophotometer according to the analysis methods of the French Association for Standardization, AFNOR [10, 34]. In addition, potassium, sodium, copper and zinc were measured by flame atomic absorption spectrometry. The total sugars were evaluated using the UV-Visible spectrophotometer (JENWAY 50/60 Hz) method according to Dubois et al. [11]. The pH of the juices was measured with HANNA pH meter previously calibrated with buffer solutions of pH 4.0 and 7.0 [12]. Total acidity (g acetic acid/L) was determined on 10 mL of juice by titrimetric method with sodium hydroxide (0.1 N) with phenolphthalein as colored indicator. The total soluble dry matter content (degree Brix) of the juice was evaluated using a PAL 3-ATAGO 0-95 digital refractometer [1]. Vitamin C was determined by iodine titration [13]. The Kjeldahl method was used for proteins dosage. After mineralization, distillation and titration, the crude protein content is determined from the nitrogen content. This nitrogen rate, with a coefficient of 6.25, was converted into protein content [14]. The lipids were assayed by soxhlet extraction with hexane for 6 h at 69°C. The extraction is followed by drying in an oven at 105°C for one hour and the balloons are cooled in the desiccator and then weighed. The lipid content is expressed as a percentage on a dry basis [15].

2.4. Chemical Characterization of Cashew Apple Juice

2.4.1. Determination of Phenolic Compounds

The juice of each variety of cashew apple was subjected to the colorimetric dosage by UV-Visible spectrophotometry (JENWAY 50/60 Hz) to quantify the phenolic compounds.

Total polyphenols: Total polyphenols were assayed by Folin-Ciocalteu reagent [16, 17]. The Folin reagent used consists of a mixture of phosphotungstic and phosphomolybdic acid which is reduced, during the oxidation of phenols as a mixture of blue oxides of tungsten and molybdenum [18]. The absorbance was measured at the spectrophotometer at 765 nm. Gallic acid was used as a reference and juice total polyphenol content was expressed in g equivalent gallic acid per L juice.

Total flavonoids: Total flavonoids were quantified by the method of aluminum trichloride ($AlCl_3$). This technique is based on the formation of the flavonoid-aluminum complex which has a maximum absorption at 500 nm [19, 20].

Condensed tannins: The condensed tannins have been identified by the vanillin sulfuric method [21]. The principle of this assay is based on the fixation of the vanillin's aldehyde group on the carbon at position 6 of the ring A of the catechin to form a red chromophoric complex which absorbs at 510 nm [18].

2.4.2. Evaluation of Anti-Radical Activity

The antiradical activity was evaluated according to the DPPH method [22]. The principle of this method is based on measuring scavenging percent of DPPH solution's free radicals. This trapping is visualized by the disappearance of DPPH's purple color. The vats are incubated in the dark for one hour and the absorbances measured at 517 nm [23]. Percentage of trapping was calculated using the formula:

P = [(Abl - Aech)/Abl] x 100.

P: Percentage of trapping; Abl: absorbance of white; Aech: absorbance of the sample

2.5. Statistical Processing of Results

Repeated trials were used to calculate the mean and standard deviation associated with each measure based on Microsoft Excel 2013. Analysis of variance (ANOVA) for appreciating the difference significance between some averages was made with the Minitab 16.0 software. The method employed to discriminate averages is that of the smallest significant difference at the probability threshold P <5%. Indeed, statistical differences with a probability value of less than 0.05 (P <5%) are considered significant. On the other hand, if the probability is greater than 0.05 (P> 5%), the corresponding statistical differences are said to be insignificant.

3. Results and Discussion

3.1. Juice Content of Cashew Apples

The results obtained for the juice extraction yield of cashew apple are reported in Table 1. The analysis of this table shows that cashew apple's yellow variety refluxed the highest juice extraction yield with (87.25±4.14)% followed by the red variety with (80.90±3,53)%. So the yellow variety of cashew apple presents a higher water content than red. Our results on the juice content of cashew apples are similar to those obtained in Côte d'Ivoire by Soro [4], who obtained the same juice content (86%) for the two varieties of cashew apple. By against, in South Africa, Deenanath et al. [24] obtained a juice content of 26.52% (v/w) for all varieties, three times lower than those found in this study. In addition, Dédéhou et al. [13] obtained for the cashew apple in Benin an average yield of 60.62% by mass of raw juice extracted compared to apples. This low juice content would be justified not only by the poor performance of the screw press used, but also by the coarse cutting of the apple.

Table 1. Juice extraction yield of cashew apples

	Yellow	Red
Weighed mass (g)	200.3 ± 0.1^{b}	302.1 ± 0.1^{a}
Volume of juice (mL)	170 ± 2^{b}	235 ± 2^{a}
Yield (%)	87.25 ± 4.14^{a}	80.90 ± 3.53^{b}

Values with the same letter in the same line are not significantly different (P < 5%) according to ANOVA and Tukey's multiple comparison tests.

3.2. Biochemical Parameters of Cashew Apples Juice

The results of the biochemical parameters investigated are reported in Tables 2 and 3. Apple juice investigated showed a high total hardness (2 g/L), regardless of the variety, with high conductivity values: 4490 µS/cm for the yellow variety and 4440 µS/cm for the red variety. The measurement of the conductivity of the samples determines the dilution factor applicable to the different samples for mineral salts's dosage. The hardness is based on dissolved salts concentration (calcium and magnesium) contained in the liquid medium to be analyzed.

The results obtained from the analysis of the physico-chemical parameters (pH, titratable acidity, density and Brix degree) of the juices of different cashew apple varieties have been reported in Table 2. The physico-chemical parameters investigated presented virtually no significant difference. The analysis of the table shows that pH of fruit juices were between (4.40±0,01) and (4.43±0,01); which makes it possible to classify the samples in the category of more or less acidic fruits [25]. pH's low values of fruit juices would been essentialy due to the fruits internal acidity. Juices pH are similar to those obtained (4.00 and 4.60) by Michodjehoun-Mestres et al. [26] in Brazil on the juices of the two cashew apple varieties. Also, titratable acidity values were perfectly correlated with pH values recorded. The juices showed a density between (1.04±0.01) and (1.05±0.01). So juices were slightly denser than distilled water. Our results corroborate those of Deenanath et al. [27] in their investigations on cashew apple juice, with respect to pH (4.52) and specific density (1.050) in Johannesburg, South Africa. The highest Brix degree (12.63±0.06) °Bx is obtained with cashew apple red variety. Dédéhou et al. [13] have obtained, in their investigations on drinks based on cashew apple juice, Brix degrees between 11 °Bx and 14 °Bx.

Table 2. Physico-chemical characteristics of cashew apple juice

Cashew apple variety	Yellow	Red
pH	4.40±0.01[a]	4.43±0.01[a]
Acidity (%)	2.52±0.16[a]	2.44±0.07[a]
Density	1.04±0.01[a]	1.05±0.01[a]
Brix Degree (°Bx)	9.25±0.26[b]	12.63±0.06[a]

Values with the same letter in the same line are not significantly different (P < 5%) according to ANOVA and Tukey's multiple comparison tests.

Table 3 presents the nutritional composition of the juices of two cashew apple varieties studied in this work. This table recapitulates contents of macronutrients (total sugars, proteins and lipids) and micronutrients (minerals and vitamin C). The values observed with all metered nutrients except the total sugars were significantly different for the two cashew apple varieties (P<5%). The red variety revealed highs macronutrient contents with values of (2.37±0.19)%, (1.09±0.01)% and (2.99±0.01)%, respectively for total sugars, proteins and lipids. Glucose and fructose represent 96 to 98% of the total sugars of cashew apples [4]. As these reducing sugars are highly fermentable, this characteristic contributes to the great perishability of cashew apples which, once harvested, must be transformed within 24 hours, otherwise they will ferment. Moreover, this richness in reducing sugars makes cashew apple products particularly sensitive to non-enzymatic brownings (for example coloration of the juice during pasteurization). Both varieties contained virtually the same amounts of vitamin C (0.99% and 1.01%) according to Tukey test (P = 0.293). Also, It was noticed that micronutrients such as potassium, calcium and sodium were detected in high content in cashew apple juice analyzed mainly with the red variety, except that magnesium is more than three times concentrated in the yellow variety (413.44 mg/L). The other micronutrients such as copper, iron, zinc, manganese and iodine were observed in low proportions. The protein content obtained in the present work was greater than that of Adou et al. [28] at Yamoussoukro in the Ivory Coast regardless of cashew apple variety. The work by Dédéhou et al. [13] on clarified cashew juice's drinks revealed a vitamin C content ranging from 147.07 to 185.79 mg/100 mL. These values are about six (06) times lower than those obtained in the present work. Also, these beverages contain potassium, magnesium, phosphorus, sodium, iron and calcium. Potassium was the mineral with the highest content (145.03 to 134.26 mg/100g), while calcium and iron had the lowest contents with respectively (2.01 to 2.09 mg/100 g) and (1.54-2.97 mg/100 g). The high potassium content was confirmed in this study. Unfortunately, despite its nutritional value, this pseudo-fruit has remained largely untapped in its production areas. Until now, consumption of raw cashew apples or processed apples does not exceed 10% of total production. This implies practically an annual post-harvest loss of about 90% of production [29]. Furthermore, Adou et al. [30] in their "in vivo" toxicity tests on mixed of cashew apple juice and milk on mice at Abidjan in Côte d'Ivoire, had not detected any trace of toxicity of this mixture.

Table 3. Nutritional composition of the juice of two cashew apple varieties

Variety	Yellow	Red
Micronutrients contents (mg/L)		
Potassium	3609.93±1.15[b]	4361.28±4.31[a]
Calcium	120.24±0.10[b]	601.20±0.51[a]
Magnesium	413.44±0.31[a]	121.60±0.24[b]
Sodium	218.03±0.22[b]	234.01±0.42[a]
Copper	0.86±0.01[b]	1.28±0.01[a]
Iron	44.80±0.11[a]	35.10±0.10[b]
Zinc	3.55±0.01[b]	4.47±0.01[a]
Manganese	19.75±0.02[a]	3.16±0.02[b]
Iode	6.25±0.01[b]	22.00±0.01[a]
Macronutrients contents (%)		
Total sugars	1.56±0.13[b]	2.37±0.19 [a]
Proteins	0.79±0.01[b]	1.09±0.01[a]
Lipids	2.25±0.01[b]	2.99±0.01[a]
Vitamine C	1.01±0.01[a]	0.99±0.01[a]

Values with the same letter in the same line are not significantly different (P <5%) according to ANOVA and Tukey's multiple comparison tests.

3.3. Phenolic Composition of Cashew Apple Juice

The results of the quantitative analyzes of phenolic compounds (total polyphenols, total flavonoids and condensed tannins) by UV-visible spectrophotometry of the juices of two cashew apple varieties are summarized in Table 4. These results are expressed in g/L of juice and indicate that the juices studied contain mostly total polyphenols; but they're less concentrated in flavonoids and condensed tannins. The two varieties of cashew apple showed no significant difference (P>0.05) in their phenolic composition. The red variety of cashew apple presented the highest content in total polyphenol (45.99±1.15) g/L and condensed tannins (0.43±0.02) g/L. The same total flavonoid content (1.68 g/L) was observed in both varieties. The work of Deenanath et al. [27] revealed in Brazil a condensed tannin content (55.34 mg/L) on cashew apple's raw juice, about ten (10) times lower than that obtained in this study. Drinks based on cashew apple juice clarified with cassava starch or rice gruel revealed tannin contents ranging from 0.05 to 0.15 g/L [13]. Also, Deenanath [31] obtained in Brazil a low content of condensed tannins (15.34 mg/L) in the previously treated cashew apple. These contents are very low compared with those obtained in the present work; which confirms clarification processes' beneficial effect of cashew apple juice with the aim of eliminating tannins to improve its organoleptic quality before any food consumption. In addition, Castro et al. [32] revealed low contents of tannins (0.16% and 0.12%) respectively in the apples of two species of cashew tree (Anacardium occidentale and A. microcarpum) in Brazil. The richness in tannins of the apple gives it a particularly strong astringency.

Table 4. Phenolic composition of juices of two cashew apple varieties

Phenolic composition (g/L)	Cashew apple variety	
	Yellow	Red
Total polyphenols	36.12±3.01[a]	45.99±1.15[a]
Total flavonoids	1.68±0.20[b]	1.68±0.19[b]
Condensed tanins	0.25±0.11[b]	0.43±0.02[b]

Values that do not share any letters in the same row are significantly different (P<5%) according to ANOVA and Tukey's multiple comparison tests.

3.4. Antioxidant Power of the Juices of Two Cashew Apple Varieties

The antioxidant activity of the juices of the two varieties of cashew apple by the DPPH method was determined by referencing to quercetin (Q), a standard antioxidant (IC50 = 0.1 mg/mL). The juices exhibited a lower antiradical power than that of the reference compound (Table 5). Nevertheless, the yellow variety has proved to be the most active (4.8 mg/mL) followed by the red variety (5.8 mg/mL). The richness of polyphenols in the juice of the cashew apple gives it its antioxidant properties [28].

Table 5. Juices and standards' antiradical activity.

Samples	IC50 (mg/mL)	ARP
Yellow cashew apple	4,8	0,21
Red cashew apple	5,8	0,17
Q	0,1	10

ARP (Antiradical power)= $1/IC_{50}$.

Indeed, cashew apple is a source rich in sugars, vitamin C and polyphenols as also indicated by the work of Michodjehoun-Mestres et al. [26] and contains significant amounts of carotenoids [33] and more than 50 aromatic compounds [4]. The work of Gordon et al. [29] showing the variation in the composition of bioactive compounds and antioxidant power of cashew apples during maturation revealed the presence of fourteen (14) phenolic compounds in this pseudo fruit, which compounds decreased during process. These works has also proved that cashew apple is an excellent source of ascorbic acid, a compound that contributes most to its antioxidant activity by its ability to trap radicals.

4. Conclusion

In the present study, characterization tests were investigated on the juices of two varieties of cashew apple. The evaluation of the chemical composition and nutritional profile of the juices of the two cashew apple varieties showed that the cashew apple is rich in vitamin C, minerals and phenolic compounds. The therapeutic and nutritional virtues of cashew apple show that this agro-resource can well be used as an interesting food. Its food valorization will contribute to solving health problems for the consumer and bring added value to this agro resource. It will also help fight environmental problems associated with rotting in fields after harvesting the nut.

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