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Improvement of Cashew Apple Juice (*Anacardium occidentale* L.) by Association with Passion Fruit Juice (*Passiflora edulis*)

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Abstract

Despite many advantages, the many technologies studied to eliminate astringency from cashew apple juice are not all accessible and not adopted by processors due to the lack of financial means to access these sophisticated technologies. Thus, the formulation of mixed juice based on cashew apple juice and passion fruit juice has proved to be a way of adding value to the cashew apple, a co-product of the production of the nut. After the formulation of the mixed juice in different proportions and the sensory evaluation, it appears that the juice of formulation E is more appreciated by the tasters. Indeed, this juice has preferred sensory characteristics in terms of color (6.90), flavor (5.47), odor (6.42), settling (6.28) and overall acceptance (6.53). These characteristics are similar to those of passion fruit juice in terms of color, odor, and overall acceptance, where the latter obtained scores of 6.94, 7.17 and 6.00 respectively; and also, to those of cashew apple juice in terms of flavor and decanting, where the latter obtained scores of 5.19 and 6.14 respectively. Therefore, the addition of passion fruit juice to cashew apple juice results in a new product that is more appreciated when mixed with proportions of 90 mL of passion fruit juice and 10 mL of cashew apple juice. For example, passion fruit juice, due to its color, flavor, and odor, has helped reduce the pronounced astringency of raw cashew apple juice. Ultimately, formulation E is recommended to improve the organoleptic value of cashew apple juice.

Keywords

Cashew Nut, Cashew Apple Juice, Passion Fruit Juice, Sensory Analysis

1. Introduction

Cashew cultivation contributes to the socio-economic development of several countries around the world [1]. The production of cashew nuts in Côte d'Ivoire has undergone a notable increase as the government has implemented new measures aimed at developing cashew processing. These measures have led to an increase in national production within a decade. Over the last 5 years (2015-2020), cashew nut production in Côte d'Ivoire has increased from 703,000 tons to 800,000 tons [2]. This success in cashew nut production has made Côte d'Ivoire the world's leading producer and exporter in this field. Currently and mainly produced for its nuts, the cashew tree also provides people with its apples (pseudo fruits). This socio-economic development would be more notable if cashew apples, which represent 9 to 10 times the weight of the nut, or more than 7 million tons of cashew apples, were processed industrially [3]. Almost all of this production is lost at the harvest site. Moreover, it is not exploited industrially in Côte d'Ivoire because it is considered a by-product and also because of certain taboos [4]. Indeed, the consumption of cashew apples with milk would be incompatible in several African countries. However, toxicological studies conducted by [5] and [6] showed that the gavage of mice by the mixture "cashew apple-milk juice" did not reveal any acute toxicity. In view of this, the concept that the cashew apple-milk apple juice combination is lethal is only a matter of prejudice. This raw material has strong nutritional potential: it is very rich in vitamin C [7], polyphenolic compounds [8] [9] [10] [11] and has a very diverse carotenoid profile [7] [12]. It also contains sugars, organic acids and minerals. Cashew apple juice can be considered a potential source of supply for adequate daily vitamin C intake [5]. A better valorization of cashew apples, a co-product of nut production, will help stabilize cashew tree exploitation and improve the added value of the sector. It will also make it possible to create new economic activities providing employment and, consequently, to fight unemployment in Côte d'Ivoire. As with many fruits, the main value added avenue that is relevant to consider is the processing into juice [4]. However, the transformation of cashew apples into juice comes up against three main problems: the astringency of the juice due to the presence of condensed tannins, the high thermosensitivity of the product both in nutritional and sensory terms and the richness in reducing sugars responsible for the Maillard reactions during heat treatment [4]. Some recent studies have been conducted to eliminate astringency from cashew apple juice [13] [14] [15]. Despite many advantages, not all of the many technologies studied in these different studies are accessible and not adopted by processors due to the lack of financial means to access these sophisticated technologies. In order to propose low-cost and accessible solutions, a study on the effect of heat and non-heat treatment on the reduction of astringency and nutrient retention in cashew apple fruit and juice was conducted [16]. In this study the different techniques resulted in the retention of high concentrations of ascorbic acid, total sugar and antioxidant activity, making it an excellent option for the mixed juice beverage market. To improve, or even eliminate the astringency of cashew apple juice, one of the solutions would be to combine it with other fruit juices such as passion fruit juice (*Passiflora edulis*). Indeed, passion fruit is known for its unique musky flavor and aroma which makes its pulp an important flavoring agent in beverages, desserts, sauces and many other foods [17]. In addition, it is widely consumed because of its nutritional value and excellent organoleptic characteristics [18]. Its association with cashew apple juice would bring added value to the latter, which is rich in nutritional compounds. In this context, the general objective of this study is to improve the overall acceptability of cashew apple juice.

2. Materials

Ripe and healthy passion fruit and cashew fruit made up the bulk of the plant material used. The yellow variety passion fruits were purchased from women traders at the Abidjan market (Côte d'Ivoire). The selected fruits were sent to the National Public Health Laboratory (LNSP) to extract the juice for the sensory test. As for the cashew apple fruits, they were picked from a cashew tree in the town of Bondoukou (Côte d'Ivoire). They were then transported, in a cooler containing ice, to the LNSP to extract the juice in order to carry out the sensory test.

3. Methods

3.1. Juice Preparation

The fruits were transported to the laboratory and their juices were extracted separately. First, the passion fruits were washed with clean water, then cut in two parts. The pulp inside was collected and kneaded with hot water. The juice obtained was filtered through a 0.5 mm mesh sieve. Before the cashew apple juice was prepared, the apples were detached from the nut. They were washed with clean water, then cut and crushed by a blender (Blender LB20E, Torrington, USA, 2002). The juice obtained by pressing the crushed material was filtered through a 0.5 mm mesh sieve. Finally, the different juices were stored for sixteen (16) days in the refrigerator (Fiocchetti, Mazzara, Italy) at 4˚C [19].

3.2. Determination of pH

The pH was determined according to [20] using a pH meter (pH meter C861, Consort, bio block, Belgium). The calibration of the instrument was ensured by the use of two buffer solutions at pH 7.0 and 4.0 and this is done systematically before the pH measurements. The measurement was made by immersing the electrode in 5 mL of sample and the reading was repeated three times.

3.3. Determination of Titratable Acidity

The determination of the titratable acidity of the juices was carried out according to the standard [21]. It was obtained by determination of 5 mL of the sample with a 0.1 N sodium hydroxide solution. The analysis was terminated by turning pink after the addition of 2 to 3 drops of phenolphthalein. The results obtained are the average of three tests. The titratable acidity expressed as a percentage of grams of lactic acid/L is calculated using the following formula:

$$\%\ \text{Titratable Acidity} = \frac{N_{\text{NaOH}} \times V_{\text{NaOH}} \times 0.09 \times 100}{V_{\text{test}}} \tag{1}$$

V_{test}: volume of the test sample;

N_{NaOH}: normality of NaOH poured (meq - g/L);

$V_{\text{NaOH:}}$ volume of NaOH poured (mL);

0.09: milli-equivalent gram of lactic acid.

3.4. Determination of the Soluble Solids Content (TSS or Brix Degree)

The rate of soluble solids was determined according to the [22] standard. The Brix (%) was calibrated according to the number of grams of cane sugar contained in a 100 g solution. The measurement was made at a temperature of 20˚C, of the refractive index of the prepared sample. The prisms of the refractometer were cleaned with distilled water in order to operate at the required temperature which must remain constant to within 0.5˚C during the determination. Then the test solution was brought to the measuring temperature. The Brix degree was measured by applying two to three drops of sample to the fixed prism of the refractometer and the reading was taken three times.

Determination of Dry Matter

Dry matter was determined according to the method described by [23]. The crucible was previously dried in an oven at 110˚C for 3 hours, then cooled in a desiccator. This crucible was weighed (*i.e.* C_0 weight) and 5 g of juice sample was introduced into it. The juice was heated slowly on a hot plate until most of the organic constituents were burnt off, then the crucible was placed in the oven for 24 hours. At the end of this time the crucible was removed and cooled with a desiccator and weighed again to obtain a weight C_1. The analyses were performed in triplicate.

$$DM = \frac{C_1 - C_0}{P_e} \times 100 \tag{2}$$

with P_e the initial weight of the sample;

C_0 the mass of the empty crucible (g);

C_1 the mass of the crucible after drying (g);

DM = dry matter (%).

3.5. Determination of Ash Content

The ash content has been determined according to [24]. A volume of 5 mL of juice sample is poured into a previously dried crucible and weighed. The whole is placed in a muffle furnace at 550˚C for 24 hours. The crucible is then removed and cooled in a desiccator and weighed again. The analyses are carried out in triplicate and the ash content is determined by the following formula:

$$\% \, C = \frac{C_1 - C_0}{P_e} \times 100 \tag{3}$$

where:

C_0 is the mass of the empty crucible (g);

C_1 is the mass of the crucible after drying (g);

P_e is the test portion (g);

C is the percentage of ash (%).

3.6. Determination of Density

The measurement was performed in a 250 mL foot cylinder. The sample was well homogenized and placed in the test tube. The density measurement was carried out by introducing the density meter into the sample at a temperature of 20˚C. The reading was taken three times.

3.7. Determination of Protein Content

The protein content was determined according to the Kjeldahl method [25]. In a matrass, 1 mL of juice was introduced and mineralized in the presence of 10 mL of concentrated sulfuric acid and 1 g of mineralization catalyst. Mineralization was carried out hot for one hour on a mineralization ramp. After mineralization and cooling of the samples, 300 mL of distilled water, as well as 50 mL of soda lye and two drops of phenolphthalein were added to each matrass containing the mineralization. The mineralization was placed in a distillation unit. During distillation, 200 mL of distillate was collected in an Erlenmeyer flask containing 25 mL of 4% boric acid and 3 drops of methyl red. The whole was titrated under stirring with a sulfuric acid solution (0.1 N) until the color changed from green to pink. The analyses were carried out in triplicate. The total protein content, expressed in g per 100 g of sample is obtained according to the following formula:

$$\% \, N = \frac{0.14 \times V}{Pe} \tag{4}$$

N: Nitrogen present in the sample (%);

V: volume of sulfuric acid standard solution (mL);

M Nitrogen 0.14: molar mass of nitrogen ($g \cdot mol^{-1}$);

Pe: test sample (g).

$$\% \, P = \% \, N \times 6.25 \tag{5}$$

$\% \, P$ = protein content;

6.25 nitrogen to protein conversion factor.

3.8. Determination of Reducing Sugars

The determination of reducing sugars was carried out according to the method described by [26]. Prior to the determination, the sample was prepared. Indeed, 10 mL of 80˚C ethanol was added to 1 mL of juice sample and then centrifuged at 2500 rpm for 15 min. The supernatant was recovered and then 2 mL lead acetate was added and centrifuged at 2500 rpm for 15 min. The supernatant was collected again and 2 mL oxalic acid was added. Everything is centrifuged at 2500 rpm for 15 minutes. In addition, the supernatant is collected and brought to the water bath (80˚C). After cooling, distilled water was added to the sample to the previous level. For the determination of reducing sugars, a volume of 0.2 mL of juice sample is introduced into test tubes. To this is added 1.8 mL distilled water and 0.6 mL of dinitrosalicylic acid (DNS). The whole was brought to the bath—marinate at 80˚C/5min and then leave for cooling. An orange coloration appears. 4 mL of distilled water was added and then the reading was taken with the spectrophotometer at 546 nm. The concentration of reducing sugars was determined with reference to a standard glucose range.

3.9. Determination of Total Sugars

The determination of total sugars was carried out by the phenol-sulfuric method [26]. Prior to the determination, the sample was prepared. Indeed, 10 mL of 80˚C ethanol was added to 1 mL of juice sample and then centrifuged at 2500 rpm for 15 min. The supernatant was recovered and then 2 mL lead acetate was added and centrifuged at 2500 rpm for 15 min. The supernatant was collected again and 2 mL oxalic acid was added. Everything is centrifuged at 2500 rpm for 15 minutes. In addition, the supernatant is collected and brought to the water bath (80˚C). After cooling, distilled water was added to the sample to the previous level. For the determination of total sugars, 2 mL phenol (5%) was added to 2 mL of the solution taken from a test tube. Then 8 mL concentrated sulfuric acid (H_2SO_4) (96%) was added rapidly without running down the walls and the mixture was stirred immediately. Everything is put in the dark for 30 min. A yellow coloration develops, stable for several hours. Absorbance is measured at 490 nm. The concentration of total sugars is determined with reference to a standard glucose range.

3.10. Preparation of the Cashew Apple/Passion Fruit Juice Mixture

The passion fruit juice was added to the cashew apple juice in proportions (**Table 1**). Thus, the mixtures are juice A (50 mL of passion fruit juice/50mL of cashew apple juice), juice B (60 mL of passion fruit juice/40mL of cashew apple juice), C juice (70 mL passion fruit juice/30mL cashew apple juice), D juice (80 mL passion fruit juice/20mL cashew apple juice), juice E (90 mL of passion fruit juice/10mL of cashew apple juice), F juice (40 mL of passion fruit juice/60mL of cashew apple juice) and G juice (30 mL of passion fruit juice/70mL of cashew apple juice).

3.11. Procedure for the Sensory Analysis of the Cashew Apple Juice/Passion Fruit Juice Mixture

The sensory evaluation of the organoleptic characteristics and formulations of the mixed juice was carried out at the National Public Health Laboratory (LNSP) in Abidjan, Côte d'Ivoire. In Côte d'Ivoire sensory analysis tests do not require formal written consent. Simply agreeing to participate in the tests is considered consent. During the test, participants simply fill out a form. Also, sensory tests do not require ethical approval. A hedonic test on a 9-point linear scale (**Figure 2**) was used to assess the degree of appreciation of the organoleptic characteristics. This study followed the method described by [27] and applied more specifically to cashew nut juice by [28]. Before the tests were conducted, subjects were instructed not to smoke or consume anything except water at least one hour before the assessment to avoid biasing the results. Fruit juices were served in transparent, plastic tasting glasses and labelled for correct evaluation. They were presented one after the other to each evaluator, taking care to remove each sample after tasting and before putting the next sample back in. Water at room temperature was given to the tasters so that they could rinse their mouths before and between each of the samples they tasted. In addition, they did not communicate with each other during the sensory evaluation. Three (03) tasting sessions were held on Thursdays over three (03) consecutive weeks under the same working and blending conditions. These sessions, lasting 2 hours for the nine (09) samples, were organized in such a way as not to cause weariness and saturation of the subjects.

3.12. Tasting Panel

A panel of 30 people chosen from among the trainees (in Superior Technician's Certificate and agrifood engineering) and some employees of the LNSP was formed. This panel was made up of people not trained on the characteristics

Table 1. Composition of mixed juices.

Jus mixtes	Passion fruit juice (mL)	Cashew apple juice (mL)	Total amount (mL)
A	50	50	100
B	40	60	100
C	70	30	100
D	80	20	100
E	90	10	100
F	60	40	100
G	30	70	100

Figure 1. Formulation of mixed juices.

chosen. However, astringency was briefly explained to them. The panel therefore proceeded to test the acceptability of the different samples of cashew apple juice, passion fruit juice and the formulations of the mixed juice prepared.

3.13. Rating Sheet

The assessment of cashew apple juice samples was based on color, flavour (taste), odour, decanting and overall appreciation using a linear hedonic scale. This nine-point scale, ranging from "extremely poor" (point 1) to "extremely good" (point 9) was used [28]. Thus, for color, the scale varied from "extremely faded" to "extremely colored". For taste, the range varied from "extremely bitter" to "extremely sweet". For the smell the range varied from "extremely unpleasant" to "extremely pleasant". For decanting the range was from "extremely unpleasant" to "extremely pleasant" and finally the overall assessment was from "extremely unpleasant" to "extremely pleasant" (Figure 2).

3.14. Statistical Analysis

The data generated by this study were statistically processed using SPSS 11.19 statistical software. The analysis of variance (ANOVA) was used to process the data from the sensory analysis of the mixed juices produced. Whenever a significant difference ($\alpha < 0.05$) was found, the ANOVA test was supplemented by

Color

Extremely discolored	Very discolored	Discolored	Rather (quite) discolored	Neither discolored nor colored	Rather colorful	colored	Very colored	extremely colored
1	2	3	4	5	6	7	8	9

Flavour (taste)

Extremely bitter	Very bitter	Bitter	Rather (quite) bitter	Neither bitter Neither sweet	Rather sweet	Sweet	Very sweet	Extremely sweet
1	2	3	4	5	6	7	8	9

Odour

Extremely unpleasant	Very unpleasant	Unpleasant	Rather (quite) unpleseant	Neither unpleseant Neither pleseant	Rather pleseant	Pleseant	Very pleseant	Extremely pleseant
1	2	3	4	5	6	7	8	9

Decantation

Extremely unpleasant	Very unpleasant	Unpleasant	Rather (quite) unpleseant	Neither unpleseant Neither pleseant	Rather pleseant	Pleseant	Very pleseant	Extremely pleseant
1	2	3	4	5	6	7	8	9

Global appreciation

Extremely unpleasant	Very unpleasant	Unpleasant	Rather (quite) unpleseant	Neither unpleseant Neither pleseant	Rather pleseant	Pleseant	Very pleseant	Extremely pleseant
1	2	3	4	5	6	7	8	9

Figure 2. 9-point hedonic scale [29].

Tukey's post-ANOVA test to identify the variable(s) with highly significant differences from the control values.

4. Results

4.1. Physico-Chemical and Biochemical Composition of the Analyzed Juices

The physico-chemical and biochemical composition of the juices analyzed is presented in **Table 2**. Cashew apple juice has a pH of 4.2 ± 0.00 and a refractive index of (1.35 ± 0.00) RI which are higher than the pH of passion fruit juice which is 3.14 ± 0.02 and the refractive index which is (1.34 ± 0.00) RI. Nevertheless, in passion fruit juice the titratable acidity is (1.17 ± 0.01)g of lactic acid/L, the density is (1.60 ± 0.00) and the Brix degree is (14.17 ± 0.00), 01)˚B are higher than in cashew apple juice with a titratable acidity of (0.79 ± 0.00) g of lactic acid/L, a density of (1.05 ± 0.00) and a Brix degree of (13.7 ± 0.0)˚B. In terms of biochemical composition, cashew apple juice has a dry matter content of (19.9 ± 0.1)%, ash content of (2.5 ± 0.7)%, total sugars of 85.3 g/L and reducing sugars of 9, 174 g/L higher than (13.43 ± 0.06)% dry matter, (0.68 ± 0.10)% ash, 43.6 g/L total sugars and 16.714 g/L reducing sugars in passion fruit juice. However, the protein content of (1.34 ± 0.05)% in passion fruit juice is higher than in cashew apple juice which is (0.22 ± 0.04)%.

4.2. Color

Figure 3 gives the appreciation of the juices according to the attribute of the color. The color of the Passion Control juice (T passion) is more appreciated with a score of 6.94 than the color of the Cashew Control juice (T cashew) which has a score of 5.75. In addition, the color of C, D, E and F juices, which score

Table 2. Physico-chemical and biochemical composition of cashew apple and passion fruit juices

	Cashew Apple	Passion fruit
pH	4.20 ± 0.00^{b}	3.14 ± 0.02^{a}
Titratable acidity (g of lactic acid/L)	0.79 ± 0.00^{a}	1.17 ± 0.01^{b}
Brix degree (˚B)	13.70 ± 0.00^{a}	14.17 ± 0.01^{b}
Refractive index (RI)	1.35 ± 0.00^{b}	1.34 ± 0.00^{a}
Density	1.05 ± 0.00^{a}	1.60 ± 0.00^{b}
Dry matter (%)	19.9 ± 0.1^{b}	13.43 ± 0.06^{a}
Ash (%)	2.5 ± 0.7^{b}	0.6 ± 0.1^{a}
Protein (%)	0.22 ± 0.04^{a}	1.34 ± 0.05^{b}
Total sugars (g/L)	85.3 ± 0.8^{b}	43.6 ± 0.1^{a}
Reducing sugars (g/L)	9.174 ± 0.1^{a}	16.714 ± 0.6^{b}

*Values in the same line with the same letter are not significantly different from each other according to Duncan's multiple comparison test at the 5% threshold (P > 0.05). Values are expressed as Mean ± Standard Deviation (n = 3 determinations).

6.66, 6.66, 6.90 and 6.52 respectively, is close to that of T passion juice. While the color of A, B and G juices, whose scores are 6.32, 6.23 and 4.47 respectively, is similar to that of T cashew juice. The color of juice E is more appreciated as it has the highest score which is 6.90.

4.3. Flavor

Figure 4 shows the evaluation of juices according to the flavour attribute. Cashew T Juice with a score of 5.19 and Passion T Juice with a score of 5.04 have virtually the same flavors; however, it should be noted that the flavor of Cashew T Juice is more appreciated. In addition, the flavor of E and F juices with a score of 5.47 and 5.66 respectively is close to that of Cashew T juice. While the flavor of A, B, C, D and G juices whose respective scores are 5.04; 5.09; 5.04 and 4.95 are close to that of T passion juice. Juice F is more appreciated because it obtained the majority score corresponding to 5.66.

4.4. Decantation

Figure 5 gives the appreciation of the juices according to the attribute of decantation. Passion T juice with a score of 5.33 and cashew T juice with a score of 6.14 have virtually the same decantation; however, it should be noted that the decantation of Passion T juice is more appreciated. On the other hand, the decantation of D, E and F juices with respective scores of 5.52, 6.28 and 5.04 is close to that of cashew T juice. While the decantation of A, B, C and G juices,

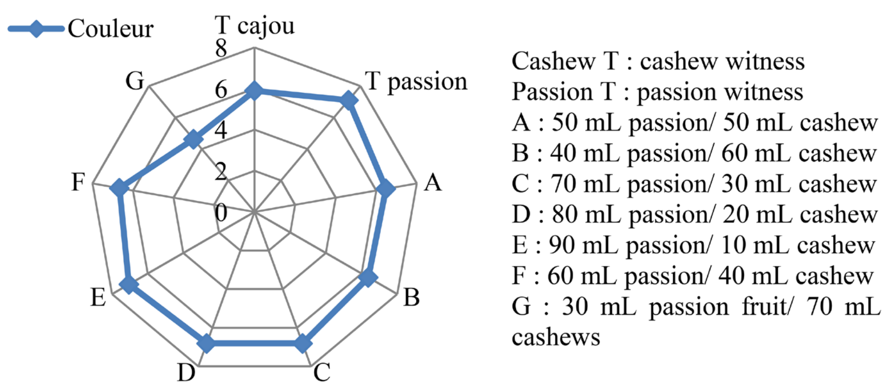

Figure 3. Color evaluation of mixed juices.

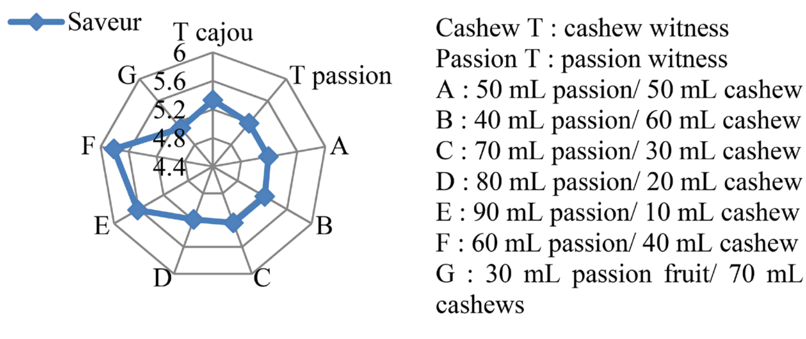

Figure 4. Flavor evaluation of mixed juices.

which have scores of 4.33, 4.71, 4.80 and 4.71 respectively, is similar to that of passion fruit T juice. The decanting of juice A is more appreciated because it settles less. It obtained a score of 4.33.

4.5. Odour

Figure 6 shows the evaluation of juices according to the odour attribute. The odor of Passion T juice with a score of 7.17 is more appreciated than the odor of Cashew T juice which has a score of 5.52. In addition, the smell of B, C, D, E and F juices, whose scores are 5.90; 6.09; 6.09; 6.42 and 5.80 respectively, is similar to that of T passion juice. While the odor of juices A and G, whose scores are 5.38 and 4.80 respectively, is similar to that of cashew T juice. The smell of E juice is highly appreciated because the majority score corresponds to 6.42.

4.6. Global Acceptance

Figure 7 shows the assessment of juices according to the attribute of global acceptance. Passion T juice with a score of 6.00 is more appreciated than cashew T juice with a score of 5.72. In addition, the overall acceptance of C, E and F juices, with scores of 5.96, 6.53 and 5.96 respectively, is close to that of passion T juice. While the overall acceptance of juices A, B, D and G, which have scores of 5.72; 5.53; 5.67 and 5.19 respectively, is close to that of juice T cashew. Juice E is the most popular with a score of 6.53.

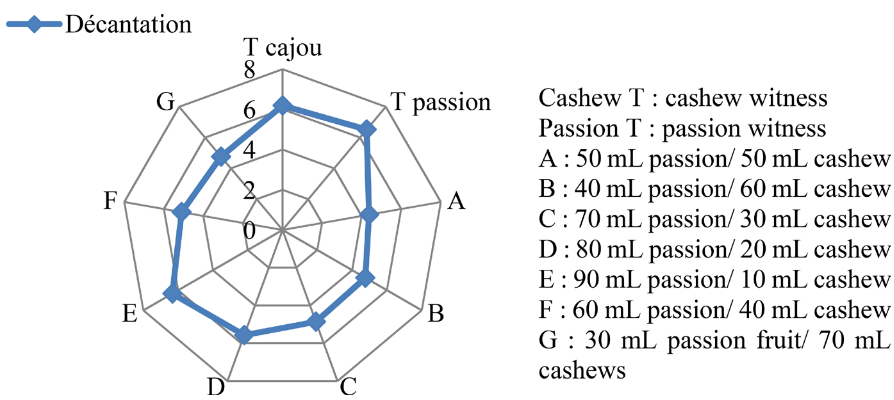

Figure 5. Evaluation of the decantation of mixed juices.

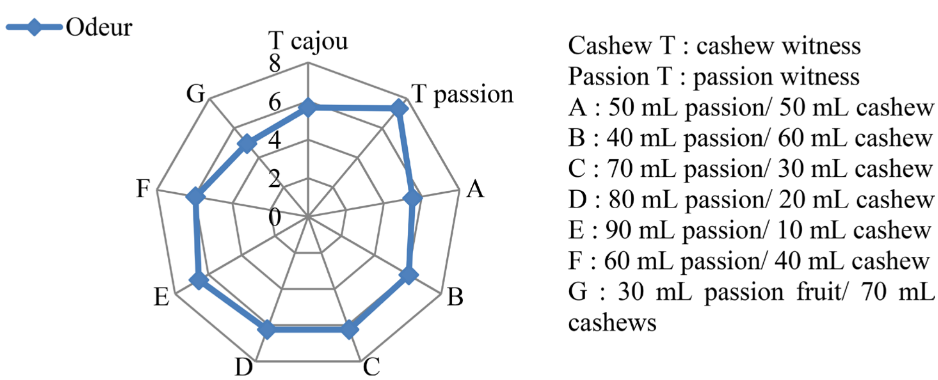

Figure 6. Odour evaluation of mixed juices.

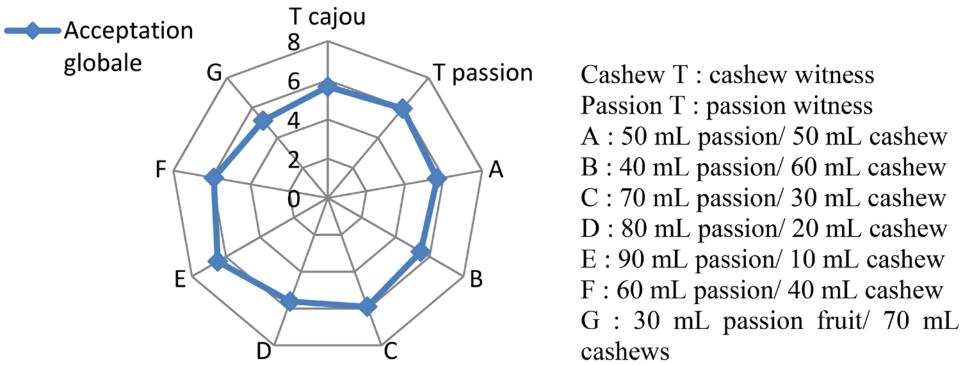

Figure 7. Evaluation of overall acceptance of mixed juices.

5. Discussion

The physico-chemical and biochemical parameters were measured. Thus, the measurements made show that both juices are acidic. Nevertheless, there is a significant difference between the pH of the juices studied ($P < 0.05$). Indeed, pH values of 3.14 ± 0.02 and 4.2 ± 0.0 were obtained in passion fruit and cashew apple juices respectively. For cashew apple juice, this value is consistent with the results found by [30] in apple juice samples from four regions of Ghana and ranged between 4.19 and 4.59. [31] also observed a mean pH = 4.5. However, these results are lower than those observed (4.86 to 5.54) in five ecological zones in India [32]. For passion fruit juice this acidity can be translated by the presence of two acids, citric acid (93% - 96%) and malic acid (3% - 6%) in the fruit [33]. This is why its titratable acidity (1.17 g lactic acid/L) is high. It is lower than the average of 3.56% citric acid/L found by [34]. The presence of acid in the juices gives them an added value. Thus, acids and sugars add a unique taste and also promote the natural conservation of fruit juice [33]. The titratable acidity in cashew apple juice (0.79 ± 0.00) g lactic acid/L is lower than the value observed (5.2 g lactic acid/L) by [35]. According to the latter, citric acid and malic acid are the bases of cashew apple acidity. However, malic acid is the majority organic acid in cashew apples [35]. In addition, the dry matter contents of the juices studied show significant differences ($P < 0.05$). Thus, in cashew apple juice the dry matter content (19.9 ± 0.1) % is higher than in passion fruit juice (13.43 ± 0.06)%. Microorganisms are therefore likely to proliferate these juices and ferment them in a very short time if they are not immediately stored in a cool place [36]. Significant differences ($P < 0.05$) in ash and protein levels were observed in the two juices. Cashew apple juice has a higher ash content (2.5 ± 0.7)% than passion fruit juice (0.6 ± 0.1)%. The ash content obtained in passion fruit juice is lower than the values (1.00 - 3.70)% obtained by [33]. The ash content represents the total amount of mineral salts present in a sample [37]. The mineral content in cashew apple juice is therefore higher than in passion fruit juice. Passion fruit juice contains more protein than cashew apple juice. Cashew apple juice contains (0.22 ± 0.04)% protein. In addition, the protein content of (1.34 ± 0.05)% in passion fruit juice is higher than that obtained (0.8% protein) by [34]. However, this value is consistent with the protein content of (0.60 - 2.80)% found by [33]. Thus, both fruit juices contain little protein that participates in the development of muscles and bones. Note also that passion fruit juice (1.60 ± 0.00) is denser than cashew apple juice (1.05 ± 0.00). The density of cashew apple juice is similar to that reported by [35] which is 1.05. Finally, there is a significant difference between the sugar content of the juices studied ($P < 0.05$). Cashew apple juice with 85.3 g/L of sugars is richer in sugars than passion fruit juice which contains 43.6 g/L of sugars. For cashew apple juice, the total sugars determined in this study are lower than those found by some authors in their respective regions. For example [38] reported 125.0 g/L and [32] reported up to 151 g/L and 143 g/L in yellow and red apple juice respectively. Despite its high astringency, cashew apple can be consumed raw, and also has good characteristics for industrial processing due to its fleshy, sweet, peeling pulp, absence of seeds, high sugar content and strong exotic flavor [39]. As for passion fruit juice, the content of total and reducing sugars in this juice is contrary to the results of [40] who obtained a value of (57.47 ± 0.03) g/L and (14.15 ± 0.01) g/L for total and reducing sugars, respectively. According to [40], the sugar content of fruits can influence the physical-chemical properties (titratable acidity, dry matter, Brix degree, microbial stability) and can provide valuable information on the whole food. The predominant sugars in passion fruit juice are sucrose, glucose and fructose, which are of economic importance [40]. In addition, the Brix degree in passion fruit juice (14.17 ± 0.01)˚B falls within the margin of that observed by [33] which is between 12.00 and 18.00 ˚B. [34] found a Brix degree of 15.56˚B slightly higher than that obtained in our work. In cashew apple juice (13.70 ± 0.00) ˚B, the value of the total soluble solids found was higher than the minimum value required by Brazilian law which is 10 ˚B. It should be noted that the Brix degree provides information on the total soluble solids in the fruit juice. This indicates that the fruit was harvested at the stage of maturity [41]. In approaching the sensory evaluation, it reveals that the color of Passion Witness (T passion) juice is more appreciated than the color of Cashew Witness (T cashew) juice. Indeed, cashew apple juice is white in color while passion fruit juice has an attractive yellow color conferred by the presence of a large quantity of carotenoids [42]. According to [43] passion fruit juice is a good source of ascorbic acid and carotenoids. Note that the color of juice formulations C, D, E and F are close to that of passion fruit juice due to the high volume of passion fruit juice in these respective blends. However, the color of juice E is more significant since it is composed of 90 mL of passion fruit juice versus 10 mL of cashew apple juice. Formulation E is, therefore, the most appreciated on the criterion of color. However, T cashew juice has a more appreciated flavor than T passion juice. This is due to the high acidity of passion fruit juice with a pH of 3.14 ± 0.02 compared to a pH of 4.2 ± 0.0 for cashew apple juice. In addition, [44] state that passion fruit also contains citric acid, L-malic acid, L-lactic acid, L-ascorbic acid and seven other types of organic acids. In contrast to the acidic taste of passion fruit juice, the high sugar content in cashew apple juice [39], gives a sweet taste to the resulting mixed juice. Indeed, according to [32], cashew apple juice contains up to 151 g/L of sugars compared to (57.47 ± 0.03) g/L of sugars [40] in passion fruit juice. In terms of flavor, mixed juices E and F are more popular than mixed juices A, B, C, D and G. This is due to the high amount of passion fruit juice versus a low amount of cashew apple juice. This is because the acidic taste of passion fruit juice is masked by the sweet taste of cashew apple juice, which makes mixed juices E and F pleasant to drink. In addition, the E and F formulations are less astringent than the other formulations. This preference could also be explained by the fact that passion fruit juice, which dominates 90% and 60% respectively, is a juice that is integrated into the dietary habits of Ivorians. In addition, cashew apple juice is decanted more than passion fruit juice. However, the decanting of passion fruit juice is more appreciated with the formation of a small deposit that appears at the bottom of the glass containing it. Like passion fruit juice, the decanting of D, E and F juices is more appreciated. Indeed these juices contain a large quantity of passion fruit juice. As far as the smell is concerned, the smell of T passion juice is more appreciated. Indeed passion fruit has a rich aroma and rich nutrients, which contain aromatic compounds up to more than 135 [44]. Also [45] noted that there is an aromatic mass of pulpy juice inside the fruit that gives it a pleasant fragrance. This fragrance is also felt in B, C, D, E and F juice formulations with higher proportions of passion fruit juice. Thus, these juices are more appreciated to the detriment of A and G juices. Finally, passion fruit juice has good overall acceptability with a score of 6.00. Its acceptability is comparable to that of E juice but the latter is more appreciated since its score is 6.53. This can be explained by its composition with a high proportion of passion fruit juice, *i.e.* 90 mL. However, the small quantity of cashew apple juice, *i.e.* 10 mL, in this formulation gives it a better, sweeter taste that makes Formulation E the preferred mixed juice for tasters. These data are comparable to those of [46] on different coconut water and cashew apple juice formulations. For this author, the formulation containing 20% cashew apple and 80% coconut water was preferred by the tasters.

6. Conclusion

The formulation of mixed juice based on cashew apple and passion fruit juices has proved to be a way of adding value to the cashew apple, a co-product of the production of the nut. After the formulation of the mixed juice in different proportions and the sensory evaluation, it appears that the juice of formulation E is more appreciated by the tasters. Indeed this juice has preferred sensory characteristics. These characteristics are similar to those of passion fruit juice in terms of color, odor and overall acceptance; and also to those of cashew apple juice in terms of flavor and decanting. As a result, the addition of passion fruit juice to cashew apple juice creates a new product that is more enjoyable when mixed in proportions of 90 mL of passion fruit juice and 10 mL of cashew apple juice. The passion fruit juice, due to its color, flavor and smell, has reduced the pronounced astringency of the raw cashew apple juice. Finally, the E formulation is to be advised to improve the organoleptic value of the cashew apple juice. However, the physico-chemical constituents, the nutritional composition, and the conditions of stability after pasteurization of mixed juice E must be elucidated.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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