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Physicochemical and sensory parameters of cashew apple jam (*Anarcadium occidental L.*) harvested in Bondoukou area (North East, Côte d'Ivoire)

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Abstract

In Côte d'Ivoire, cashew apples represent waste in plantations due to lack of processing. This study deals with their transformation into jam for a better valorization. Cashew apple jam were analyzed for physicochemical and sensory properties. Proximate physiochemical were determined using standard analytical procedures and the sensory acceptance test was performed by 50 panelists on the following attributes. Proximate result showed that moisture content of cashew apple jam was 26.5±1.77% ; carbohydrate 67.7±02.45%, protein 0.7±0.01%; fat and ash contents were 0.16±0.0 and 2.4±0.01% for respectively. pH and titratable acidity were 3.9±0.01 0.06% respectively. Soluble solids (°Brix) was 25±0.98%. Vitamin C and total sugar contents were 276±4.67 (mg/100g) and 51.87±2.18% respectively. Major minerals in the jam were potassium (2762±43.2 mg/Kg), phosphorus (298±4.1 mg/Kg), magnesium (146±1.1 mg/Kg) and calcium (143±2.21mg/Kg). phytochemical analysis revealed presence of tannins (0.8±0.01%), phenol (0.35±0.02%), oxalate (1.87±0.02%) carotenoids (0.70±0.01%), flavonoid (0.20±0.01%), phytate (1.16±0.03%) Results from sensory analysis showed color (7.88±0.55), consistency (8.22±0.83), sweet (8.44±1.09) odour (5.4±0.36) and general acceptability 5.22. Parameters (acidity, astringency and afteraste) scores are less than 3.

Keywords: *Anarcadium occidental*; Cashew apple; Jam; Physicochemical; Sensory parameters; Côte d'Ivoire

1. Introduction

The cashew tree (*Anacardium occidentale L.*) is cultivated in different parts of the world [1,2] and in some Africa countries, including Côte d'Ivoire. These fruits represent an important part of the production of cashew nuts (fruit) but cashew apple is non-used in the food industry after the extraction of juice [3]. The cashew tree is a tropical plant and the nut (the true fruit) has excellent nutritional and sensory properties and widely consumed by people in the world. Cashew apple belongs to the family Anacardiaceae, is a pseudo-fruit formed by an enlarged peduncle, and the true fruit, a kidney-shaped (reniform) achene is about 3 cm long with a hard grey-green pericarp [4,5]. Plantations are made for cashew nuts to the detriment of cashew apples which represent waste due to lack of transformation processes into other products (jam, juice, wine, liqueur...). In addition, majority of cashew apples rot in the ground and this represents huge losses for the farmers. The cashew nuts represent only 10% of the total fruit weight, and large amounts of cashew apples are left in the field after the removal of the nut [6].

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Côte d'Ivoire's agricultural dynamism continues to surprise commodity markets, especially those of cocoa and rubber. The country has also become the world's leading producer of cashew nuts [7]. Production increased from 235,000 tonnes in 2006, to over 738,000 tonnes of raw cashew nuts in 2018 [8]. In general, jam is produced by taking mashed or chopped fruit or vegetable pulp and boiling it with sugar and water. The proportion of sugar and fruit varies according to the type of fruit and its ripeness, but a rough starting point is using equal weights of each. Jam processing is one of the most important methods of fruit preservation. Jam is a preservation technique which is an early process to preserve fruit for consumption the during offseason. Preparation of jam is prepared by mixing fruit, sugar, pectin, acid and other ingredients such as preservatives, colouring and flavouring agents. Then this mixture is boiled until obtaining suitable gelled consistency [9]. Since low cost, long availability for all year and organoleptic properties jam is one of the most popular product [10]. Jams are one of the most popular food products because of their low cost, all year long availability and organoleptic properties [11]. Reducing postharvest losses of indigenous fruits through value addition will ensure sustainable supply of quality fruits and provision of a wide range of products [12].

To our knowledge, nutritional contents of cashew apple jam in Côte d'Ivoire are not yet documented hence, the objective of this research work was to produce jam from cashew apple and determine its proximate, physicochemical and sensory characteristics.

2. Material and methods

2.1. Samples

Cashew (*Anacardium occidentale* L.) has two edible parts known as cashew nut (fruit) and cashew apple (pseudo-fruit), this part was used as a sample. Physiologically developed fruits of cashew apple were collected from plants in bondoukou area (North East, Côte d'Ivoire). At physiological maturity, cashew apples are picked during the fruiting period (February-May). They were then sorted in order to retain those with no abnormalities (wounds, rotting...) and then transported to Laboratory of Biocatalysis and Bioprocessing of University Nangui Abrogoua (Abidjan, Côte d'Ivoire) for various analysis.

2.2. Methods

2.2.1. Jam preparation

Cashew apples at physiological maturity are picked from cashew trees, washed and trimmed. They are then blanched at 100°C for 2 minutes, then cooled. They are cut into small pieces, crushed and sugar is added (50/50; P/P). After maceration, whole is brought to the cooking at (104°C, 5 minutes) or we add lemon juice (350 milliliters for 100 Kg of fruit). The mixture is conditioned at 85°C in jars (previously sterilized) and then pasteurized for 10 minutes.

2.2.2. Proximate Analysis of cashew apple Jam

Proximate and nutritional parameters of cashew apple jam evaluated were moisture, carbohydrate, protein, ash, fat, reducing sugar, total titratable acidity, fibers. Analysis were carried out using methods as described [13]. Soluble solids of cashew apple jam calculated in °Brix were determined using Abbey refractometer (Bausch and Lomb). pH was determined using pH meter (model BA 350 EDT instruments) [14]. Total sugar content was determined using the phenol sulfuric acid method [15] Dubois et al. (1956). Vitamin C content was determined by the method proposed by [16] and [17] modified using dinitrophenylhydrazine (DNPH) and using ascorbic acid as a standard. Energy content of cashew apple jams was calculated by summation of multiplication of protein, carbohydrate and fat by values of 4, 4 and 9 factors, respectively. The value is expressed as kilocalories (kcal).

2.2.3. Phytochemical determination

The phytate content was determined using methods [18,19]. The determination of oxalate and tannins were carried out according to the methods [20,21].

2.2.4. Total phenol content (TPC)

TPC was determined using the Folin Ciocalteu's reagent [22]. 0.3mL of diluted cashew apple jam was taken and 1.5 mL of Folin-Ciocalteu's reagent (diluted 10 times with distilled water) was added and the reaction was neutralized with 1.2 mL of sodium carbonate (7.5% w/v). The tubes were then vortex for a min, covered with parafilm and allowed to stand for 30 min and read at 765 nm against reagent blank.

The total flavonoïds content was measured by a colorimetric assay developed [23], with modifications. Briefly, 250 µl of extract or standard solution of catechin at different concentration (20-260 µg/ml) and 1 ml of distilled water were mixed in a 10 ml test tube. The following were successively added : at zero time, 75 µl of 5% $NaNO_2$; at 5 min, 75 µl of 10% $AlCl_3$; and at 6 minutes, 500 µl of 1N NaOH. The solution was then immediately diluted by adding 2.5 ml of distilled water and mixed thoroughly. The absorbance of the mixture, pink in color, was directly measured in a spectrophotometer at 510 nm against a blank sample and the results were expressed as catechin equivalents (mg CE/g FW).

The amount of total carotenoïds was determined using the method [23]. Briefly, 20 ml of solvent mixture (hexane acetone-ethanol, 2:1:1; v: v: v) were added to 5 g of the homogenized samples. After 30 min of agitation, the supernatant was collected and the residue was added with 10 ml of hexane for a second extraction. The amount of carotenoïds was determined after measuring the absorbance of the supernatant at 420 nm. The results were expressed as mg of β-carotene equivalent per 100 g of fresh weight (mg β-CE/100 g FW).

2.3. Mineral analysis

Minerals were analyzed by dry- ash the sample at 550°C to constant weight and dissolving the ash in 100 ml standard flask using distilled deionized water with 3ml of 3M HCl. Sodium and potassium were determined by using a flame photometer (model 405, corning, U.K). All other minerals were determined by Atomic Absorption Spectrophotometer (Perkin & Elmer model 403, USA).

2.4. Sensory evaluation

An acceptance test of cashew apple jam samples was carried out at the laboratory of the Department of Food Science and Technology of the University Nangui Abrogoua (Abidjan, Côte d'Ivoire). Evaluation of sensory characteristics of cashew apple jam was carried out using a hedonic test on a pamel of 28 members, all volunteers of the university community of both sexes and all ages. They were selected based on their interest and availability to participate in the tests. Evaluation parameters were 9 (Color, Translucent, Consistency, Sweet, Acid, Astringent, Aftertaste, Odor, General acceptability) and scores assigned varied from 1 to 10. Jam samples were served in clear glasses to individual panelist. Each sensory attribute was scored on a 10 – point Hedonic Scale which ranged from 10–1 (liked extremely and disliked extremely), respectively according to method [25].

2.5. Mineral analysis

2.5.1. Statistical Analysis

All chemical analyses and assays were performed in triplicate, unless otherwise indicated. Results were expressed as mean values ± standard deviation (SD). Analysis of variance (ANOVA) was done.

3. Results and discussion

3.1. Physicochemical parameters

Physicochemical parameters of cashew apple jam is shown in Table 1. Generally, the moisture content of foods can be used as an indicator of its shelf life [26]. Moisture content decides the shelf life of the fruit and high moisture content of fruit is not desirable for jam production [27]. Low moisture content indicates that jams have a long shelf life.

Moisture content of cashew apple jam was 26.5%, which is close to those observed [28] between 27 and 34% but higher than that obtained by [29] with 24.60% moisture on jackfruit jam.

pH value is an important factor in jam processing since it is related with gel formation. pH value recommended for jam production is between 3 and 3.5 [30].The low pH will contribute to high stability in the formulated jam. pH value of Cashew apple jam (3.6±0.01) was lower than pH value (3.79) of strawberry jam [31].

Soluble solids (°Brix) content is an important characteristic for products that are sold fresh, since consumers have a preference for sweeter fruits [32,33].

The soluble solids content is an important characteristic for products that are sold fresh, since consumers have a preference for sweeter fruits [32,33] .The high °Brix value (55.4±0.98%) found in cashew apple jam can reduces water activity of food and food is become safer for microbial and some of biochemical deteriorations.

High carbohydrate content in jams can be associated to the large presence of sugar (> 50g/100 g) as observed from the nutrition labelling on its packaging. Carbohydrate content has been reported to range from 14 g/100 g to 48 g/100 g for pineapple and jackfruit jams [29], which is lower than for cashew apples jam (67.7±2.45%).

Ash content of cashew apple jam was 2.4±0.01g/100g which is higher than of pineapple, jackfruit and mango jams (0.15–0.49 g/100g) [29, 34] and apricot jam (0.2 g/100g) [35,36]. Generally, high ash content indicates that jams analysed are a rich source of minerals.

For protein content, cahew apple jam (0.7±0.01mg/100g) had lower which is comparable to protein content of jackfruit (0.19 g/100 g) and pineapple jam (0.46 g/100 g) [29]. According to jams nutrition labelling, common ingredients are fruits, sugar, pectin and citric acid. None of the ingredients used are an abundant source of protein hence the low protein content of jams found in this study.

Level of acidity in fruit pulp is an important aspect in jam processing which has an influence on the gel formation [37].Low titrable acidity is important in facilitating conversion of added sucrose during cooking and prevents crystallization and also gives imperative effect on the gelatinization property of pectin [38]. [39] found titratable acidity values for blackberry jam between 1.27 and 1.62 (%), values that are higher than the one found in this study (0.6±0.001%). Low titrable acidity is important in facilitating conversion of added sucrose during cooking and prevents crystallization and also gives imperative effect on the gelatinization property of pectin [38].

Similarly, [10] reported that the differences in vitamin C content between fruit and jam might be linked to destructive nature of jam making process. Processing of fruit into jam was revealed to be most damaging towards vitamin C [40,41] which explains low vitamin C value in cashew apple jam (276±4.67 mg/100g). The importance of vitamin C in human health is well understood, particularly as an antioxidant and in collagen synthesis [42,43]. Vitamin C in mango jams in the range of 15.8–33.57 mg/100 g reported by [44] was lower than in cashew apple jam (276±4.67 mg/100g).

Total and reducing sugar content of cashew apple jam was 51.87±2.18 and 34.46± 3.02 respectively. Sugar content in jam represent the amount of sugar added and sugar content of fruit that being used as material in jam. In jam, sugar not just affect the taste but also the texture and appearance of jam. Jam that content higher amount of reducing sugar have higher shiny aspect, lesser crystallization level during storage, more stable level of sweetness, and, less exudation. Total sugar and reducing sugar in melon jam was 56.18 ± 0.66 and 26.89 ± 0.21 respectively [45], while the reducing sugar amount of in black-plum fruit jam was 24.22 ± 0.08 [46].

Table 1 Physico-chemical composition of cashew apple jam

Parameters	Cashew apple jam (%)
Moisture	26.5±1.77
pH	3.6±0.01
Soluble solids (°Brix)	60.4±0.98
Carbohydrate	67.7±2.45
Total sugar	51.87±2.18
Reducing sugar	34.46±3.02
Protein	0.7±0.01
Fat	0.16±0.001
Vitamin C (mg/100g)	276±4.67
Titrable Acidity	0.06±0.001
Ash	2.4±0.01
Fibers	1.34±0.06
Energy (Kcal/100g)	275.04±7.34

Each value is a mean ± standard deviation for 3 determinations

Energy value of cashew apple jam could be attributed to the addition of sugar during the jam making process as it is a great source of energy (389 Kcal/100 g) (US Department of Agriculture [47]. Energy value (275.04±7.34 kcal/100g) of cashew apple jam is close those papaya jam fortified with soya protein [47].

3.2. Mineral composition

Mineral composition of cashew apple jam are presented in table 2. Cashew apple jam had higher potassium (2762±43.2mg/kg), phosphorus (298±4.1 mg/Kg) magnesium (146±1.1 mg/Kg) and calcium (143±2.21 mg/Kg) content. As sources of potassium, phosphorus, magnesium and calcium, cashew apple jam provide important health benefits. Potassium is critical for muscle function and nerve transmission and involved in energy metabolism glycogenesis and cellular growth and division [48]. Phosphorous is critically important and is mostly found in bone with some in soft tissue and in the phospholipids of erythrocytes and plasma lipoproteins Phosphorus and calcium occur together in the body to maintain body blood [49].

Magnesium is in bones, soft tissue and in all compartments of cells performing many cellular reactions and involved in at least 300 enzymatic steps in metabolism [50].

Table 2 Mineral composition of cashew apple Jam

Minerals	Composition (mg/Kg)
Phosphorus	298 ±4.1
Potassium	2762±43.2
Magnesium	146±1.1
Manganese	5.2±0.2
Calcium	143±2.21
Sodium	36.8±0.4
Copper	0.4±0.01
Lead	0.13±0.0
Zinc	nd
Iron	2.1±0.01

Each value is a mean ± standard deviation for three determinations

Phytochemical composition of cashew apple jam is presented in table 3. Phytochemicals are biologically active, naturally occurring chemical compounds found in plants, which provide health benefits for humans, further than those attributed to macro and micronutrients [51]. Tannins content in cashew apple cause an astringent taste [52], are also an anti-nutritional factor, acting as metal ion chelators and digestion inhibitors [53]. In moderate consumption, it aids the healing of burns, increase blood clotting and protect the kidney [54]. Tannin content of cashew apple jam (0.8 ± 0.01%) is higher than total tannin in cashew (0.64±0.01%) apple jam in india [55, 56]. Apart from the ability to precipitate protein, tannin equally decreases digestibility and palatability [55,56].

Knowledge of phytate content in any food is necessary because high concentration can cause adverse effects on the digestibility [57]. Therefore, low content of phytate in cashew apple jam (1.16±0.03) would positively affect digestibility and hence, aid its quick digestion in small intestine.

Phenolic compounds are partly responsible for the astringency of the cashew apple [58]. Presence of total phenolic in cashew apples jam (0.35±0.02%) could be advantageous for cashew producing countries. Many studies have indeed shown that phenolic are effective in reducing risk of cardiovascular disease [59,60,61].

Flavonoids are among the most studied phytochemicals components in plant foods. They contain within them, a variety of molecules which can result in diverse biological activities [62]. Numerous studies have revealed their character and their antioxidant action on free radicals in the human body [63,64].

Table 3 Phytochemical composition of cashew apple jam

Parameters	cashew apple jam (%)
Tannins	0.8±0.01
Phenol	0.35±0.02
Oxalate	1.87±0.02
Carotenoid	0.70±0.01
Flavonoid	0.20±0.01
Phytate	1.16±0.03

Each value is a mean ± standard deviation for three determinations

Sensory parameters of cashew apple jam is presented in table 4**.** The organoleptic tests are always a necessary guide of the quality from the consumer's point of view [65]. Consumer tests are important to evaluate the development of new products as it is possible to assess the personal response of current or potential customers of a product [66]. Many studies of fruit-based products such as jam have used this type of analysis [67,68, 69, 70].

Cashew apple jam recorded better scores for color (7.88±0.55), consistency (8.22±0.83), sweetness (8.44±1.09) and lower scores for sour taste (2±0.01 and parameters astringency (2.29±0.02) and aftertaste (2.92±1.94) Odor of cashew apple jam registers an average score of 5.4±0.36.

Coloration is generally the first characteristic observed in fresh foods, and very often predetermines the consumer expectation in relation to the flavor and quality. However, during food processing, for example in the production of jams, a change in the color of the original fruit commonly occurs [71]. This can be explained by many factors, such as darkening reactions (the Maillard reaction) and the degradation of pigments responsible for fruit coloring, such as anthocyanin, that is the main pigment in berries [72].

Color is an important sensory attribute on which the consumer preference depends. Good jam has a soft even consistency without distinct pieces of fruit, a bright color, a good fruit flavor and a semi-jellied texture that is easy to spread but has no free liquid [73]. The importance of colour, which affects appearance, thus seemed to be responsible for the lower score [74,75].

Good jam has a soft even consistency without distinct pieces of fruit, a bright color, a good fruitflavor and a semi-jellied texture that is easy to spread but has no free liquid [73].

Table 4 Sensory parameters of cashew apple jam

parameters	Scores (1-9)
Color	7.88±0.55
Translucent	4.63±0.20
Consistency	8.22±0.83
Sweet	8.44±1.09
Acid	2±0.01
Astringent	2.29±0.02
Aftertaste	2.92±1.94
Odour	5.4±0.36
General acceptability	5.22

Each value is a mean ± standard deviation for three determinations

Flavor jam is originated from the fruit and citric acid added to adjust the pH. Some flavor compounds may be lost during processing, which reduces the intensity of flavor or releases other flavor/aroma compounds.

Consistency of jam is a parameter that affected by pectin concentration, processing temperature and sugar added to jam during processing [38]. Consistency jam is influenced by gelling agent pectin, sugar and acidity concentration [76]. Consistency jam is a parameter that affected by pectin concentration, processing temperature and sugar added to jam during processing [38].

4. Conclusion

This study showed that cashew apple jam is a good source of nutrients, phytochemicals and energy. Panelists appreciated cashew apple jam through certain parameters (colour, consistency, sweetness). Cashew apple jam could be an alternative for Côte d'Ivoire, through better knowledge and popularisation. It's important to encourage the valorisation of cashew apple jam in order to contribute to the nutritional needs of the population and to provide a solution to enormous losses recorded in fields.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no competing interests exist.

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