

Characterization and Physico-chemical Evaluation of Fresh and Pasteurized Juices from Cashew Apple (*Anacardium occidentale*) of Different Varieties

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Received 10 October 2025, Accepted 3 December 2025, Published 12 December 2025

Direct Research Journal of Agriculture and Food Science



Vol. 13(3), Pp. 257-280, December 2025

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<https://journals.directresearchpublisher.org/index.php/drjafs>; <https://www.ajol.info/index.php/drjafs>

Research Article
ISSN: 2354-4147

ABSTRACT

This study investigated the physicochemical, nutritional, and microbiological characteristics of fresh and pasteurized juices produced from different varieties of cashew apple. Cashew fruits were sourced from the Michael Okpara Cashew Orchard, Okigwe, Imo State, and analyzed at Grifeon Project Limited Laboratory, Umuahia, Abia State. Seven juice samples (FPJ900, PPJ901, FYJ902, PYJ903, FYJ904, and PRJ905) were processed and assessed for proximate composition, vitamin and mineral content, phytochemicals, organic acids, sugar profile, sensory quality, and shelf-life attributes. Proximate analysis showed moisture, ash, fat, protein, and carbohydrate levels with no significant differences at $P>0.05$ across varieties. Similarly, pH, titratable acidity, total soluble solids, total sugar, and specific gravity exhibited no significant variation. Vitamin C (14.31–25.76 mg/100 g), vitamin A (0.064–9.85 RAE), vitamin B2 (0.48–2.40 mg/100 g), vitamin B6 (2.65–45.25 mg/100 g), and vitamin E (9.32–15.77 mg/100 g) also showed statistically similar values. Mineral contents for calcium (2.01–8.02 mg/100 g), potassium (4.81–6.45 mg/100 ml), phosphorus (0.50–0.62 mg/100 ml), and iron (0.06–0.09 mg/100 ml) followed the same trend. Phytochemical concentrations were low, while the sugar profile indicated moderate levels of glucose (22.21–32.21 g/L), fructose (3.41–30.57 g/L), and sucrose (16.11–16.73 g/L). Sensory evaluation revealed that FPJ900 (fresh pink juice) demonstrated superior acceptability. Shelf-life studies showed increasing microbial counts during storage, although pasteurization at 75°C enhanced stability. Overall, all cashew apple varieties exhibited comparable quality attributes, confirming the fruit's high nutritional value and strong potential for processing into marketable products. Further research on improved preservation techniques is recommended to extend shelf life and minimize postharvest losses.

Keywords: Chemical, physical, characterization, pasteurization, fresh, microbial



Citation: Archibong, U. R., Ndife, J. &Offia-olua, B. (2025). Characterization And physico-chemical Evaluation of Fresh and Pasteurized Juices from Cashew Apple (*Anacardium occidentale*) of Different Varieties. *Direct Research Journal of Agriculture and Food Science*. Vol. 13(3), Pp. 257-280: <https://doi.org/10.26765/DRJAFS17993688>

INTRODUCTION

A fruit juice is an unfermented, undiluted extractable fluid content, obtained from the expression of fruit. Juice can also be defined as “the extractable fluid contents of cells or tissues”. Fruit juices are tasteful food beverages which provide energy and contained considerable amount of important vitamins (especially vitamin C) and mineral (Olmeduet *et al.*, 2006). Juices which include single strength and concentrates are important means of utilizing fresh fruits, which provides an important source of nutrients in a convenient and most refreshing form (Olmedu *et al.*, 2006). Fruit juice can also be defined as “the fermentable but unfermented product obtained from the edible part of fruit which is matured and ripe, fresh or preserved by chilling or freezing of one or more kinds mixed together having the characteristic colour, flavour and taste typical of the juice of the fruit from which it comes (the juice obtained directly from fruit). This product is often described as “direct juice” or “not from concentrate (NFC) juice” although these names are not controlled by the regulations. Fruit juices are made from pure filtered fruit juice with nothing added. Sodium benzoate can be added as a preservative to extend the shelf life, but this is not essential. Properly pasteurized juice has a shelf life of several months. Most fruits can be used to make juice. The most popular ones are pineapple, orange, mango, grapefruit and passion fruit. Cashew (*Anacardium occidentale*) is a crop of afforestation and soil conservation, belonging to the family *Anacardiaceae* and genus *Anacardium*. The cashew fruit consists of the cashew nut (the true fruit) and the cashew apple (pseudo fruit), and has excellent nutritional and sensory properties. It is very juicy, sweet, spongy, and nutritious compared with many other tropical fruits.

The cashew fruit consists of an apple (also called crab apple) and a nut, which is a kidney bean shaped appendage at the end of the apple. The true fruit is the cashew nut, which resembles a miniature boxing-glove. It consists of a double shell, containing a caustic phenolic resin in honeycomb-like cells, enclosing the edible kidney-shaped kernel. Cashew apple, the pseudo fruit (or false fruit) is soft and nutritious. It is actually the swollen receptacle or the flower stalk of the crop (Mini *et al.*, 2005). The aim of this study is to characterize and evaluate the physico-chemical, nutritional, microbial, sensory, and shelf-life properties of fresh and pasteurized cashew apple (*Anacardium occidentale*) juices produced from different Nigerian varieties (red, yellow, and pink).

MATERIALS AND METHODS

Fresh cashew apples (*Anacardium occidentale*) of three Nigerian varieties (yellow, Pink, red) used for this research was obtained from Micheal Okpara cashew orchard in Okigwe Local government area, Imo state. Other ingredients used for the clear juice production were obtained from a supermarket in Akwalbom State.

Reagents

The reagents used for this research were obtained from Grifeon Project Limited. Laboratory. A private laboratory located at Maranatha Estate, new timber market, Umuahia, Abia state.

Extraction and production of high-quality cashew-apple (*Anacardium occidentale*) juice

Extraction and production were carried out by method as described by Mini *et al.* (2005), with some slight modifications. Fresh, mature and healthy cashew apples of three varieties (Plates 1, 2 and 3, Figures 1 and 2) were washed and weighed using a platform baking scale. Washing was done to eliminate impurities which may have been brought from the field that may contaminate raw materials and result in problems related to equipment wearing out during the processing stage due to the presence of sand and pebbles. Washing also serves the purpose of reducing heat caused by friction during handling, bagging and transportation. Harvested cashew apples, brought from the field for processing generally have high microbial load, due to the harvesting procedures where harvested apples fall to the ground and are bruised. The bruised area serve as an entry point for micro-organisms. Washing is aimed at reducing the microbial load on the surface of fruits and this was achieved by soaking cashew apple fruits in 2g sodium chloride (NaCl) solution. Nuts extraction was done manually by hand by turning the nut around and pulling them out. Sorting was done to remove unwholesomeness among fruits which may deter organoleptic result. Cashew apples were placed on a sorting table, made of stainless steel, from which sorting was done by removing rotten, unripe and imperfect fruits. Small imperfections and rotten spots were removed using stainless steel knife, in order to have a good quality end product, thorough sorting of raw materials was carried out to remove uneven fruits. Fruit crushing was done using a Q-link powered electric blender, juice extraction was carried out by simple hand pressing of juice pulp from the cashew apple while filtration was carried out using a 3-layered muslin cloth to remove impurities leaving out a clear-filtered juice (Plate 4). Clarification for this analysis was done using Gelatin. Gelatin was dissolved in warm water to form a solution, this was added in small droplet, that is, the ratio of 100g of gelatin to 900ml of warm filtered-juice heated to the approximate temperature of 50 to 60°C. Heating enables gelatin to dissolve further in the juice (Tables 1 and 2).

Moments after the gelatin solution was added to the juice, its color changes to whitish, cloudy or milky solution. This milky color remains until floccules were formed. On further addition of more of the gelatin solution to the juice mix, larger floccules were formed, making the juice look like milk coagulated after lemon drops were added to it.



Plate 1 Red cashew apple

Plate 2 Yellow cashew apple



Plate 3 pink cashew apple

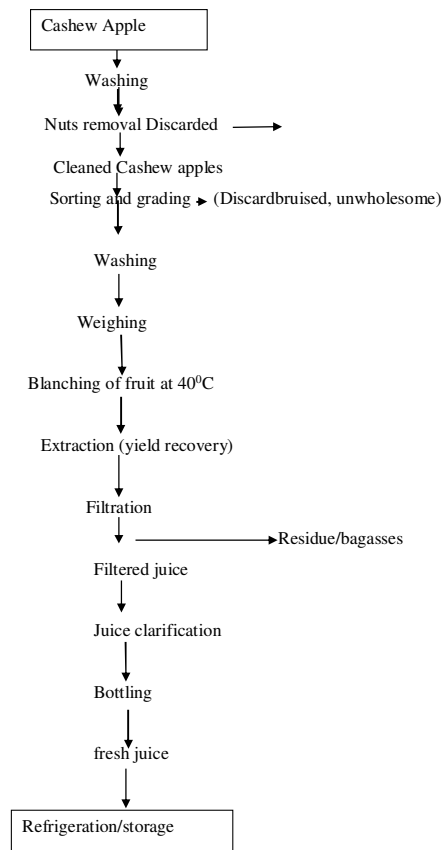


Figure 1: Schematic representation of Fresh cashew apple juice production.

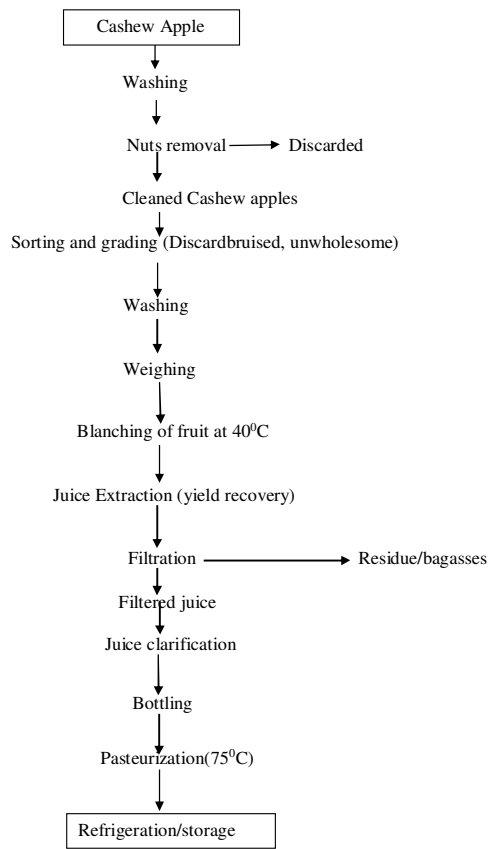


Figure 2: Schematic representation of pasteurized cashew apple juice production.



Plate 4 Cashew apple juice

Table 1: Formulation of the single strength cashew apple fresh juice.

Ingredient	Quantity
Cashew puree	12kg
Sweetener	15g
Distilled Water	500ml
Flavor	5g
Gelatin	10g

Table 2: Formulation of the single strength cashew apple pasteurized juice.

Ingredient	Quantity
Cashew puree	12kg
Sweetener	100g
Sodium benzoate	1.5g
Distilled water	500ml
Carboxyl-methyl-cellulose (CMC)	1.0g
Food Emulsifier	1.0g
Flavour	2.0g
Gelatin	5g

Filtration was carried-out on the cashew juice after clarification to obtain a good quality end product and yield. For the filtration, a three-layered muslin cloth was used. The juice collected was re-filtered until clear and glossy juice was obtained. After this step was completed, a clear, clarified, colorless, transparent juice, resembling white wine was obtained.

Clarified juice were filled into a 60ml plastic containers. After filling, bottles were then closed with plastic screw caps in a specific capper, and thermally treated (Pasteurization). During packaging, 30 bottles containing fresh cashew apple juice and 30 bottles containing pasteurized cashew apple juice were obtained, respectively (Plate 4). Thermal treatment of cashews is an important method to preserve and stabilize juice. Pasteurization of cashew apple juice was done at a temperature 75°C for one (1) minute using a bathtub. Temperature was monitored using a hand thermometer. Clarified cashew juice was kept in a chiller at a temperature of approximately 10°C.

Proximate determination of cashew apples (*Anacardium occidentale*) juice

Determination of fat

Fat determination was carried out using the AOAC methods (AOAC, 2016). Modified Mojonnier method was carried out using three replicates of 10 ml each cashew apple juice samples loaded into a Mojonnier fat extraction flask. Two millilitres (ml) of ammonium hydroxide, 10 ml of 95% ethanol and 25 ml ethyl ether were added into the flasks and shaken vigorously to neutralize the acid, dissolved protein, prevents gel formation and dissolved lipid in cashew apple juice samples. After that, cashew apple juice samples were centrifuged for 30 seconds at

121 RCF (600 rpm). Then, clear solvent was decanted from Mojonnier flask into pre-weight Mojonnier fat dish and was dried on a hot plate at 100 °C in a hood. Dish and fat were dried to a constant weight in the oven at 100 °C and finally, the dish was cooled at room temperature and weighed.

Determination of Protein

The micro-Kjeldahl method described by AOAC, 2012 was used in the determination of crude protein, which involved the following stages.

Digestion: One gram of cashew apple juice was digested with a mixture of 20 ml concentrated sulphuric acid, a pinch of copper sulphate, 2 g sodium sulphate, and a pinch of selenium catalyst. The mixture was heated till the black liquid cleared. Heating continued until the sample became completely digested. The digested sample was transferred into a 100 ml volumetric flask, which was weighed in preparation for distillation.

Distillation: Kjeldahl distillation apparatus was used. 10 ml of 4% boric acid mixed indicator was introduced into a conical flask of 100 ml. The conical flask was positioned at the receiving end of the distillation unit using a clamp. 10 ml of the digested cashew apple juice was first introduced into the distillation unit followed by the addition of 10 ml of 50% NaOH gradually. The distillation process lasted for 5 to 10 min, during which ammonia (NH₃) was trapped in excess boric acid. The presence of ammonia changed the purple colour of boric acid to green which is a common characteristic of an alkaline gas. Ammonia trapped in the boric acid indicator was titrated using 0.01 NHCl. Crude protein content was calculated by the following formula:

$$\% \text{ nitrogen} = \text{titre} \times 0.01 \times \text{DF} \times \text{MWN} \times 100 \text{ weight of the sample (mg),}$$

Where

DF is the dilution factor (100 ml/5 ml) which is equal to 20. MWN is the molecular weight of nitrogen which is equal to 10.01.

Then,

$N \times 6.25$ was used to convert nitrogen content into protein content.

Determination of ash

The dry ashing procedure was performed according to AOAC methods (AOAC, 2016). Six cashew apple juice samples with 30g each were weighed and placed in the 50 ml crucibles and dried in an oven at 105 °C for 72 hours. Then, they were covered, cooled in the desiccators, and weighed. The samples were re-dried for one hour in the oven, cooled, and re-weighed. The process was repeated at 1 hour drying intervals until the differences in weight were less than 0.1%. After that, the dried samples in the crucibles were subjected to ashing in an electrical furnace with temperature 550 °C for 16 hours. Finally, they were covered, cooled in the desiccators and the final weight was recorded.

Determination of moisture

Moisture determination was carried out using the AOAC methods (AOAC, 2016). Three 20g cashew apple juice samples were weighed and filled in 50 ml beaker and then dried in air oven drier at 70 °C for 48 hours. The drying process was continued until three consecutive constant weights (equilibrium) were achieved. Percentage of moisture was calculated using the equation below;

$$\text{Moisture (\%)} = \frac{(\text{initial weight} - \text{equilibrium weight})}{(\text{initial weight})} \times 100$$

Determination of carbohydrate

Carbohydrate was measured using the calculation by difference adopted from AOAC methods (AOAC, 2016). Carbohydrate content in cashew apple juice was determined by subtracting the total percentage of other components such as protein, fat, moisture, ash and fibre from 100 using the following equation below;

$$\text{Carbohydrate (\%)} = 100 - (\text{percentage (protein + fat + moisture + ash + fiber)})$$

Energy Calculation

The Atwater method was used for energy calculations:

$$\text{Energy (kcal)} = (\text{g protein} \times 4) + (\text{g carbohydrate} \times 4) + (\text{g fat} \times 9).$$

Determination of phyto-chemicals in cashew apples (*Anacardium occidentale*) juice

Determination of Carotenoids

The determination was carried out as described by Kimura and Rodriguez-Amaya (2004), with slight modifications. A portion of cashew apple juice samples was weighed, 4g of the homogenized sample of cashew juice was transferred to a conical flask and 0.3 g of MgCO_3 was added. The mixture was shaken together with 25 ml of cold acetone (refrigerated for about 2 hours). The extract was filtered using a Whatman filter paper.

Determination of Tanin

The tannin content of the cashew apple juice was determined following the procedure described in AOAC, (2010). 1 ml of the cashew apple juice were mixed with folin-ciocalteu reagent (0.5 cm³), followed by the addition of saturated Na_2CO_3 solution (1 cm³) and distilled water (8 cm³). The reaction mixture was allowed to stand for 30 minutes at room temperature. The supernatant was recorded by centrifugation and absorbance was recorded at 725 nm using a UV-visible spectrophotometer.

Phenol determination

Phenolic content was determined using a modified version of the Folin-Ciocalteu method. From the aqueous samples (of CAJ), 0.25 mL were accurately transferred to a test tube and mixed with (1) 4.8 mL of distilled water, (2) 0.5 mL of Folin-Ciocalteus phenol reagent, and (3) 1.5 mL of 20% (w/v) sodium carbonate solution after 2 minute incubation at room temperature. The reaction mixture was allowed to react for 2 hours at room temperature in darkness, and the absorbance was measured at 765 nm. A calibration curve with gallic acid over a concentration range of 25 mg/L to 500 mg/L was used as standard.

Physio-chemical analysis of cashew apples (*Anacardium occidentale*) juice

Determination of Total Soluble Solids (Brix Level) of the Cashew

Cashew apple juice content was measured as percentage sugar by the use of a refractometer. The sample was poured into the sample holder and covered. The readings was taken directly from the scale when viewed from the eye-piece after adjusting the knob until there was a clear demarcation between yellow and a red light with a red line passing at the centre. The analysis was carried out for the respective samples and recorded.

Determination of the Specific Gravity of the Juice

The specific gravity of the juice samples was measured by the use of hydrometer. The hydrometer was placed into the juice sample when it was cooled at 20°C after extraction in a measuring cylinder and was allowed to float. The readings were taken directly from the hydrometer scale by reading the upper meniscus.

Titrateable Acidity (TTA)

Ten (10ml) of the cashew apple juice samples was pipetted into a conical flask and 25ml of distilled water will be added as described by AOAC (2012). Two hundred millimetres (200ml) of 0.1M NaOH was poured into a burette and titrated against the sample in the flask using three drops of phenolphthalein as indicator. It was titrated until a pink colouration was observed and the corresponding burette reading was taken using the following formula.

$$\text{Titrateable acidity (\%)} = \frac{\text{Titre x blank x normality of base x ml equivalent of citric acid}}{\text{weight of sample}}$$

Determination of Total sugar

For the estimate of total sugars, the titrate obtained in the estimation of reducing sugars was used. An aliquot from the filtrate was taken. 10 ml of dilute HCl was added and the inversion was carried out at room temperature for 24 h. Subsequently, contents were cooled and neutralized with 40% sodium hydroxide solution using phenolphthalein as indicator and the final volume was made. The solution was filtered and titration was carried out using filtrate as detailed for reducing sugars. The total sugars content was expressed as percentage in terms of invert sugars according to the formula (Ranganna, 1986).

$$\text{Total sugar (\%)} = \frac{\text{Glucose equivalent x Total vol.made up x Vol.made after inversion}}{\text{Titre x weight of sample x aliquot taken for inversion}} \times 100$$

Determination of pH of the Cashew Juice

Determination of pH of the Cashew Juice The pH of the cashew juice was determined by using a standard pH meter (PHYWE, range 0-14). The pH of 7 after which the bulb was dipped in another buffer solution and the reading on the scale was adjusted. The process was repeated with another known pH (Tap water) to standardize the pH meter. Each time, the bulb was dipped into another solution it was thoroughly rinsed with distilled water after the calibration of the pH meter, the bulb was dipped into the juice samples and the pH reading of the juice were repeated 3 times and the average were recorded.

Estimation of the TSS to Acid Ratio

The sugar-acid ratio contributes to the unique flavour of

cashew apple juice. At the beginning of the ripening process, the sugar-acid ratio is low, because of low sugar content and high fruit acid content—this makes the fruit taste sour. During the ripening process, the fruit acids are degraded, the sugar content increases and the sugar-acid ratio achieves a higher value. The total soluble solid to Acidity ratio (TSS/acidity) was calculated by dividing the total soluble solids by percent acid (Lacey, 2020).

$$\text{TSS: Acid} = \frac{\text{°Brix value}}{\text{Percentage acid}}$$

Determination of the Cashew Juice Colour

This was done using spectrophotometer method. The absorbance values of the juice were determined at 450nm and 600nm wave length using a spectrophotometer. Before the analysis, the juice was diluted with distilled water and was used as blank. The measurement was made by inserting the coveter (glass tube) containing the samples into the light path of the spectrophotometer which measured the intensity of light at various wave lengths transmitted by the solution. The intensity of light was determined by the electric detector, which converted radiant energy to electric energy. The diluted juice samples which had the absorbance value at 450nm was used as a standard and the other filled with the juice were inserted into the instrument and knob was switched off before taking the reading of the absorbance on the electronic scale.

Sugar determination cashew apples (*Anacardium occidentale*) juice

Determination of glucose

This was determined using spectrophotometric method. The sample was prepared by measuring 1 g of cashew apple juice samples in 10 ml distilled water. A 5 mL of the sample solution was measured inside 50 mL beaker and 5mL of the 6N HCl solution was added and boiled for 10 mins. After then 8ml of 2.5N NaOH solution was added and 2 mL of 0.05N DNSA (3, 5-Dinitrosacrylic acid) was added and shaken, before heating in a water bath for 10 min for brick red colour development, after which the absorbance reading was taken at wavelength of 580 nM. Also, standard glucose solutions were prepared at different concentrations and treated similarly like the samples. Calculation: The concentration of the glucose was calculated through extrapolation using glucose standard curve.

Determination of fructose

This was determined by spectrophotometric method. The sample was first prepared by dissolving 1g of the sample in 10 ml distilled water. 3ml of the filtrate was measured

inside 50 mL flask. 3 mL of acetate buffer was added followed by addition of 0.1% ferric chloride solution. Then, heating under water bath for 50 min was done, before absorbance reading at wavelength of 540 nm. Standard fructose solutions were also prepared in similar manner like the sample.

Calculation

The concentration of the fructose was calculated from the standard curve by extrapolation.

Determination of sucrose

This was determined by spectrophotometric method described by Borjiet *al.* (2017), with slight modifications.

The sample was prepared by mixing 1g of each cashew apple juice sample solution in 10 ml distilled water and measured at a wave length of 420 nm. Also, standard sucrose solutions were also prepared at different concentrations of 5, 10, 15, 20, and 25 mg/100 mL. An aliquot of 1 mL of the sample was taken in a boiling tube with 4 mL of 0.02% Anthrone reagent and heated in a water bath at 100 °C for 10 mins. The standard was also treated as the sample solution. Absorbance of the sample and standard solution was taken at 420 nm.

The concentration of the sucrose was calculated through extrapolation using the sucrose standard curve.

Determination of different organic acids for cashew apples (*Anacardium occidentale*) juice

Determination of Citric Acid content

Citric Acid (titratable acidity) is a measure of the total acid present in a juice. The predominant acid naturally occurring in some acidic and sub acidic citrus fruits (Sweet lemon, Lime, Pineapple, and Mango) juice is citric acid. The amount of acid present in the juice is reported as percent citric acid. It needs to be noted that the total acid cannot be measured by 'pH' because the acids concerned are "weak acids" and not completely ionized. The acid content was measured using titration with sodium hydroxide. The acidity of the juices was determined (in duplicate) by acid-base titration (Lacey, 2020).

$$\text{Percentage acid} = \frac{\text{Titer} \times \text{Acid factor} \times 10}{10\text{ml of Juice}}$$

Acid factor for citric acid is 0.064 (citrus fruit)

Where; Titer = Consumed volume of Sodium hydroxide by the juice.

Determination of acetic acid

The total acetic acid was measured using titration with sodium hydroxide. The acidity of the juices was determined (in duplicate) by acid-base titration (Lacey, 2020).

$$\text{Percentage acid} = \frac{\text{Titer} \times \text{Acid factor} \times 10}{10\text{ml of Juice}}$$

Acid factor for acetic acid is =0.088

Where; Titer = Consumed volume of Sodium hydroxide by the juice.

Determination of oxalic acid

The total acetic acid was measured using titration with sodium hydroxide. The acidity of the juices was determined (in duplicate) by acid-base titration (Lacey, 2020).

$$\text{Percentage acid} = \frac{\text{Titer} \times \text{Acid factor} \times 10}{10\text{ml of Juice}}$$

Acid factor for oxalic acid is =0.095

Where; Titer = Consumed volume of Sodium hydroxide by the juice.

Determination of malic acids

The total acetic acid was measured using titration with sodium hydroxide. The acidity of the juices was determined (in duplicate) by acid-base titration (Lacey, 2020).

$$\text{Percentage acid} = \frac{\text{Titer} \times \text{Acid factor} \times 10}{10\text{ml of Juice}}$$

Acid factor for malic acid is =0.075

Where; Titer = Consumed volume of Sodium hydroxide by the juice.

Determination of minerals of cashew apples (*Anacardium occidentale*) juice

Determination of iron

A stock solution containing 1000mg/ml of Fe³⁺ ions was prepared from 1.0g of pure ion wire. The wire is dissolved in 100ml concentrated HNO₃, boiled on a water bath and diluted to 1000ml with distilled water, from a stock solution of 2.0ppm prepared as a standard (Onwuka, 2018).

Determination of phosphorus

Phosphorous was determined with molybdate method using hydroquinone as a reducing agent. To every 0.5ml cashew apple juice sample selected 1.0ml of ammonium molybdate, 1.0ml sodium sulphate and 1.0ml hydroquinone. The mixture was agitated and allowed to stand for 30minutes. The blue colour that developed was quantitated using a colourimeter at 660nm against a standard curve. (Onwuka, 2018).

Determination of potassium

A stock solution of 100mg/ml of k⁺ ions was prepared by dissolving 1.907g of KCL in water. From the solution, standard was prepared, A stock solution of 1% lithium-chloride is prepared and added to the potassium standard solution such that the concentration in the final solution is 0.1%. The concentration of these element are determined using a calibration curve. (Onwuka, 2018).

Determination of Calcium

This was determined following the procedure of AOAC, 2010. 10 g of the ash solution of cashew apple juice were taken into a 250 ml beaker. 1 ml 30% citric acid solution were added followed by 5 ml 5% ammonium chloride solution. This was made up to 100 ml with distilled water and brought to boiling. 10 drops of 0.04% bromocresol green solution will be added. This were followed by the addition of a 30% warm saturated 4.2% ammonium oxalate solution. The precipitate formed were dissolved in few drops of concentrated HCl. this was neutralized slowly by the drop wise addition of ammonia (0.88). The beaker was placed on a steam bath for 30 min. the beaker was removed and its content will be filtered. The beaker was thoroughly washed and the precipitate was dissolved by passing through 50 ml 2NH₂SO₄. This will be filtered. The filter paper was rinsed and the filtrate was made up to 100 ml with distilled water. The filtrate was heated to 70–80°C and then titrated with 0.02 N KMnO₄ solution to a pink that persisted for about 30 seconds: Calculation: 1 ml KMnO₄ = 2.004 mg Ca.

Determination of vitamins for cashew apples (*Anacardium occidentale*) juice

Determination of Vitamin C

The method of AOAC, (2012) was used. 5 g of cashew apple juice were weighed into a flat bottomed flask and 60 ml TCA/acetic acid solution was added. The mixture was left for about 60 min before it was filtered. The filtrate was made up to 200 ml. 10 ml was taken for titration with 0.05% 2, 6-dichlorophenol indophenol. The vitamin C content was calculated as follows:

$$K = \frac{y \times z \times DF}{\text{weight of sample}}$$

Where

y was the titre of the sample.

z is the figure obtained when 50 mg of the standard vitamin C were divided by its titre value.

DF was the dilution factor, and K was then multiplied by a factor of 20 to give vitamin C content in mg/100 g.

Determination of Vitamin A

1.0 g each of the cashew apple juice samples was mixed with 30 mL absolute ethanol, 3 mL of 5% potassium hydroxide, and boiled gently under reflux for 30 minutes in a stream of oxygen-free nitrogen. It was allowed to cool rapidly and 30 mL of water was added and transferred to a centrifuge where it was separated into different layers for 15 minutes. After complete separation, the lower layer was discarded and the upper layer was washed with 50 mL ether and four times with 50 mL water, during the first two washes, the formation of the emulsion was avoided cautiously. The evaporated sample was washed down to about 5 mL. The remaining ether in the sample was removed in a stream of nitrogen at room temperature. The residue was dissolved in sufficient isopropyl alcohol to give a solution containing 9-15 units per mL and measure the extinctions at 300 nm, 310 nm, 325 nm and 334 nm and the wavelength of maximum absorption 350 nm. Person, (1975).

Determination of Vitamin B2

Determination of Vitamin B2 (Riboflavin) 5g of the cashew apple juice sample was extracted with 100ml of 50% ethanol and shaken for one hour. This was filtered into 100ml flask 10ml of the extract was pipette into 50ml volumetric flask. 10ml of 5% potassium permanganate and 10ml of 30% H₂O₂ was added and allowed to stand over a hot water bath for 30min. 2ml of 40% sodium sulphate was added. This was made up to 50ml mark and the absorbance was measured at 510nm using a spectrophotometer (Achikanu *et al.*, 2013).

Determination of Vitamin B6

Determination of Vitamin B6 (pyridoxine hydrochloride). Twenty milligram of 60 ml of liquid samples of cashew apple juice was added into a 125 ml Erlenmeyer flask, filtered and degassed by sonicating for five minutes. A 10 ml aliquot of the degassed sample was placed in each of five 100 ml volumetric flasks which were then made up using 0.1 N HCl after which absorbance was measured at 290 nm (Achikanu *et al.*, 2013).

Determination of Vitamin E

1.0 g of the cashew apple juice sample was weighed in a 100 mL flask fitted with a reflux condenser, then 10 mL of absolute alcohol and 20 mL of 1M alcoholic sulphuric acid were added. It was then refluxed for 45 minutes and cool. 50 mL of water was added and transferred to a separating funnel of low actinic glass with further addition of 50 mL of water. The unsaponifiable matter was extracted with 30 mL diethyl ether five times. The combined ether extract was washed (free from acid) and dried over anhydrous sodium sulfate. The extract was evaporated at a low temperature to protect it from being denatured. The residue was dissolved in 10 mL absolute ethanol and both the standard and the sample were transferred to a 20 mL volumetric flask, 5 mL of absolute ethanol was added, followed by 1 mL concentrated nitric acid. The flask was placed in a water bath at 90°C for 3 minutes and passed under running water to cool. It was then made up to the volume 20 mL with absolute ethanol. The absorbance was read at 470 nm against a blank containing absolute ethanol. Person (1975).

Microbial analysis for cashew apples (*Anacardium occidentale*) juice

Total bacteria, moulds and coliform, were analyzed separately by spreading technique. 1 mL of homogenized cashew apple juice was mixed with 9 mL of sterile peptone salt (LOBA Chemie, India) and was shaken uniformly by rotation and tilting the tube. Then, 1 mL of the suspension was transferred into the peptone salt diluents (9 mL) up to 10-10 dilution series. From each dilution, 1 mL of diluted sample was inoculated into the respective growth medium: total bacteria (plate count agar), yeast and mould (potato dextrose agar), and coliform (violet red bile agar). The incubation conditions were bacteria (30° C, 24 h), mould and yeast (37° C, 72 h), and coliform (30° C, 48 h). Microbiological analyses. The total yeast, coliform and bacterial counts were carried out using the Potato dextrose agar (PDA), Violet red bile lactose agar (VRBL) and Plate count agar (PCA) media respectively (Olorunjuwone *et al.*, 2014).

Total yeast count

Potato Dextrose Agar (PDA) (4.2g) was dissolved in 100mL of distilled water. It was autoclaved at 121 C for 1 h in an electric pressure steam sterilizer (Model No.25X) and allowed to cool to about 45 C. The work environment was sterilized with 70% alcohol. 1mL of each sample was pipetted into labelled petri-dishes with the use of a micro pipette (Gilson Pipetman, 060087N). The medium (PDA) was poured into the Petri dish and agitated gently to homogenize with the sample. This solidified and formed a gel in the Petri dish. It was then incubated (DHP-9050) at 37 C for 24 h. After 24 h, the total yeasts were counted as colony forming units (CFU).

Total bacteria count

2.4g of Plate Count Agar (PCA) was dissolved in 100mL of distilled water. It was autoclaved at 121 C for 1 h in an electric pressure steam sterilizer (Model No.25X) and allowed to cool to about 45°C. The work environment was sterilized with 70% alcohol. 1mL of each cashew apple juice sample was pipetted into labelled petri-dishes with the use of a micro pipette (Gilson Pipetman, 060087N). The medium (PCA) was poured into the Petri dish and agitated gently to homogenize with the sample. This solidified and formed a gel in the Petri dish. It was then incubated (DHP-9050) at 37 C for 24 h. After 24 h, the total bacteria were counted as colony forming units (CFU).

Total coliform count

Violet Red Bile Lactose Agar (VRBL) (6.2g) was dissolved in 150 mL of distilled water. This solution was allowed to boil while shaking over a Bunsen burner flame until it was completely dissolved. It was then allowed to cool to about 45 C. The work environment was sterilized with 70% alcohol. One millilitre (1mL) of each sample was pipetted into labelled petri-dishes with the use of a micro pipette (Gilson Pipetman, 060087N). The medium (VRBL) was poured into the Petri dish and agitated gently to homogenize with the sample and allowed to set. More of the medium was poured to prevent entry of Oxygen. The solidified gel was then incubated (DHP-9050) at 42 C for 24 h. After 24 h, the total coliforms were counted as colony forming units (CFU).

Sensory evaluation of cashew apples (*Anacardium occidentale*) juice

The sensory evaluation took place in a well-ventilated room, ensuring a suitable environment for accurate assessments. Panelists were instructed to refrain from smoking, snacking, or chewing gum for at least 20 minutes prior to the evaluation session. The samples were served at ambient temperature and presented in transparent cups. Each sample was assigned a three-digit random code to prevent any bias in evaluation. To avoid order effects, the samples were presented to the panelists in a randomized sequence. Panelists were provided with portable water to rinse their mouths before and between testing different samples. A designated sheet was given to the panelists to record their evaluated results (Iwe, 2002). The sensory attributes were evaluated on the first day and at 7-days intervals for each storage time point up to 14 days.

Determination of shelf-life stability of cashew apples (*Anacardium occidentale*) juice

Shelf-life study of pasteurized cashew apple juice was studied at refrigerating temperatures of each pasteurized sample. At each analysis, 3 bottles were collected for

analysis of each interval. The quality parameters of the juices monitored during the storage were microbial growth, pH, vitamin-C, Titrable acidity and sensory attributes for a 2-weeks period.

Statistical analysis

This study was carried out using a two factor (2×3) factorial design, with two factors A and B representing method of processing and varieties respectively. The two factors for method of processing was fresh and pasteurized (75°C) while varieties was represented by pink, yellow and red. Analysis of variance (ANOVA) was applied using a Response surface methodology (design expert) version 13 with the central composite design. Statistical analysis was conducted using version 21 of the SPSS statistical software. A two-way analysis of variance (ANOVA) was employed to perform the statistical comparisons, with P values < 0.05 considered significant.

RESULTS AND DISCUSSION

Chemical properties of cashew apple (*Anacardium occidentale*) juice from different cashew varieties

Results of the chemical analyses of cashew apple juice showing the physico-chemical are presented in (Table 3). Generally, the values varied non significantly ($p < 0.05$) with varieties and method processing.

pH

The pH value of the various samples of the juice are shown in (Table 3) ranged from 5.50 for sample FPJ900 (fresh pink juice) to 5.90 for sample FRJ904 (fresh red juice) indicating a non-significant ($p < 0.05$) difference in the pH values of the different cashew juice varieties. These values also showed the absence of fermentation that gives a grossly reduced pH and a characteristic sour taste and aroma, thereby making the juice very suitable for both industrial production and consumers' consumption (Dziedzoave *et al.*, 2005). For sample FPJ900 (fresh pink juice), FYJ 902 (fresh yellow juice) and FRJ 904 (fresh red juice) the pH values were higher in these fresh samples than those of sample PPJ 901 (pasteurize pink juice), PYJ903 (pasteurize yellow juice) and PRJ 905 (pasteurize red juice) being their respective pasteurize forms, this may mean that the thermal processing (pasteurization) applied on the latter samples lowered the pH of these samples, the same were observed by Nkechi *et al.* (2020). The pH values of freshly extracted juice and the pasteurized samples showed slight acidity among the samples depending on the variety (pink, yellow and red) with the fresh samples showing more acidity than the pasteurized samples. Values are means \pm standard deviation of duplicate determination. Means with different superscripts in the same column are significantly different ($p < 0.05$).

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The low pH for the fresh juices shows the high acid strength of the cashew apple at a fresh state whereas pasteurization at 75°C weakened the strength by causing a slightly raised pH Ndife *et al.*, (2013) observed a reduced pH leading to an increased acidity value of different varieties of orange. The pH in the fruit pulp plays an important role in flavour promotion as well as a preservation factor, (Saeed *et al.*, 2010). As the fruit matured, the pH was increased and contributed less acidity to the cashew apple juice. While, when concentration increased, the acidity increased due to the increase in hydrogen ions present in the solution. Hydrogen ions determined the degree of acidity. As the concentration of hydrogen ions were reduced, so it was expected pH value to increase. Fruit pH increases at the high rate of respiration by accelerated acid metabolism and accumulated cations. The pH values obtained also reflected a significant extent to the microbial stability of the various cashew apple juice varieties Wardy *et al.* (2009). This is in agreement with the report of Ndife *et al.* (2013), who observed a reduced pH leading to an increased acidity value of different brands of orange juice. Fruit juices generally have low pH because they are comparatively rich in organic acid.

Total titratable acidity (TTA)

Total titratable acidity (TTA) of the cashew apple juices ranged from 0.21% for sample FRJ904 (fresh red juice) to 0.38% for FPJ900 (fresh pink juice) (Table 4.1). The result shows no level of significant difference ($p > 0.05$) in the juice varieties. This result also implies that the fruit used were at their optimal maturity stage. This is due to the fact that as the maturity and ripening of the fruit peaks, the acidity in the fruits becomes lower. In this study, the titratable acidity (TTA) found in the cashew apple juice varieties corresponds with that reported by (Adou *et al.*, 2012). Ranging from 0.20% - 8.5%. The difference of the total titratable acidity between the cashew apple juice fresh varieties juices (FPJ 900, FYJ 902 and FRJ 904) and Pasteurized juices from cashew apples (PPJ 901, PYJ 903 and PRJ 905) show a very slight difference with no significance different at ($p > 0.05$). From the result of the analysis above the pink variety of cashew seems to have a higher titratable acidity (TTA) than the yellow and red variety. Reduction in titratable acidity (TTA) of the pink and red varieties of cashew apple juice could be due to degradation of citric acid due to increased activity of citric acid glyoxylase during ripening while reduction in acidity may be due to their conversion into sugars and their further utilization in metabolic processes like respiratory climacteric in the fruit. These results were in agreement with those obtained by Rathore, *et al.*, (2007); Doreyappa-Gowdaad Huddar, (2001). Decrease in total acidity and increase in total sugars and Total Soluble Solids (TSS) during storage at room temperature was also reported recently by Policegoudra and Aradhya (2007) in mangoes. It has been suggested that during storage, fruits utilize

Table 3: Chemical property of fresh and pasteurized cashew apple juice from different varieties

Variety	Method of processing	Sample	pH	TTA (%)	Colour	TS (mg/l)	TSS (⁰ Brix)	SG	TSS/TTA
Pink	Fresh	FPJ 900	5.50 ^a ±0.14	0.38 ^a ±0.00	1.74 ^a ±0.21	4.60 ^a ±0.00	43.50 ^b ±0.71	1.05 ^a ±0.00	114.47
	Pasteurized	PPJ 901	5.60 ^{ab} ±0.00	0.35 ^a ±0.00	1.82 ^a ±0.01	4.58 ^a ±0.00	25.50 ^c ±0.71	1.04 ^a ±0.01	72.86
Yellow	Fresh	FYJ 902	5.75 ^{ab} ±0.07	0.25 ^b ±0.00	1.66 ^c ±0.01	4.21 ^b ±0.07	15.50 ^d ±0.71	1.05 ^a ±0.00	62.00
	Pasteurized	PYJ 903	5.55 ^{ab} ±0.07	0.24 ^b ±0.02	1.64 ^c ±0.01	3.98 ^b ±1.14	8.50 ^e ±0.71	1.05 ^a ±0.01	35.42
Red	Fresh	FRJ 904	5.90 ^c ±0.00	0.21 ^b ±0.02	1.69 ^b ±0.01	3.98 ^c ±0.14	47.00 ^e ±0.00	1.04 ^a ±0.02	223.81
	Pasteurized	PRJ 905	5.50 ^b ±0.14	0.22 ^b ±0.0	1.68 ^{bc} ±0.01	2.01 ^c ±0.00	43.50 ^b ±0.71	1.05 ^a ±0.05	197.73

organic acids for metabolic activities and this results in a decrease in the Titratable acidity content during the storage periods. They reported the decrease in acidity coincided with an increase in sugar concentration in the pomegranate fruits. Kulkarni and Aradhya (2005) suggested that a slow decrease in acidity, concomitant with increased Total Soluble Solid (TSS) and total sugar content, is an intrinsic process during ripening of fruits to impart the flavour. During ripening, organic acids are respired or converted to sugars and acid levels decline (Fernando and De Silva, 2000). The Total Soluble Solid (TSS) and acid content are the factors influencing consumption quality (Joomwong, 2006).

Total Soluble Solid

Total Soluble Solid (TSS) of cashew juice varieties varied from 8.5⁰ Brix to 47⁰ Brix for sample PYJ 903 and FRJ 904 respectively (Table 3). The Analysis of Variance (ANOVA) shows a no significant difference in the different varieties of cashew apple juice ($P>0.05$). This may be attributed to soil nature and climatic conditions. This high content of soluble solids causes turbidity in the juice and can be related to a high presence of nonstructural sugars that can be highly solubilized in water during the juice elaboration. For sugar content as noted by several other authors, glucose, fructose and sucrose are the major sugars found in apples (Wallrauch and Faeth, 1988; Fuleki *et al.*, 1994) and especially in the cashew apple (Sivagurunathan *et al.*, 2010). Total Soluble Solid (TSS) content of fruit is related to the different levels of fruit maturation. Total Soluble Solid (TSS) is an important quality factor for many fruits during ripening. The soluble solids content is also used as an indication of fruit maturity and quality. Senescence is enhanced by increasing sugar content in fruits. Soluble solids are also known to impact sweetness index than does the total sugars. Unlike findings from Naka *et al.* (2015), who reported that the Total Soluble Solids (TSS) content between the red and yellow variety, in his analysis, it was revealed that the yellow variety was higher (14.40) than the red variety which was (9.66) and none was reported for the pink variety of cashew. TSS has a strong implication on the choice of fruit for processing as well as fresh consumption, Total Soluble Solid (TSS) of 15⁰C Brix and above at ripe stage is recommendable for products like fruit juices, nectar and jam products. TSS of 16⁰Brix and above is suitable for wine processing. Wine varieties

had an average TSS of 14⁰Brix, best for processing products of low sugar content and sour taste like mango chutney, mango powders, and canned mango bits that are preserved in cane sugar. The variability in total soluble solids of different varieties at different stages of maturity is attributed to the alteration occurring in structure during ripening processes at various hydrolytic processes enzymatic instigated breakdown complex carbohydrates to smaller ones like sucrose, glucose and fructose (Saeed *et al.*, 2009; Rathore *et al.*, 2007). The values for total solids obtained in this study are much higher than results obtained by other researchers: 11.75–17.53% for 100% pineapple juice (Ohwesiri *et al.*, 2016), 7.22–9.28% for cocktail juices (Adubofuor *et al.*, 2010) and 5.50–11.80% for different brands of orange juice samples (Ndife *et al.*, 2013). It was higher in the orange based juices than in the lemon in line with reports from Nelofer *et al.* (2015). The variations observed could be attributed to the difference in the fruit type used (Ohwesiri *et al.*, 2016). The Federal Institute of Industrial Research, Oshodi, (FIIRO) reported that the differences in production processes may explain most differences observed in juice composition and quality (FIIRO, 2005).

Total Sugar

The levels of total sugar determined in this present study are higher than those found by some authors in their respective regions. Thus, Wu *et al.* (2007) reported 125.0 g/L and Sivagurunathan *et al.* (2010) up to 151g/L and 143 g/L respectively in the yellow and red apples juices. Concerning the three sugars study, fructose is the predominant sugar compared to glucose and sucrose and this is consistent with the work of Wu *et al.* (2007) who found that fructose was more abundant in the apple juice followed by glucose. During fruit ripening and softening process, starch is broken down to the simple soluble sugars and also the amount of soluble pectin will increase, leading to fruit softening. During cashew apple fruit development, glucose and fructose were the predominant sugars until six weeks before harvesting sucrose begin to accumulate rapidly and ultimately exceeded the glucose and fructose concentration. Glucose and fructose remained relatively constant throughout development. The solids included soluble sugars sucrose, glucose and fructose as well as acids.

The total sugar content varied among the three different

varieties of cashew apple juice. The mean values obtained ranged from 2.01mg/l as obtained in sample PRJ 905 to 4.60mg/l to 4.60mg/l obtained in sample FPJ 900 as the highest and maximum value. These variations may be attributed to their differing varieties, environmental conditions, genotypic factors as well as the hydrolysis of their various polysaccharides into simple sugar during ripening of the fruit (Naka *et al.*, 2015).

The type of sugars involve are glucose, fructose and sucrose as they have been reported as the major sugar found in cashew apples (Sivagurunathan *et al.*, 2010 and Adou *et al.*, 2012). The total sugar showed a non-significant difference among the different cashew apple juice varieties at ($P>0.05$) and also showed a non-significant difference between the fresh samples (FPJ900, FYJ 902 and FRJ 904) and the pasteurized samples (PPJ 901, PYJ903 and PRJ 905).

Specific gravity

The Specific gravity (SG) of the cashew apple juice ranging from 1.04 in sample FPJ901 and sample FRJ904 to 1.05 in sample FPJ900, PYJ902 and PRJ 905 respectively. The result shows that there was no significant difference in the Specific gravity (SG) among the different varieties of cashew apple juice ($P<0.05$). Specific gravity of young cashew apples range from 1.04 to 1.15. Ripe apples have specific gravity less than one (Augustin and Unnithan, 1982; Kutty, 2000).

Sugar: Acid ratio (TS/TTA)

TS/TTA ratio: The sugar: acid ratio gives accurate information on sugar- to-acid ratio balance in the fruit. It increased with increase in ripeness. The lowest was exhibited by the pasteurized Yellow cashew apple juice variety (sample PYJ 903) with a mean value of 35.42 and the highest mean was 223 by the red cashew Apple juice varieties (sample PRJ 905) at the well ripen stage of ripeness. Fruits high in this ratio of up to 200 are said to be of high quality due to sweat taste of well balance sugar and acid whereas those with below 100 are of low quality due to a higher sour taste high (acid ratio), (Hafar *et al.*, 2011). The sugar: acid ratio was found to be greatly influenced by the fruit variety and stage of ripeness.

Color

Color is considered one of the most important external factors for the quality of cashew apple, as they are mainly marketed as fresh fruits, and the visual aspect of the product is considered an index of quality and maturation. However, skin maturation or morphological maturation always coincide with juice maturation in cashew apple juice grown in warmer tropical regions. In addition, cashew is harvested based on its internal quality (edibility), and skin changes which always describe best harvest times

(Srilakshmi, 2010). The colour of samples FPJ900, PPJ 901, FYJ 902, FYJ 903, FRJ 904, PRJ 905 did not record much changes but they maintained a bright white colour during storage. This maintenance of colour could be attributed to the pasteurization and the preservative effects on the juice samples which inactivated enzyme browning in the juice, which could have led to dis-colouration of the cashew apple juice. There was no significant difference at ($p>0.05$) in all samples recorded.

Proximate composition of cashew apple juice

Fruits and vegetable are known as high rich diet in food nutrient and in protection of age related illnesses and cancers (Willett, 2001 and Zafra *et al.*, 2007). The consumption of fruit is truly encouraged as nutrient present therein are consumed fresh, thus minimizing losses. Generally, the fruits juices had low lipids, fibre and protein contents. From the results on table 4.2, the moisture contents of the juices were very high irrespective of their varieties, with PPJ 901 (Pasteurized pink juice) having the least value (91.92). The different juice varieties had the following moisture content in each sample FRJ 904 (fresh red juice) (94.51)%, PRJ 905 (pasteurize red juice) (93.44)%, PYJ903 (pasteurized yellow juice) (93.27)%, FYJ 902 (fresh yellow juice) (93.11)%, FPJ 900 (fresh pink juice) (92.60)% and PPJ 901 (pasteurized pink juice) (91.92)% in its decreasing order. There was a non-significant different difference ($p>0.05$) among the cashew varieties of the juice. The high moisture content encouraged greatly the high microbial action which led to high perishability of the juice product by aiding microbial and enzymatic spoilage of the cashew apple juice. The results of Moisture content agreed with those obtained by Othman, *et al.*, (2009) for another succulent and high moisture fruit, who analyzed Dodo and Virige mango varieties grown in Morogoro, Tanzania found that they had a moisture content ranging from 56.3- 96.1%.

Ash content

The ash content of the different cashew juice varieties was very low. It ranged from 0.07 in sample FYI 902 to 0.009% in sample PPJ 901 which had the highest value in ash content as shown in (Table 4). The low ash content indicates low inorganic components of the fruits which are mainly minerals. They serve as co-factors of enzyme catalyzing important biochemical reactions in the body, thus contributing significantly to the general well-being of the body. Ash was found to have no defined pattern of behavior with increasing ripeness. Ash content gives a measure of the total amount of inorganic compounds like minerals present within the cashew apple fruit. This is influenced by variables like soil composition and climate condition of the area of growth, the variety/ breed and level of farm management practices (tree and soil management especially fertilizers added during planting), thus the

Table 4: Proximate composition of cashew apple juice.

Variety	Method of processing	Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy value (Kcal)
Pink	Fresh	FPJ900	92.60 ^d ±0.08	0.07 ^b ±0.01	6.25 ^a ±0.03	0.08 ^a ±0.01	1.01 ^c ±0.04	60.61
	Pasteurized	PPJ901	91.92 ^a ±0.08	6.25 ^{ab} ±0.03	6.74 ^a ±0.08	0.06 ^{ab} ±0.00	1.20 ^{bc} ±0.01	65.70
Yellow	Fresh	FYJ902	93.11 ^c ±0.04	0.07 ^b ±0.00	5.32 ^b ±0.21	0.06 ^b ±0.01	1.45 ^{ab} ±0.15	53.92
	Pasteurized	PYJ903	93.27 ^{bc} ±0.08	0.08 ^{ab} ±0.01	6.27 ^a ±0.10	0.06 ^{ab} ±0.00	0.32 ^b ±0.03	57.95
Red	Fresh	FRJ904	94.51 ^a ±0.05	0.12 ^a ±0.02	3.85 ^d ±0.18	0.05 ^b ±0.01	1.47 ^{ab} ±0.13	40.73
	Pasteurized	PRJ905	93.44 ^b ±0.15	0.12 ^a ±0.01	4.55 ^c ±0.36	0.05 ^b ±0.00	1.85 ^a ±0.23	48.55

Values are means ± standard deviation of duplicate determination. Means in the same column followed by different superscripts are significantly ($p < 0.05$) different.

variability observed. Ash content of the three varieties of cashew apple juice used in this study was found to be lower than those obtained from juices from other fruits like oranges ($0.68 \pm 0.06/100\text{g}$, Mbogo et al., 2010).

Crude fat

The fat content as displayed in (Table 4) ranged between 3.85% in sample FPJ 904 to 6.74% in sample PPJ 901 as the highest value. Fat occurred in small increasing amounts in all samples analyzed. There was no significant difference at $p > 0.05$ among the cashew apple variety. The highest content was 6.74% which was statistically not different at $p > 0.05$ from 3.85% which was the lowest. Fat promotes the absorption of fat soluble vitamins in our diet. This result on the crude fat content of this analysis did not align with work of Umar and Birnin-Yauri (2005) whom reported the fat content of cashew apple to be 0.5%.

Crude protein

The protein content for FPJ900 (0.08)%, PPJ 901 (0.06)%, FYJ 902 (0.06)%, PYJ 903 (0.06)%, FRJ 904 (0.05)%, PRJ 905 (0.05)%. There was no significant difference among the cashew varieties at $P > 0.05$. There was also a significant difference among the fresh and pasteurized samples at $P > 0.05$ (Table 4). Protein refers to organic compound with complex structural organization consisting of amino acid linked into a chain called peptide bond. The nutritive value of food is determined by its protein content. The results are in agreement with finding made by Gomez-Lim, 1997; Mamiro, et al., 2007; Mathooko, 2000, who attributed it to dramatic increase in the enzymes required for ripening, the proximate composition of the mango varieties studied was within limits (Mamiro, et al., 2007; Doryappa, et al., 1994) and was mainly influenced by the variety and stage of maturity rather than ecological zone of origin. The result of this analysis is in line with Cashew apple contains protein (0.5–1.09%) although in very minute quantities as established by Singh et al. (2019).

Carbohydrate

The carbohydrate content of any food product determines its energy producing substances. The carbohydrate content in the cashew apple juice was relatively low. Table 4 showed the following values for carbohydrate FPJ 900

(1.01)%, PPJ 901 (1.20)%, FYJ902 (1.95)%, PYJ 903 (0.32)%, FRJ904 (1.47)%, PRJ905 (1.85)%. There were no significant difference among the cashew varieties at $P > 0.05$. This result is not consistent with that reported by Jeremiah, (1992) and Adam et al. (2011) reported that, Terminaliacatappa fruits contains of 38.32% carbohydrate while Colocynthiscitrullus has 11.89% carbohydrates; but in line with reported value by Morton, (1987) for Mango pulp which ranged between (16.2-17.8g) respectively. This makes it a good calorific option for use in fruit juices or meals for children, the convalescent and the elderly as a source of energy.

Vitamin analysis of cashew apple (*Anacardium occidentale*) juice

Table 5 shows the levels of ascorbic acid (vitamin C), Vitamin A, Vitamin B2, Vitamin B6 and Vitamin E of cashew apple juice. These levels range from 14.31 mg/100 g in FRJ 904 to 23.73 mg/100 g in FPJ900. Comparison of these levels shows a no significant variation ($P > 0.05$).

Vitamin C

The level of ascorbic acid (vitamin C) of cashew apples juices confirm the trend in vitamin C of cashew apple juice as shown by several authors (Morton, 1987; Moura, 1998; Akinwale, 2000; Azam and Judge, 2001). Unlike studies of some authors, who concluded that the colour did not influence the vitamin C (Assunção and Mercadante, 2003; Lowore and Agyente, 2009), in the present study the colour has an influence on this level. The pink cashew apples juices had the highest levels of vitamin C (Table 5) and this is consistent with the conclusions of the authors raised. In addition, levels of vitamin C in this study are significantly lower than those found by Morton (1987) which is 372 mg/100 g, and that of Lowore and Agyente (2010) which vary between 206.2 and 268.6 mg/100 g. Lower levels in this study could be explained by these facts. Pasteurization of cashew apple juice at a temperature of 75°C must have caused a breakdown of Vitamin C content of the juice, the majority of dosages of vitamin C were carried out by titration (AOAC, 2005) while the method used in this study is the high performance liquid chromatography (HPLC and AOAC, 2005) which is more sensitive and better quantifies the item determined (Wimalasari and Wills, 1983), the medium used in the

Table 5: Vitamin analysis of cashew apple (*Anacardium occidentale*) juice.

Variety	Method of processing	Sample	Vitamin C (mg/100 g)	Vitamin A (RAE)	Vitamin B2(mg/100ml)	Vitamin B6 (mg/100ml)	Vitamin E (mg/100ml)
Pink	Fresh	FPJ900	23.73 ^a ±1.01	16.17 ^a ±0.00	2.26 ^a ±0.11	43.09 ^b ±2.88	11.30 ^a ±0.04
	Pasteurized	PPJ901	25.76 ^a ±0.00	9.85 ^a ±0.00	2.38 ^a ±0.03	28.30 ^b ±0.15	9.32 ^c ±0.27
Yellow	Fresh	FYJ902	20.04 ^b ±0.98	8.23 ^a ±0.00	2.33 ^a ±0.06	45.25 ^a ±0.19	19.58 ^b ±0.08
	Pasteurized	PYJ903	23.05 ^a ±0.00	2.55 ^b ±0.00	2.40 ^a ±0.01	28.14 ^b ±0.07	12.12 ^c ±0.19
Red	Fresh	FRJ904	14.31 ^c ±0.14	2.55 ^b ±0.01	0.56 ^b ±0.01	12.19 ^c ±0.00	15.77 ^b ±0.44
	Pasteurized	PRJ905	17.74 ^b ±1.00	0.064 ^a ±0.00	0.48 ^b ±0.00	2.65 ^a ±0.01	10.29 ^a ±0.09

Values are means ± standard deviation of duplicate determination. Means with the column followed by different superscripts are significantly (P<0.05) different.

stabilization of vitamin C in the sample of juice was citric acid, unlike other assays using 6% meta-phosphoric acid. Albuquerque *et al.* (2005) have shown through their study that citric acid was a better stabilizer of vitamin C. But first of all, these figures reveal the richness in vitamin C of cashew apples juices studied. The biological functions of vitamin C are numerous in the body, based on available biochemical, clinical, and epidemiological studies, the current recommended daily acceptance (RDA) for ascorbic acid is suggested to be 100mg–120 mg per day to achieve cellular saturation and optimum risk reduction of heart diseases, stroke and cancer in healthy individuals (Naidu, 2003). Vitamin C plays a relative role in the immune system, the biosynthesis of collagen, iron absorption and inhibition of the formation of nitrosamines (Vannuchi and Jordão, 1998). Its antioxidant property is associated with reduced cancer incidence in the body (Lupulescu, 1990; Lupulescu, 1993). Moreover, these high levels are an important asset for the preservation of vitamin C during the heat treatments such as pasteurization, despite his state of thermolability (Walingo, 2005).

The high values Vitamin C content in the samples above is an indication that cashew apple juice is known to be a good antioxidant and keeps cells healthy against free radicals, specifically for delaying osteoblast ageing as well as monitoring diabetic progression. Ascorbic acid is highly susceptible to oxidative destruction at ambient temperatures, Ishtiaq *et al.*, (2010) as well as freezing temperatures; this did not affect the high level in vitamin C with ripening and storage. Vitamin C is a precursor component in nutrition. It helps the body develop resistance against infectious agents and it is an excellent antioxidant against cancerous agents. Vitamin C is an essential component in human diet required for prevention of scurvy, presents biological functions in collagen formation, inorganic iron absorption, inhibition of nitrosamine formation and immune system enhancement. It acts as an antioxidant protecting the body against oxidative stress related diseases (Padayatty *et al.*, 2003). Vitamin C plays an antioxidant role and possesses several health benefits (May and Qu, 2005). Ascorbic acid is used not only to fortify food and losses during processing, but also contributes to the product stability and appearance (Tasnim *et al.*, 2010). This study revealed that, the vitamin C content ranged from 14.31-25.86 mg/mL (Table 5), which are fairly higher than those reported by Cook (2009) for water melon juice and can meet the Recommended

Daily Intake as reported by (Adedeji *et al.*, 2014). This is of great health importance and indicates that the juice can successfully been used in vitamin C deficiency and scurvy (Edem and Miranda, 2011). The consumption of vitamin C has also been reported to improve the rate of transformation of cholesterol, to prevent cancers and disorders associated with a lack of collagen (May and Qu, 2005).

B vitamins

Vitamin B has been suggested to elucidate a possible therapeutic potential in the treatment and management of peripheral nerve injury (Nedeljkovic *et al.*, 2018). Values obtained for vitamin B6 were found to be the highest compared to other vitamins that were analyzed (Vitamins B2 - riboflavin). There is the premise that vitamin B6 (Pyridoxine) levels, when increased can proferneuroprotective effects (Hwang *et al.*, 2007). FYJ902 (Fresh Yellow Juice) was found to have the highest content of vitamin B6 (45.25mg/g) while the two other species and fresh pink (FPJ900) and fresh red juice (FRJ904) contained 43.09 and 12.19mg/g respectively. In summary for Vitamins, the Fresh yellow variety (FYJ902) has the highest contents of Vitamins (B6 and E) (Table 5). Although in the recommended dietary allowance for vitamins, vitamin B3 is required more than other vitamins. Supplementation of vitamin B3 with essential dietary antioxidants may help to reduce the damage caused by free radical toxicity in diabetes mellitus (Abdullah *et al.*, 2018). Unhealthy diets which lack vitamins are an important cause of malnutrition. They are now responsible for more adult deaths and disability than alcohol and tobacco use (WHO, 2018). Unlike fat soluble vitamins, B complex vitamins are water soluble and are not stored in the body and should therefore be adequately available in the diet. Correct application of vitamins can achieve significant clinical therapeutic efficacy, which is of great significance for the maintenance of human health (Du, Zhang and Du, 2018). There was no significant difference (P>0.05) between the cashew apples varieties and pasteurization had no effect on B vitamins.

Vitamin A

Vitamin A which is a precursor obtained from the determination of beta-carotene in this study, beta-carotene which is utilized in the human body as vitamin A (Ross,

1999). It varied between 0.064 mcg/RAE in sample PRJ905 (pasteurized red-apple juice) to 16.17mcg/RAE in sample FPJ900 (fresh pink juice) (Table 5). This result also showed that cashew apple is very rich in vitamin A which is very good for vision enhancement, among the different varieties, yellow variety was the highest in-terms of quantity of Vitamin A present. Comparison of these levels shows a no significant variation ($P>0.05$) among the cashew apples varieties.

Vitamin E

Vitamin E also showed a high quality in all the samples analyzed which ranged from 9.32 in sample 19.58 (pasteurized pink juice) to 19.58 in sample FPJ900 (fresh pink juice) (Table 5). Comparison of these levels shows a no significant variation ($P>0.05$) among the cashew apples varieties.

Phyto- chemical analysis of cashew apple (*Anacardium occidentale*) juice

Phytochemicals are plant chemicals that possess varying degrees of therapeutic activities (Omorieg and Osagie, 2012) and may display their health protective effects in diverse ways. They can act as antioxidants (polyphenols, carotenoids) and protect cells against free radical damage (Omorieg and Osagie, 2012). They also have antibacterial, antimalarial (alkaloids), anti-tumour and antiviral (tannins) properties (Dua *et al.*, 2013). The presence of these phytochemicals in the juices gives them some nutraceutical characteristics (Lawal *et al.*, 2013). Table 6 shows the different phytochemical analyzed in this study.

Result for sugar analysis of cashew apple (*Anacardium occidentale*) juice

Glucose

The result in (Table 7) shows that cashew apple is predominantly rich in fruit sugars especially glucose in all its varieties which ranged from 22.21(g/l) in sample PYJ903 (pasteurized yellow juice) to 45.05(g/l) in sample FYJ902 (Fresh yellow juice). According to Kallioet *al.* (2000) who also determined higher concentrations of glucose in juices of different strawberry varieties ranging from 18.9 g/L in juice of Senga VP. in 1998 to 45.2 g/L in juice of Polka, 1997, this research showed an even much higher glucose range and was not significantly different at ($P >0.05$). Although, Lundahl *et al.* (1989) achieved a considerably lower concentration of glucose in strawberry juice 11.8 g/L.

Fructose

From the result in (Table 7), fructose content ranged from

3.41(g/l) in sample FYJ902 (Fresh yellow juice) to 30.57(g/l) in sample PRJ905 (pasteurized Red Juice). According to Stój and Targoński, (2005), in his analysis contents of fructose in strawberry juices ranged from 18.61 g/L in juice of Ducat to 36.63 g/L in juice of Marmolada which was higher than that reported in this analysis, the low level of fructose as reported by this analysis may have been due to hydrolysis during the preparation of juices, due to pasteurization. However, Lundahl *et al.* (1989) determined less fructose in strawberry juice (13.5) g/L.

Sucrose

From the result in (Table 7), sucrose content ranged from 16.11 g/l in sample PRJ905 (pasteurized Red Juice) to 16.73 g/l in sample PYJ903 (pasteurized yellow juice) and FRJ904 (Fresh Red Juice). This result also indicated a no significantly different at ($P >0.05$). According to Stój and Targoński, (2005) in his analysis of strawberry ranged from 0.16 g/L in 1999 to 4.19 g/L in 2000 which was very much lesser than that analyzed in this study. The absence or low concentrations of sucrose in raspberry juices examined by Durst *et al.* (1995) as well as by Spanos and Wrolstad, (1987) might result from its hydrolysis during the preparation of juices, due to pasteurization and concentration of juices at high temperatures, which then were diluted and analyzed for sucrose content.

Result for organic acid analysis of cashew apple (*Anacardium occidentale*) juice

Organic acids are naturally found in fruits as the product of metabolic processes, biochemical, hydrolysis, and bacterial growth. They have a vital role in the quality and nutritional value of foods, significantly contribute to the organoleptic properties, chemical and microbiological stability of different foods and beverages, and act as emulsifier, acidity regulators, and antioxidants (Silva *et al.*, 2018). Organic acid content is an important indicator of the flavor and nutritional quality of the fruits. Malic and citric acid were the major organic acids in the berry species (Mikulic-Petkovsek *et al.*, 2012). Also, these acids were the main organic acids in fruits of citrus, apple, pear, and nectarine and their contents decreased in mature fruits (Zhao *et al.*, 2007; Huo *et al.*, 2009; Zhang *et al.*, 2010; Mu *et al.*, 2018).

In Juices, Organic acids play important roles in juices due to their effect on the flavor, taste, and organoleptic qualities, stability, and microbiological control of the products. They are a suitable index of authenticity in fruit products due to their lower susceptibility to alteration in processing and storage stage comparing with other fruits components (Cunha *et al.*, 2002; Chen *et al.*, 2013; Talekar *et al.*, (2013). The most abundant organic acids in juices are citric, malic, and ascorbic acid. The predominant content of malic acid is in cherry, grape, and apple juices; citric acid in citrus, pineapple, and black currant juices;

Table 6: Phyto- chemical analysis of cashew apple (*Anacardium occidentale*) juice.

Variety	Method of processing	Sample	Tannins (g/100g)	Phenol (g/100g)	Carotenoids (g/100g)
Pink	Fresh	FPJ900	0.14 ^b ±0.00	1.37 ^b ±0.02	96.81 ^a ±2.68
	Pasteurized	PPJ901	0.13 ^{bc} ±0.01	1.40 ^{ab} ±0.01	58.98 ^b ±2.69
Yellow	Fresh	FYJ902	0.17 ^a ±0.00	1.21 ^c ±0.01	49.30 ^c ±0.00
	Pasteurized	PYJ903	0.16 ^a ±0.00	1.50 ^a ±0.02	38.00 ^d ±0.00
Red	Fresh	FRJ904	0.12 ^{cd} ±0.01	1.04 ^d ±0.02	15.26 ^e ±0.01
	Pasteurized	PRJ905	0.10 ^d ±0.00	0.88 ^e ±0.01	3.86 ^f ±0.01

Values are means ± standard deviation of duplicate determination. Means in the same row followed by different superscripts are significantly ($p < 0.05$) different.

Table 7: Result for sugar analysis of cashew apple (*Anacardium occidentale*) juice.

Variety	Method of processing	Sample	Glucose (g/l)	Fructose (g/l)	Sucrose (g/l)
Pink	Fresh	FPJ900	30.48 ^b ±0.42	11.46 ^c ±0.63	16.30 ^b ±0.08
	Pasteurized	PPJ901	30.48 ^b ±1.16	11.26 ^c ±0.08	16.71 ^a ±0.01
Yellow	Fresh	FYJ902	45.05 ^a ±0.86	3.41 ^e ±0.13	16.70 ^a ±0.42
	Pasteurized	PYJ903	22.21 ^c ±1.58	8.55 ^d ±0.13	16.73 ^a ±0.07
Red	Fresh	FRJ904	31.23 ^b ±0.57	16.23 ^b ±0.13	16.73 ^a ±0.57
	Pasteurized	PRJ905	32.21 ^b ±0.57	30.57 ^a ±0.13	16.11 ^b ±0.05

Values are means ± standard deviation of duplicate determination. Means in the same column followed by different superscripts are significantly ($p < 0.05$) different.

Table 8: Organic acid analysis of cashew apple (*Anacardium occidentale*) juice.

Variety	Method of processing	Sample	Acetic acid (%)	Malic acid (%)	Oxalic acid (%)	Citric acid (%)	Ascorbic acid (mg/100 g)
Pink	Fresh	FPJ900	0.12 ^{cd} ±0.04	0.25 ^a ±0.01	0.24 ^{ab} ±0.00	0.38 ^a ±0.00	23.73 ^a ±1.01
	Pasteurized	PPJ901	0.24 ^{bc} ±0.00	0.15 ^b ±0.01	0.14 ^c ±0.00	0.35 ^a ±0.00	25.76 ^a ±0.00
Yellow	Fresh	FYJ902	0.36 ^a ±0.00	0.27 ^a ±0.01	0.25 ^b ±0.00	0.25 ^b ±0.00	20.04 ^b ±0.98
	Pasteurized	PYJ903	0.33 ^{ab} ±0.42	0.16 ^b ±0.01	0.17 ^c ±0.01	0.23 ^b ±0.02	23.05 ^a ±0.00
Red	Fresh	FRJ904	0.16 ^d ±0.00	0.24 ^a ±0.01	0.22 ^c ±0.01	0.21 ^b ±0.02	14.31 ^c ±0.14
	Pasteurized	PRJ905	0.12 ^d ±0.00	0.10 ^c ±0.01	0.09 ^d ±0.01	0.22 ^b ±0.02	17.74 ^b ±1.00

Values are means ± standard deviation of duplicate determination. Means in the same column followed by different superscripts are significantly ($p < 0.05$) different.

tartaric acid in grape juice (Gensler and Schmidt, 1994). The major organic acids found in different species of cashew apple are citric and malic acid and in different kinds of commercially available fruits are citric and malic acids (Nishiyama *et al.*, 2008). Malic and citric acids are the main organic acids in the pomegranate juice, quinic, galacturonic, and malic acids in apple juice, and malic, tartaric, and citric acids in grape and white grape juices are the major acids. Moreover, grape juice contains a high content of galacturonic, malic, and citric acids (Chen *et al.*, 2013).

The content of acetic, citric, oxalic, and malic acid in cashew apple fruits juice decreased after 14 days storage in cold condition (Mezey and Mezeyova, 2018). During storage, the content of malic acid decreases particularly in conditions of high oxygen concentration (Róth *et al.*, 2007). The contents of vitamin C and organic acids including citric, malic, tartaric, oxalic, and fumaric acids of two strawberry cultivars ("Dorit" and "Selva") decreased during cold storage at 0°C for 10 days. Since the citric and malic acids were major organic acid in the strawberry fruit, they can affect the flavor of the fruits (Koyuncu and

Dilmacunal, 2010). Adhikari *et al.* (2002) demonstrated that, during storage stage, the contents of acetic and lactic acid were increased, pyruvic acid was initially decreased and then increased, citric and uric acid remained stable, and no specific patterns were found in propionic or butyric acid content in plain set and stirred yogurts (Adhikari *et al.*, 2002).

Acetic acids with IUPAC name of ethanoic acid and common names include vinegar (diluted form), hydrogen acetate, and methane carboxylic acid which are known as the oldest chemicals to human (Anyasi *et al.*, 2017; Ricke, 2003).

Malic acid

From (Table 8) malic acid ranged from 0.27% in sample FYJ902 (fresh yellow juice) to 0.10% in sample PRJ905 (pasteurized red juice). This result showed a no significant difference at $P > 0.05$, it also showed that the yellow variety cashew apple has the most content of malic acid in them. Malic acid is known as hydroxybutanoic acid or hydroxysuccinic acid and is an alpha hydroxy organic acid,

which has been derived from Latin word “malum,” meaning apple, and has been discovered with fumaric acid using the dry distillation of malic acid (Theron and Lues, 2010; Goldberg *et al.*, 2006). Malic acid is used as acidulant, a buffering agent, an antioxidant flavoring, and a chelating agent. The (L) enantiomer of malic acid possesses a petty apple flavor and is applied as a flavoring agent to cover the bitter tastes and to provide tartness and is also used as an alternative to citric acid in tooth cleaning tablets, mouthwashes, and effervescent powders (Brittain, 2001). Furthermore, it has chelating and antioxidant properties and may be used as a synergist, with butylatedhydroxytoluene, to retard oxidation in vegetable oils (Brittain, 2001). This acid is water-soluble and has less hygroscopic properties as compared to others, and thus, provide a good storage shelf-life (Mohan Rao and Ramalakshmi, 2011). It is commonly found in apples, plums, pears, and bananas and as the secondary acid existing in citrus fruit rather than citric acid (Perera and Smith, 2013; Mohan Rao and Ramalakshmi, 2011).

Citric acid

From the (Table 8), citric acid ranged from 0.21% in sample FRJ904 (fresh red juice) to 0.38% in sample FPJ900 (fresh pink juice). This analysis showed that the pink cashew apple variety had the highest content of citric acid while the red variety had the lowest content of citric acid in them. This analysis also reveals that pasteurization at 75°C had no effect on significant the analysed organic acid. The name of citric acid was derived from the Latin word of citrus, the citron tree that bears a fruit such as a lemon (Mattey and Kristiansen, 1999). It is a tricarboxylic acid and a popular acidulant used in many preserved food due to its flexibility and ability to enhance the flavor of citrus-based foods (Soltoft-Jensen and Hansen, 2005; Marz, 2002). However, its sharp acidic taste makes it mostly preferable in specific products such as citrus-flavored drinks (Theron and Lues, 2010; Fowlds, 2002). It is not an antioxidant itself, but enhances the efficiency of phenolic primary antioxidants by chelating metal ions for catalyzing the lipid autoxidation. Together with ascorbic acid, it is used for the prevention of enzymatic browning in vegetable and fruit products (Berk, 2018; Søltoft-Jensen and Hansen, 2005). This acid is common in lemons, oranges, and bananas and foods preserved with citric acid include beverages, tomato juice, jams, jellies, ice cream, sherbets, and salad dressings (Søltoft-Jensen and Hansen, 2005; Perera and Smith, 2013).

Ascorbic acid

Ascorbic acid or vitamin C belongs to the family of monosaccharides which is not produced in body cells, and so, it should be taken up orally by adding it to foods (Gutierrez *et al.*, 2012; Quitmann *et al.*, 2013; Varvara *et al.*, 2016). The name of ascorbic acid is derived from the

Latin a (meaning no) and scorbutus which refers to scurvy disease caused by deficiency of vitamin C developed among ship crew in the past (Varvara *et al.*, 2016). From this analysis it can be seen that cashew apples are exceptionally rich in ascorbic acid which can get rid of every vitamin C deficiency and related ailment while helping to boost the proper functioning of the human body. From table 4.7, it showed that ascorbic acid is not significantly different ($P > 0.005$) in each cashew apple variety, with the pink variety having the most content of ascorbic acid content in them. Ascorbic acid can be present in all compartments of the plant cells and tissues and is widely used in fruit and vegetable products, but the amount in various species is highly variable (Arrigoni and De Tullio, 2002; Kalt, 2005). This acid has diverse functions and is used as an antioxidant for preventing damage from free radicals and other reactive oxygen species, synergist with phenolic antioxidants, sequestrants, and reducing agents or oxygen scavenger and as an important cofactor for a number of enzymes in plants and animals (Smith and Hong-Shum, 2011; Ford, 2012; Walker and Famiani, 2018). Further, ascorbic acid influences many metabolic processes such as defense reactions, cell division, and gene expression (Arrigoni and De Tullio, 2002; Smirnof, 2011; Walker and Famiani, 2018). This acid facilitates the intestinal absorption of the iron and removes the toxic heavy metals such as nickel, lead, and cadmium and is important for the carnitine synthesis in the zymotic transformation of the cholesterol in the bile acid or in vitamin D (Varvara *et al.*, 2016). L-ascorbic acid and its different by-products are the customary preservatives in the manufacture of canned foods (Perez-Ruiz *et al.*, 2007). Ascorbic acid is traditionally formed by chemical synthesis route via the Reichstein process with several steps. About 25% of universal annual ascorbic acid production is used as an antioxidant in food, 15% in beverage manufacturing, and 10% in animal nutrition (Oster and Fecht, 2012; Quitmann *et al.*, 2013).

Acetic acids

With IUPAC name of ethanoic acid and common names include vinegar (diluted form), from the (Table 8). The content of acetic acid as analyzed ranged from 0.12% in both sample FPJ900 (fresh pink juice) and sample PRJ905 (pasteurized red juice) to 0.36% in sample FYJ902 (fresh yellow juice). The yellow variety had the highest amount of acetic acid for both fresh and pasteurized samples. The acetic acid content were not significantly different at $P > 0.05$. Under anaerobic conditions, acetic acid can be produced by several members of the genus *Clostridium*, through which this species without using ethanol as an intermediate can convert directly sugars to acetic acid (Anyasi *et al.*, 2017; Xu *et al.*, 2011). In addition, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* or for topical treatments (Sloss *et al.*, 1993; Thorp *et al.*,

1998; Akiyama *et al.*, 1999; Martineau and Dosch, 2007) and various types of otitis media (Aminifarshidmehr, 1996). Acetic acid is produced by bacterial fermentation and synthetically.

Oxalic acid

Oxalic acid the analysis result in (Table 8) showed that sample FPJ900 had oxalic acid content of 0.24, PPJ901 had oxalic acid content of 0.14, FYJ902 had oxalic acid content of 0.25, PYJ903 had oxalic acid content of 0.17, FRJ904 had oxalic acid content of 0.22, PRJ905 had oxalic acid content of 0.09 respectively, this result also showed that oxalic acid was not significantly different at $P > 0.05$ in all samples analyzed. The contents of vitamin C and organic acids including citric, malic, tartaric, oxalic, and fumaric acids of two strawberry cultivars ("Dorit" and "Selva") decreased during cold storage at 0°C for 10 days. Since the citric and malic acids were major organic acid in the strawberry fruit and cashew apples, this can affect the flavor of the fruits (Koyuncu and Dilmac, 2010).

Sensory evaluation result of cashew apple (*Anacardium occidentale*) juice

Flavour

From (Table 9), it shows a significant difference ($p < 0.05$) in all samples analyzed, their means ranged from 5.80 in sample FYJ902 to 6.35 in sample FPJ900 and sample PYJ903. The average mean of flavor from the table above is 6.18, from the 9-point Hedonic scale rating, this shows that the flavor was liked slightly by the panelist. Flavour is an important attributes that influences customers acceptance of a food product. Volatile compounds that impacted flavor were formed during pasteurization (Onimawo and Akubor, 2012).

Appearance

The result presented in (Table 9), showed a significant difference ($p < 0.05$) in all samples above FPJ900, PPJ901, FYJ902, PYJ903, FRJ904, PRJ905 with a mean score of 6.80, 6.70, 6.45, 5.50, 6.30 and 6.60 respectively. The cashew juice samples maintained a bright whitetish coloured in all samples and throughout the 14-days storage period of short storage even when yeast fermentation occurred. According to Ubbor and Akobundu, (2009), appearance is another attributes that influences customers' acceptance of a food product even before tasting.

Taste

Results showed in (Table 9), revealed that there was a

significant difference ($p < 0.05$) in the samples FPJ900, PPJ901, FYJ902, PYJ903, FRJ904, PRJ905 tasted due to the full maturation of the cashew apples used in the juice production which were fully ripened. The mean score was 6.95 for sample FPJ900, 6.85 for sample PPJ901, 6.55 for sample FYJ902, 6.85 for sample PYJ903, 6.00 for sample FRJ904 and 6.60 for sample PRJ905.

Tartness

Table 9 showed a significant difference $p < 0.05$ in the different cashew apple juice varieties. Tartness relates to the biting sensation felt by the Tongue of the panel members during the sensory analysis. The mean value from the result above ranges from 6.00 in sample FRJ904 to 6.85 in sample PRJ905 and also the fresh samples FPJ900, FYJ902, FRJ904 possessed more tart concentration than the pasteurized samples PPJ901, PYJ903, PRJ905, this greatly implies that pasteurization of the cashew apple juice at 75°C had greatly affected the tannin concentration in the samples thereby detoxifying it.

Clarity

The scores given by the panel of judges on clarity shown in (Table 9), reveal that there was a significant difference ($p < 0.05$) in the samples FPJ900, PPJ901, FYJ902, PYJ903, FRJ904, PRJ905 according to the scores by the semi-trained panel members using the 9-point Hedonic scale (9- like extremely, 8-like very much, 7-like moderately, 6- like slightly, 5- neither like or dislike, 4- dislike slightly, 3- dislike moderately, 2- dislike very much, 1 dislike extremely) with the mean score of 6.35, 6.90, 6.85, 6.85, 6.90 and 6.85 respectively.

General Acceptability

On general acceptability, results presented in (Table 9), showed there was a significant difference between sample at $P < 0.05$. The samples FPJ900, PPJ901, FYJ902, PYJ903, FRJ904, PRJ905 had the following mean score 7.10, 6.80, 6.80, 6.80, 6.30, 6.26 respectively. The acceptability of the juice could be attributed to the reduction in the astringency caused by the tannin content of the fresh cashew apple juice. This was in line with the study of Ukonze *et al.* (2018), who found out that cashew apple juice was not consumed like other fruit juices due to its characteristic astringent taste, which caused a biting sensation of the tongue and throat.

Shelf life stability result

From the analysis result from (Table 10), it was observed that there was a slight decrease in pH and vitamin C over 14 days of storage in the refrigerator, this has been reported by (Ibrahim, 2016) for pawpaw, pineapple and watermelon juices. The decrease in vitamin C (Table 10)

Table 9: Sensory evaluation of cashew apple (*Anacardium occidentale*) juice.

Variety	Method of processing	Samples	Flavor	Taste	Appearance	Tartness	Clarity	General Acceptability
Pink	Fresh	FPJ900	6.35 ^a ±1.95	6.95 ^a ±1.50	6.80 ^a ±1.96	6.35 ^a ±1.39	6.35 ^a ±1.04	7.10 ^a ±1.17
	Pasteurized	PPJ901	6.30 ^a ±1.97	6.85 ^a ±1.63	6.70 ^a ±1.30	6.40 ^a ±1.54	6.90 ^a ±0.91	6.80 ^a ±1.15
Yellow	Fresh	FYJ902	5.80 ^a ±1.79	6.55 ^a ±1.79	6.45 ^a ± 1.28	6.05 ^a ±1.60	6.85 ^a ±1.09	6.80 ^a ±1.51
	Pasteurized	PYJ903	6.35 ^a ±1.42	6.85 ^a ±1.31	5.50 ^a ±1.99	6.15 ^a ±1.50	6.85 ^a ±1.09	6.80 ^a ±1.51
Red	Fresh	FRJ904	6.15 ^a ±1.53	6.00 ^a ±1.29	6.30 ^a ±1.84	6.00 ^a ±1.62	6.90 ^a ±0.72	6.30 ^a ±1.17
	Pasteurized	PRJ905	6.10 ^a ±2.02	6.60 ^a ±1.43	6.60 ^a ±1.19	6.85 ^a ±0.99	6.85 ^a ±0.99	6.26 ^a ±1.41

Values are means ± standard deviation of duplicate determination. Means in the same row followed by different superscripts are significantly ($p < 0.05$) different.

Table 10: Physio-chemical proerties of cashew apple juice (14-days).

Variety	Method of processing	Sample	pH	Total Titrable Acidity (%)	Total Soluble Sugar g/L	Vitamin C mg/100g
WEEK 1						
Pink	Pasteurized	PPJ901	5.20 ^a ±0.00	0.37 ^a ±0.21	1.86 ^a ±0.00	24.21 ^a ±0.01
Yellow	Pasteurized	PYJ903	5.30 ^a ±0.00	0.26 ^b ±0.00	1.81 ^b ±0.01	21.54 ^b ±0.02
Red	Pasteurized	PRJ905	5.30 ^a ±0.00	0.22 ^b ±0.00	1.62 ^c ±0.00	15.66 ^c ±0.01
WEEK 2						
Pink	Pasteurized	PPJ901	5.05 ^a ±0.07	0.41 ^a ±0.02	1.86 ^a ±0.00	22.65 ^a ±0.00
Yellow	Pasteurized	PYJ903	4.95 ^a ±0.07	0.34 ^{ab} ±0.02	1.81 ^b ±0.81	19.29 ^a ±1.01
Red	Pasteurized	PRJ905	5.15 ^a ±0.07	0.28 ^b ±0.02	1.62 ^c ±0.00	13.56 ^a ±1.01

Values are means ± standard deviation of duplicate determination. Means in the same rows followed by different superscripts are significantly ($p < 0.05$) different.

observed in the juices with increase storage time could be as a result of the effect of oxidation reactions taking place during storage considering the unstable nature of Vitamin C (Okorie *et al.*, 2009). Despite the decrease in the vitamin C content, the juices which were stored at refrigeration temperature had higher values because the juice was more stable at the low temperature. Increase in total soluble solid content has been reported to be as a result of solubilization of fruit constituents during storage while increase in titrable acidity may be due to breakdown of pectin into pectinic acid (Yadav *et al.*, 2014). Increase in total soluble solids indicates proper preservation of the juice whereas a decrease signifies deterioration which may be due to fermentation of carbohydrates (sugars) into carbon dioxide, water and ethyl alcohol (Wisal *et al.*, 2013). Furthermore, breakdown of glucose, fructose and other polysaccharides increases the reducing sugar content of the juice with increase in storage time. As a result of breakdown due to acid hydrolysis, the non-reducing sugar (sucrose) content of the juice decreased with increase in storage time. A decrease in reducing and non-reducing sugar could also be as a result of microbial absorption of nutrients during fermentation (Wisal *et al.*, 2013). The juices were better preserved in the refrigerator, though a combination of cold preservatives alongside pasteurization at 75° C for 5 min has been reported to improve the shelf life stability of mulberry juice for a period of 9 months (Yadav *et al.*, 2014).

The panel's choice for the clarified and pasteurized 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 is responsible for the astringency of the latter. Sensory profiles of cashew apple juice show that clarified and pasteurized juice is whitish in colour, less acidic and less astringent. This decrease in astringency is explained by the removal of tannins. Pasteurization did not affect the clarity and appearance of the juice. The same observation was made by during the heat treatment of cajuina at 80°C and 121°C. The depreciation of clarified and pasteurized cashew apple juice stored at juice stored at 10°C is based to the change in colour and aroma of the latter. Indeed, with the fluctuations in electricity, we observe the continuation of the Maillard reaction which has the effect of impacting the colour of the juice. The juice stored at 10°C retained its original whitish colour. This observation was also made by Gössinger *et al.*, (2009) 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. This results from the simultaneous degradation of natural red anthocyanin pigments into colourless compounds and the formation of brown pigments as a result to enzymatic and/or non-enzymatic reactions. Non-enzymatic browning reactions are related to the degradation of ascorbic acid, Maillard-associated reactions and acid-catalyzed degradation of sugars. Intermediates of ascorbic acid and sugar degradation, such as carbonyl compounds, can polymerize or react with amino acids and participate in Maillard-associated reactions to form brown pigments (melanoidins). Also, factors favouring non-enzymatic browning reactions include pH, ascorbic acid concentration, sugars and amino

Table 11: Microbiological analysis on fresh and pasteurize cashew apple (*Anacardium occidentale*) juice

Variety	Method of processing	Sample	TBC(cfu/ml)	TCC(cfu/ml)	TYC(cfu/ml)
Pink	Fresh	FPJ900	4.84 X 10 ⁵	NIL	2.2 X 10 ⁵
	Pasteurized	PPJ901	3.6 X 10 ³	NIL	2.2 X 10 ²
Yellow	Fresh	FYJ902	2.2 X 10 ⁴	NIL	2.2 X 10 ⁵
	Pasteurized	PYJ903	5.00 X 10 ⁵	NIL	2.4 X 10 ²
Red	Fresh	FRJ904	7.40 X 10 ⁵	NIL	2.8 X 10 ⁵
	Pasteurized	PRJ905	5.60 X 10 ⁴	NIL	2.1 X 10 ²

Table 12: Microbiological analysis on cashew apple (*Anacardium occidentale*) juice.

Variety	Method of processing	Sample	Total plate count (cfu/ml)
Week 1			
Pink	Pasteurized	PPJ901	1.33×10 ⁵
Yellow	Pasteurized	PYJ903	3.70×10 ⁵
Red	Pasteurized	PRJ905	1.51×10 ⁵
Week2			
Pink	Pasteurized	PPJ901	1.81×10 ⁶
Yellow	Pasteurized	PYJ903	1.88×10 ⁶
Red	Pasteurized	PRJ905	3.07×10 ⁶

acids, oxygen availability and processing and storage conditions.

Microbiological analysis on cashew apple (*Anacardium occidentale*) juice

Factors that affect the microbial colonization of juices include redox potential (pH), water activity, nutrients, temperature, antimicrobial agents and relative humidity (Raybaudi-Massilia *et al.*, 2009). In the present study, the juice contained more bacteria than yeast as stated by Rivas *et al.* (2006) that at pH values of 1.5, moulds and yeasts are capable of growth. As observed in (Tables 11 and 12), there was an increase in microbial quantity with time between value obtained for week1 and week 2. The pH values ranging from 2.9–3.5, pH 3.0–4, and 3.6–4.5 allow the growth of lactic acid bacteria, acetic acid bacteria and enteric bacteria respectively are higher than those for growth of yeasts (Lawlor *et al.*, 2009).

Conclusion

The result of this research reveals that cashew apple (*Anacardium occidentale*) juice processing is one of the prime areas of utilizing the indigenous fruit which opens up wider market possibilities and hence, tremendous scope for commercialization. Physical, chemical and bio-processing methods have also been used to improve sensory qualities of the products by removing the tart sensation felt by the consumers. Cashew apple, which otherwise go as waste can be employed for making diversified products. The crops like cashew can be a boom to the farmers which can sustain with limited inputs and care, still earning higher revenue to the grower. Processing of cashew apple is an economically viable enterprise in cashew growing tracts. Farmers can very well

take up this enterprise, thereby effectively contributing to the cause of women empowerment for production of value added foods it can substantially enhance the income from cashew apple processing. Cashew apple is highly nutritious and comparable with many other tropical fruits. Processing of cashew apple is an economically viable enterprise in cashew growing tracts. Women Self Help Groups can very well take up this enterprise, thereby contributing to the cause of women empowerment.

Conflict of interest

There is no conflict of interest on this publication

Source of funding

No source of funding

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