Sensory Profile and Physico-Chemical Characteristics of Clarified and Pasteurized Cashew Apple Juice during Storage

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Received January 20, 2022; Revised February 23, 2022; Accepted March 01, 2022

Abstract The cashew apple is the false fruit of the cashew tree and is not valued in Côte d'Ivoire and rots at the point of harvest. This study focuses on the valorization of cashew apples into juice. However, its nutritional and organoleptic parameters are affected by temperature and storage time. The objective is therefore to determine the nutritional and organoleptic characteristics of cashew apple juice during its production and conservation. The physico-chemical analyses carried out are pH and soluble dry extract. The sensory profile consisted of hedonic and descriptive analyses. The clarified and pasteurised cashew juice was found to be the best with an acceptability rate of 42%. Descriptive characteristics were clarity, colour, aroma and non-astringency. The juice stored at room temperature was more appreciated until the 90th day and then depreciated to the profile of the juice stored at 4°C. Statistical analysis shows that there is no significant difference between the pH and Refractometric Soluble Dry Extract (RSDE) values during storage. Clarified and pasteurised cashew juice retains its properties better at a storage temperature below 27°C.

Keywords: cashew apple, juice, sensory profile, physicochemical characteristics


1. Introduction

Originating from the coast of Brazil, the cashew tree was discovered by the Portuguese and then introduced to colonies in Africa and Asia [1,2]. However, the largest production areas are South-East Asia, West Africa, East Africa and Brazil [3].

Introduced in Ivory Coast in the 1960s to combat desertification, cashew (Anacardium occidentale L) is now a cash crop after cocoa. In 2018, Ivory Coast produced approximately 711,236 tonnes of cashew nuts, making it the world's leading producer [4]. The cashew tree produces two fruits: the cashew nut (real fruit) and the cashew apple (false fruit).

The cashew nut is a grey or grey-brown, kidney-shaped achene measuring on average 2.7 cm long by 2.1 cm wide and 1.6 cm thick. Its weight varies from 3 to 10 g with an average of 5 g, but some can reach 20 g in Brazil [3]. When shelled, it can be eaten salted or spiced or used in the food industry to make cakes, chocolate, nougat, confectionery, ice cream and oil. [5]. Also cashew balsam can be extracted from the shells surrounding the nut, which is a blackish, caustic oleaginous liquid [6].
Heart-shaped. This apple is 9 to 10 times the weight of the walnut and is usually left at the harvesting site where it rots.

Cashew apples are rich in nutrients. It is very juicy (85-90% water) and moderately sweet (7-13% carbohydrates) [3]. It is also rich in vitamin C, polyphenols [7] and contains significant amounts of carotenoids [8,9]. In spite of this great richness, cashew apples are not exploited and valued in Ivory Coast.

For its valorisation, we therefore opted for processing into juice. However, its heat sensitivity due to the abundant vitamin C and reducing sugars, its strong astringency linked to the presence of condensed tannins limit its processing.

One of the major challenges in fruit juice production is the removal of turbidity without losing sensory characteristics [10,11]. Techniques used to remove suspended particles from juices consist of the addition of clarifying agents, such as gelatin, bentonite, albumin. There is also the chemical method with the use of enzymes such as proteases and pectinases, and physical methods such as filtration and centrifugation. Although these show successful results, these practices can also remove some essential compounds such as colour and aroma from juices [12,13]. Also, these processes can be very laborious, time-consuming and operate in a batch mode. In addition, the use of additives can leave a slight aftertaste in the juice [14,15]. Indeed, treatment with proteases and pectinases caused a loss of proteins and active phenols in the juice [16,17].

Several studies have been carried out in order to clarify raw cashew apple juice. We have the use of cassava starch and rice grits which have been experimented in Benin [18] as well as the use of tangential microfiltration in Brazil. Gelatin clarification is also used.

To better guarantee the quality of the finished products, different parameters such as physico-chemical, microbiological, biochemical parameters are taken into account and also organoleptic or sensory analysis. The latter is a new science that appeared in the 1940s and 1950s in the American army with the aim of optimising the acceptability of the menu followed by its soldiers [19]. Sensory analysis is based on the organisation of evaluation sessions with a panel where the subjects have a level of knowledge about the product universe or not and/or the method used more or less developed depending on the task to be performed [20].

Two types of analysis make up the sensory analysis. We have the descriptive analysis and the hedonic analysis. Descriptive analysis is used to qualify the differences between products by establishing a sensory profile for each of them. Training of subjects is a key to descriptive analysis. The conventional profile is the reference method recommended by AFNOR standards [21]. The conventional profile can be summarised in four main phases [22]: (1) establish a descriptor list as exhaustive as possible with the aim of covering all the sensory characteristics of the products to be evaluated; (2) measure the intensity of the sensation perceived for each of the sensory attributes from a scale (structured or not) defined upstream; (3) establish the profile of the products via all its sensory characteristics. To do this, different representations are possible (histogram, graph, polar); (4) compare the profiles of the different products evaluated.

Hedonic analysis, on the other hand, involves naïve subjects who have had no practice in sensory analysis [23].

The general objective of our work is to produce a non-astringent cashew apple juice of nutritional and sensory quality. The specific objectives are on the one hand to determine the type of cashew juice appreciated by the consumer and on the other hand to monitor the organoleptic characteristics of the cashew apple juice most appreciated during its conservation at different temperatures.

2. Materials and Methods

2.1. Plant Material

For the plant material, mature cashew apples were used, which can be either yellow or orange-red. These fruits were harvested at Béoumi in the Gbêkê region of central Ivory Coast in the savannah zone.

2.2. Method

2.2.1. Method of Production of Cashew Apple Juice

The juice production process is summarised in the diagram in Figure 2.
2.2.2. Harvesting and Extraction

The mature cashew apples (yellow and red) were harvested by picking from the trees or by collecting fallen apples that were still healthy. In order to avoid any injury to the apple that could lead to the beginning of fruit degradation, the nuts were carefully separated from the apples with nylon threads. The cashew apples were then cleaned and washed to remove physical impurities such as sand, dead leaves and then disinfected with 100 ppm active chlorine for 15 minutes in tubs. Rinsed with water, the apples were pressed with an automatic hydraulic press (Solano, France) at a pressure of 300 bars.

2.2.3. Method of Clarifying Cashew Apple Juice with Gelatine

For clarification we used commercial gelatin powder from fish skin. A 10% gelatin solution was prepared. The solution obtained is left to rest for 1 hour. 2.5 ml/L of the 10% gelatin solution is added to the juice obtained after pressing. A flocculation is observed, which will decant over time. The clarified juice is obtained after filtration on a cotton cloth which retains the decanted fraction containing the precipitated tannins and gelatin.

The juice obtained is pasteurised at 85°C for 10 min.

2.2.4. Juice Preservation Method

During our work, the samples were stored at three (03) different temperatures: 4°C and 20°C in different refrigerators and at room temperature (28°C on average).

2.2.5. Method of Analysis

The analyses carried out on the juice concern: the Hydrogen Potential (pH), the soluble dry extract (SDE) and the sensory analysis.

- **Hydrogen potential (pH)** [24]
  The principle of pH determination is to create a potential difference in the test solution at the double electrode. The pH meter determines and displays the value. Before the pH of solutions is determined, the pH meter is calibrated at the reading temperature with two buffer solutions of pH4 and pH7. The pH of the liquid solutions is determined by introducing the electrode into 20 ml of the solution taken from a 50 ml beaker. After 5s the value is displayed by the Hanna ha 118 pH meter.

- **Refractometric Soluble Dry Extract (RSDE)** [25]
  The soluble dry extract is determined using a refractometer with a precision of 0.01. It is also called Brix degree and is expressed in g/100g. It is also called Brix degree and is expressed in g/100g. The determination consists in placing a drop on the prism of the refractometer and the value is displayed after 5s.

- **Sensory analysis**
  The sensory analysis consisted of two tests, namely the hedonic test by classification on the three types of cashew apple juice (raw, clarified, clarified pasteurised) as well as the clarified and pasteurised cashew apple juice stored at different temperatures on the one hand, and the descriptive test of the three types of cashew apple juice (raw, clarified, clarified pasteurised) on the other hand. A 9-point linear scale was used to evaluate the degree of appreciation of the organoleptic characteristics.

- **Hedonic test**
  A panel of fifty (50) people was set up. This panel was composed of people who had not been trained in the selected characteristics. The aim was to test the acceptability of different cashew juice samples. Cashew juice samples were presented simultaneously and randomly to each panelist in a blind distribution (coded samples). Each panelist ranked the different juices according to the pleasure they experienced. Following the hedonic test by ranking, a descriptive test was carried out on these different juices. Next, hedonic tests were conducted on clarified and pasteurised cashew apple juice during storage at different temperatures [26].

- **Descriptive analysis**
  The method consisted of evaluating and quantifying the relevant descriptors (colour, fluidity, clarity, aroma, sweetness, acidity and astringency) according to a category scale. The intensity of the descriptors was assessed on an unstructured 9 cm scale. From 0 for no perceived descriptor to 9 for extremely intense. The samples were presented to a panel of 50 people. The latter consisted of both women and men. The judges were selected on the basis of their availability and not having any dislike for the product. Their degree of sensory sensitivity, their motivation and their ability to describe a product were also selection criteria. This jury was trained in sensory analysis. The sample was presented monadically to each panelist [26].

2.2.6. Statistical Analysis

Statistical analysis was performed using Excel 2016 and Statistica 7.1. Comparisons between variables were determined by analysis of variance ANOVA, Fisher's test with a significance level of 5%.

3. Results

3.1. Production of Cashew Apple Juice

After extraction, the raw cashew juice obtained has a whitish colour. The production yield of the raw juice is therefore 79%.

After the addition of gelatine, flocculation is observed, which settles over time. The tannins in the presence of proteins complex. This property is used to clarify cashew juice. Filtration with a clean cotton cloth produces colourless clarified juice.

Pasteurisation of the juice at 85°C for 10 minutes gives a brown juice. This colouring is due to a non-enzymatic browning called the Maillard reaction. Indeed, cashew apple juice contains glucose and fructose which are reducing sugars. During heating the carbonyl groups of these sugars will condense with the amino groups of the amino acids of the proteins to give glucosamines and fructosamines. Through a series of rearrangement and polymerisation reactions, these molecules will give melanoidins which are brown in colour, hence the brown colour of our juice.
3.2. Physico-chemical Analyses

3.2.1. Raw Juice, Clarified Juice and Pasteurised Clarified Juice

The results of the physico-chemical analyses of the raw juice and the clarified and pasteurised juice during processing are given in Table 1.

Table 1. Evolution of physicochemical parameters of cashew juice during production

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>Raw juice</th>
<th>Clarified juice</th>
<th>Pasteurised clarified juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.2 ± 0.0 ⁰</td>
<td>4.11 ± 0.0 ⁰</td>
<td>4.21 ± 0.0 ⁰</td>
</tr>
<tr>
<td>SDE (g/100g)</td>
<td>9.3 ± 0.0 ⁰</td>
<td>8.4 ± 0.15 ⁰</td>
<td>9.6 ± 0.0 ⁰</td>
</tr>
</tbody>
</table>

The clarification allowed the elimination of all the tannins responsible for the astringency of the juice. The pH of the juice during processing is almost stable, going from 4.27 to 4.21. This implies that gelatine clarification and pasteurisation have no influence on the pH. In addition, the acidic pH (4.21±0.01) reflects the stability of the clarified and pasteurised cashew apple juice. In fruit juices, the soluble dry extract corresponds to the soluble sugar content of the juice. The results show that after pasteurisation this content increases due to a concentration of the juice.

3.2.2. Evolution during Storage

The evolution of the pH of cashew juice samples (Figure 3) varies according to the storage temperature and the storage time. In general, this evolution is marked by an increase in pH under the three storage conditions and then returns to the initial pH at room temperature. In the pasteurised clarified juice samples stored at 4°C, the pH increased from 4.21±0.01 to 4.49 ± 0.00, for the samples stored at 20°C from 4.21±0.01 to 4.39 ± 0.01 and from 4.21±0.01 to 4.20 ± 0.01 for the samples stored at room temperature. There was no significant difference (p <0.05) between the pH variations of the juice stored at the different temperatures.

![Figure 3. Evolution of pH during storage at different temperatures of clarified and pasteurized cashew juice](image)

![Figure 4. Evolution of SSE during storage at different temperatures of clarified and pasteurized cashew juice](image)
The evolution of the soluble dry extract (SDE) of clarified and pasteurised cashew juice samples stored at different temperatures is marked by a decrease for all samples (Figure 4). The variations of the SSE are respectively from 9.6 ± 0.0 to 9.27 ± 0.15 °Brix and from 9.6 ± 0.0 to 8.77 ± 0.05 °Brix for the samples kept at 4 and 20°C. For those kept at room temperature, a slight increase is observed, varying from 9.6 ± 0.0 to 9.7 ± 0 °Brix. The different variations recorded are not statistically significant (p <0.05).

3.3. Sensory Profile

3.3.1. Raw Juice, Clarified Juice, Pasteurised Clarified Juice

- Hedonic test

The results of the hedonic test presented in Figure 5 show that the different cashew apple juices were variously appreciated. The clarified and pasteurised cashew apple juice was the most appreciated at 42% followed by raw cashew apple juice at 35% and clarified cashew apple juice at 23%.

- Descriptive test

The average sensory characteristics of cashew apple juice are presented in Figure 6. The characteristics studied are: colour, fluidity, clarity, aroma, flavour, acidity and astringency.

The clarified and pasteurised cashew juice has a yellow colour while the raw juice is cloudy and the clarified juice is colourless. Compared to the other two juices, the clarified and pasteurised cashew apple juice has a stronger aroma, is more fluid with good clarity. It is also sweeter, less acidic and less astringent. Hence the choice of the panel.

3.3.2. Hedonic Test during Storage

During storage, it appears that the clarified and pasteurised cashew apple juice stored at room temperature is more appreciated by the panel to the detriment of those stored at 4 and 20°C. However, from the third month of storage (session 4), the latter is depreciated in comparison to the juice stored at 4°C.

Figure 5. Cashew juice acceptability chart

Figure 6. Descriptive test chart for cashew juice

Figure 7. Diagram of the evolution of the appreciation of clarified and pasteurised cashew juice during its conservation
4. Discussion

The raw, clarified and clarified pasteurized cashew apple juices analysed have a pH of 4.2, 4.11 and 4.21 respectively. [27,28,29], in their work, obtained a pH of 4.15; 4.4; 4.37 to 4.5 for raw cashew apple juice respectively. This slight difference is due to the fact that these authors worked on raw (non clarified) cashew apple juice. Also, [29] used cashew apples from two different regions of Ivory Coast, namely the central and the northeast. Factors such as variety, agro-ecological zone, climate, cultivation practices, level of maturity of the fruit at harvest [30], storage conditions of the fruit [31,32] and even the colours and shapes of cashew apples affect their physicochemical composition [29]. During storage the pH changes from 4.21 to 4.49 at 4°C, 4.39 at 20°C and 4.20 at room temperature. This variation is different from that observed by [33] where they observed a decrease in pH during storage. Indeed, the pH varied from 3.92 to 3.87 for the temperature of 22°C and from 3.92 to 3.83 for 5°C. This difference would be to the nature of the juice as they worked on raw cashew apple juice.

The soluble dry extract of cashew apple juice is 9.3°Brix for raw juice, 8.4°Brix for clarified juice and 9.6 for pasteurised clarified juice. [34] in Nigeria and [29] in Ivory Coast obtained a soluble dry extract content of 11 and 10.2 to 10.9 °Brix respectively for raw cashew apple juice. These values, which are not identical to those found in the present study, can be explained by differences in soil and climatic conditions in these countries. During storage there is a decrease in the soluble dry extract content at 4 and 20°C and an increase in this content at room temperature. It increases from 9.6 °Brix to 9.27 and 8.77 respectively at 4 and 20°C and to 9.7 °Brix at room temperature. The evolution at 4 and 20°C is similar to that observed by [33] where the evolution was marked by a decrease for all samples at all storage temperatures.

The panel’s choice for the clarified and pasteurised cashew juice can be explained by the fact that it is the sweetest with a soluble dry extract of 9.6 °Brix compared to the raw and clarified juices which have respectively a °Brix of 9.3 and 8.4. This better result is also due to the use of gelatine as a clarifying agent, which allowed the removal of tannins from the raw juice. Indeed, the naturally high content of tannins in raw cashew juice [29] is responsible for the astringency of the latter [35].

Sensory profiles of cashew apple juice show that clarified and pasteurised juice is yellow in colour, less acidic and less astringent. This decrease in astringency is explained by the removal of tannins. Clarification, filtration and pasteurisation affect the clarity, colour and browning index of the juice. Heating the juice for a relatively long time results in much darker juices. The same observation was made by [28] during the heat treatment of cajuna at 80 and 121°C.

The depreciation of clarified and pasteurised cashew apple juice stored at room temperature compared to juice stored at 4°C is based to the change in colour and aroma of the latter. Indeed, during storage at room temperature, we observe the continuation of the Maillard reaction which has the effect of impacting the colour of the juice. The juice stored at room temperature changed from yellow (blond) to brown (caramel), whereas the juice stored at 4 and 20°C retained its original yellow colour. This observation was also made by Gössinger who showed that one of the main problems of strawberry products is that their red colour changes easily during storage and is replaced by a dull brownish colour [36]. This results from the simultaneous degradation of natural red anthocyanin pigments into colourless compounds [37,38] and the formation of brown pigments as a result to enzymatic and/or non-enzymatic reactions [36,39,40].

Non-enzymatic browning reactions are related to the degradation of ascorbic acid, Maillard-associated reactions and acid-catalysed degradation of sugars. Intermediates of ascorbic acid and sugar degradation, such as carbonyl compounds, can polymerise or react with amino acids and participate in Maillard-associated reactions to form brown pigments (melanoidins) [39,41,42,43,44].

Also, factors favouring non-enzymatic browning reactions include pH, ascorbic acid concentration, sugars and amino acids, oxygen availability and processing and storage conditions [38,39,45]. Although browning of fruit products during storage has already been intensively studied, the understanding of this problem is still limited [39].

5. Conclusion

This study is part of the valorization of cashew apple in Ivory Coast. The hedonic analysis carried out on the three types of cashew apple juice showed that the clarified and pasteurised juice is the most popular.

The unitary operations of clarification, filtration and pasteurisation have contributed to obtaining a cashew apple juice of nutritional and organoleptic quality. This juice has a good colour (yellow), good clarity, a good cashew apple aroma, low acidity and above all its non-astringency. The study of the stability of the different samples kept at different temperatures showed that the pH varied little and remained below 4.5 as recommended by the standard on fruit juices. Also the variation of soluble dry extract was not significant hence the nutritional stability of the clarified and pasteurised cashew apple juice during storage. However, it was noted that the clarified and pasteurised cashew juice stored at room temperature changed colour and depreciated after three months of storage. In general, heat treatment and low temperature (<28°C) storage are effective means of preserving clarified and pasteurized cashew juice. Finally, to determine the overall quality of the clarified and pasteurized cashew apple juice, it is necessary to carry out an ageing test through microbiological analyses.

Conflicts of Interest

No conflicts of interest.

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NF EN ISO 13299 : Sensory analysis - Methodology - General guidelines for the establishment of a sensory profileTitle: Sensory analysis - Methodology - General guidelines for sensory profiling Classification number : V09-007


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